Proceedings of the 10th Conference on Videogame Sciences and Art

PORTO, 21 & 22 NOVEMBER 2018
http://vj2018.fba.up.pt

TITLE

Videojogos 2018
Proceedings of the 10th Conference on Videogame Sciences and Arts

EDITED BY

Miguel Carvalhais
Pedro Amado
Pedro Cardoso

PUBLISHED BY

i2ADS – Research Institute in Art, Design and Society
University of Porto, Faculty of Fine Arts

ISBN

978-989-54111-6-0

DESIGN

Pedro Brochado

ORGANISING COMMITTEE

Miguel Carvalhais
INESC TEC / Faculdade de Belas Artes
da Universidade do Porto

Pedro Amado
i2ADS / Faculdade de Belas Artes
da Universidade do Porto

Pedro Cardoso
INESC TEC / Faculdade de Belas Artes
da Universidade do Porto

Teresa Matos
INESC TEC / Faculdade de Engenharia
da Universidade do Porto

SCIENTIFIC COMMITTEE

Ana Amélia Carvalho
Universidade de Coimbra

André Carita
Universidade Lusófona

André Sier
s373.net/x / Plymouth University /
Universidade de Évora

António Coelho
INESC TEC / Faculdade de Engenharia
Universidade do Porto

Bruno Giesteira
INESC TEC / Faculdade de Belas Artes
Universidade do Porto

Carlos Martinho
Instituto Superior Técnico
Universidade de Lisboa

Carlos Santos
Universidade de Aveiro

Conceição Costa
Universidade Lusófona de Humanidades e Tecnologias

Duarte Duque
2Ai / Instituto Politécnico do Cávado e do Ave

Eva Oliveira
Instituto Politécnico do Cávado e do Ave

Filipe Costa Luz
Universidade Lusófona

João Alves de Sousa
Universidade Lusófona Porto

João Jacob
LIACC / Faculdade de Engenharia
Universidade do Porto

Jorge Martins Rosa
Faculdade de Ciências Sociais e Humanas
Universidade Nova de Lisboa

José Carlos Neves
Universidade Lusófona de Humanidades e Tecnologias

Licínio Roque
Universidade de Coimbra

Manuel José Damásio
Universidade Lusófona de Humanidades e Tecnologias

Mariana Vital
Universidade Lusófona de Humanidades e Tecnologias

Mário Vairinhos
DiGiMedia Research Center / Universidade de Aveiro

Miguel Carvalhais
INESC TEC / Faculdade de Belas Artes
Universidade do Porto

Patrícia Gouveia
CIEBA, Faculdade de Belas Artes
Universidade de Lisboa

Pedro A. Santos
INESC-ID / Instituto Superior Técnico
Universidade de Lisboa

Pedro Amado
i2ADS / Faculdade de Belas Artes
Universidade do Porto

Pedro Cardoso
INESC TEC / Faculdade de Belas Artes
Universidade do Porto

Ricardo Melo
Politécnico do Porto
Instituto Superior de Contabilidade
e Administração do Porto / CEOS.PP

Rui Antunes
BioISI, Faculdade de Ciências, Universidade de Lisboa

Rui Nóbrega
INESC TEC / Faculdade de Engenharia
Universidade do Porto

Rui Prada
INESC-ID / Instituto Superior Técnico
Universidade de Lisboa

Rui Rodrigues
INESC TEC / Faculdade de Engenharia
Universidade do Porto

ORGANISATION

FBAUP – Faculty of Fine Arts, University of Porto

FEUP – Faculty of Engineering, University of Porto

i2ADS – Research Institute in Art, Design and Society

INESC TEC – Institute for Systems and Computer Engineering, Technology and Science

SPCV – Sociedade Portuguesa de Ciências dos Videojogos

VOLUNTEERS

Filipe Costa

Joana Pereira

José Raimundo

Livia Lopes

Margarida Rocha

Marisa Pinheiro

Olga Almeida

Pedro Reis

Rita Cruz

Rodrigo Assaf

Valter Abreu

SPECIAL THANKS

Almeida Garrett Municipal Library

Margarida Dias

Patrícia Campos

Roberto Correia

SUPPORT

Câmara Municipal do Porto

Porto.

FCT – Fundação para Ciência e Tecnologia

FCT Fundação para a Ciência e a Tecnologia

FOREWORD

PORTO,
JULY 2019

–
MIGUEL CARVALHAIS
PEDRO AMADO
PEDRO CARDOSO

Welcome to the Proceedings of the 10th edition of Videojogos, the Conference about Sciences and Arts of Video Games, that took place on November 21st, at the auditorium of the Almeida Garrett Municipal Library, and was organised by the Faculty of Fine Arts of the University of Porto, the i2ADS (Research Institute in Art, Design and Society), and the SPCV (Sociedade Portuguesa de Ciências dos Videojogos).

This annual conference has the goal to promote the scientific culture, research, and the industry of video games in Portugal, in which participated students, researchers, and professionals that work in the broad scope of video games.

This edition of the conference (VJ2018) followed the format of previous editions, featuring the presentation of the communications by national and international researchers, and the presentation of projects and demos that resulted from a call for papers, in a total of fourteen accepted and presented submissions, focused on Accessibility, Aesthetics, Art Games, Critical Games, Games and Creativity, Gaming Culture, Game Development, Games and Learning, Games as Methods, Game Studies, Games as Tools or Instruments, Gamification, Gaming and Performance, Narrative, Non-Digital Games, Pervasive Games, Serious Games, Speculative Games, Technology, VR / MR / AR, and Music and Games.

The exhibition space presented four posters covering education, graphic design, and biology. And eleven prototypes were demonstrated by researchers, students and developers in a varied scope of technologies and implementation fidelity, ranging from paper to software, using different languages (e.g. Processing, Unity, or C++) and using specific hardware (e.g. HTC Vive).

André Sier closed the program as the guest speaker, presenting the closing keynote “21 Games for the 21st Century”, a reflection on the evolution of the industry and the technology with artistic cases authored by himself.

During the conference, we confirmed the presence of 115 registered participants: professors, researchers, post-graduate and under-graduate students, directly linked to the field of action and research of videogames, from at least four main public and three private higher education institutions, as well as professionals in computer graphics, software engineering and game development and digital media industries.

As a closing remark, we'd like to thank all the authors, participants, invited speaker, the members of the Scientific Committee, Organising Committee that helped to make this edition possible. We would also like to express our gratitude for the financial support from UP and FCT and the support of the city of Porto by allowing us to use the awesome space of the Almeida Garrett Municipal Library. A special thanks to the SPCV, for promoting the organization of this conference throughout all these years.

KEYNOTE

21 Games for the 21st Century

ANDRÉ SIER[1]

0. SETUP(){

Since 1997, I am running a small electronic arts studio, s373.net/x, dedicated to my arts practice, exploring intersections between art, games, interaction, immersion, mathematics, poetry, cyberspace, and machines. This text is based on a keynote address during the conference "VideoJogos X" that took place at Almeida Garrett public library, in Porto's Palácio de Cristal, on the 21st November 2018. Therein, I proposed 21 Games for the 21st Century, which I have built in the new century's early years. Looking back, the selection could differ in some minor details, some pearls were eclipsed, but nevertheless, under shinned, the ones presented are representative of the main points driving this article.

Games. Games seen as interactive logical ludic constructs targeting alternative directions other than mainstream triple a gaming or even indie gaming tends to focus on. Art Games, Proto Games, Ambient Videogames, Not Games, Immersive Cyber-environments. As stated on a 2016 article at *Cibertextualidades* (2016b), my main fascination with videogames lays in its technical apex of computation by running programs on computers, as well as its integration of multiple artistic disciplines: "Videogames merge sciences, arts, engineering and logic to provide a virtual time-space continuum, closer to the experience of alternative experienceable realities." (2016b)

My arts practice, after studying music, painting, sculpture, philosophy, has mutated into exploring computation and its intersections with arts. Inspired by early contact with videogames, fascinated with its immersive capabilities, I started delving into computing exploring *techné* and media to create, synthesize, host and navigate cyber-virtual-environments. Programs, ethereal objects that call for

[1] s373.net/x art codex studios | Planetary Collegium
UÉvora | FBAUL

your actions to unfold their *spatium*.[2] Cathartic otherness artistic laboratories. Human interfaces towards Non-Human worlds to feedback the Human. Artistic constructs refocusing mythological ideas, actualized in the self that experiences and perhaps merges with the proposed ambiance.

1. BACKGROUND(COSF(FRAME*5E-4)*127+128);

Back in the late nineteen eighties, with the introduction of consumer-level micro-computers with very limited capabilities (Atari, Commodore, Spectrum), even as a youngling, I was deeply fascinated and engaged at the rudimentary logical constructs, graphics and sounds early game programmers set afoot: by interacting with physical devices I could role play and control on-screen characters with rudimentary graphics, unfold absurd or fantastic storylines, train faster responses to stimulus and increase my dexterity navigating the logical space within a game, while arousing my illusion of actively participating in endless parallel worlds that quickly changed the space around my body by immersing its attention in the videogames being played.

Although my first experiences with gaming and programming were on a Spectrum computer and the BASIC programming language, it was not until the nineties, with the appearance of more powerful commercial personal computers, and of games such as *Wolfenstein 3-D, Doom, Quake* (iD Software, 1992, 1993, 1996), *Unreal* and its editor *UnrealEd* (Epic Games, 1998), that have heightened the immersive capabilities of the gaming experience near a seamless plateau of roaming imaginary and tangible three-dimensional spaces, where I could find the tools to start experimenting building virtual spaces. Here, immersiveness refers not to the modality of human computer interface, but to a strong engagement with the programs' simulations and their innovative recreation of a real-time interactive and vast Cartesian simulated virtual space, usually made by computer graphics and sounds that are interac-

[2] Deleuze's intensive space, an ideal or metaphysical surface, a hyperspace, a plane of immanence where the being and its thinking expresses its full scope. See, for example, Burchill, L. (2007), *The Topology of Deleuze's Spatium*, in Philosophy Today, 51, pp. 154-160.

tive to the players' control (Sutherland, 1965; Baudrillard, 1981; Benedikt, 1991).

These types of games are played in the first person and the player experiences the action through the eyes of the protagonist. Although the FPS (First Person Shooter) gaming genre debuted nearly 20 years before[3] my first experiences, it was usually restrained to non-standard and cutting-edge computational research platforms which were only available at research institutions like NASA or MIT, not to a standard consumer/artist. Affordable personal computers bridged this gap and massified access to games and tools, even though they were written in cryptic logical programming languages with steep learning curves.

First-person 3-D perspective computer graphics have since layered the computational foundations for the recreation of a playable virtual space inside the memory of computers, exposed through a variety of computer peripherals that target the human senses. Videogame users saw the playing field as if they themselves were walking on it, with the virtual game space being rendered in one-point perspective as if seen from the users point of view. These types of early kinds of graphics and immersion could also be considered a very early virtual reality system. But it could also do more. As the father of virtual reality stated (Sutherland, 1965), still echoing years to come:

A display connected to a digital computer gives us a chance to gain familiarity with concepts not realizable in the physical world. It is a looking glass into a mathematical wonderland.

Combining these gaming experiences with artistic research in painting, sculpture, music and installation I was already undertaking in the nineteen nineties was an obvious natural step. These early immersive gaming experiences on computers, that initiated first person navigation on vast three dimensional spaces, by using the keyboard and mouse as interfaces on the PC between my body and the virtual constructs, have since transformed my view on what art

[3] In 1973 Steve Colley, Greg Thompson et al programmed Maze War on a Imlac PDS-1 at the NASA Ames Research Center in California. The program depicted mazes on a 16x16 bit resolution that could be navigated from a first-person perspective and shared on a network setting amongst similar machines. [http://www.digibarn.com/history/04-VCF7-MazeWar/stories/colley.html, accessed 21 October 2018].

could be: as an arts student, I quickly extrapolated this immersive quality on computerized ludic constructs to being transported into a traditional art piece's objective space.

Instead of experiencing traditional *static* works of art, by mind playing/wandering with the sense data paintings or sculptures offer, where the eyes and the imagination move according to what some masterpiece is inscribed with, returning a sense of *beyondness*, awe, terror or delight, to name a few, I started picturing what if we could merge art experiencing with videogame interacting? What if we could enter a painting and browse through it, touch it, play with it, dive within it and immerse in the artists piece conception scattered over an interactive virtual space and time? How would we conceive different spaces and mechanics where a concept of a cybernetic, interconnected and limitless body augments the real one and dilutes itself in a cyber-realm? Could these new technologies promote a heightened deeper engaging with themes unheard of in reality? Not that the mere experience of static art masterpieces does not carry along already this game within – of which numerous philosophers and artists have tried to give accounting for –, that countless human-made artifacts through the course of millennia with each epoch's technologies are proof of. But through these new computerized techniques we could almost physically venture into artistic realms, themes, interact and play with them, as no other technique has managed to actualize before, engaging deeper illusions with almost concrete tangibility into navigable, interactive experience spaces, which are distinct from what the body knew so far from its experience in a non-computerized non-augmented reality. New bodies could be forged, with distinct motion characteristics. New (virtual/cyber) spaces could be built. Spaces that could be shared, communicated through networks, bodies that could blend into other lifeforms sharing same cyberspaces.

This idea of a cyberspace, rooted in Norbert Wiener's cybernetics, where in 1948 he defined the cybernetic discipline as "the scientific study of control and communication in the animal and the machine" (Wiener, 1948), provides the infra-structural plateau on top of which such phenomena of shared topologies for human augmentation gain concreteness. It comes as no surprise that an artist pioneering artworks and first embracing these cybernetic grounds tackles the seemingly endless possibilities of these new media as a major leap, both for our understanding of the world and for its impact into forging new arts that could embrace this unbefore seen potential, reviving the ideas of a *gesamtkunstwerk* as con-

ceived by Trahndorff in 1827 and Wagner in 1849,[4] although now set and framed in a cybernetic context. Roy Ascott, in his 1989 text Gesamtdatenwerk, shares with us both of these groundbreaking topics foreseen in their full applicability (Ascott, 1989):

Increasingly, as artists, we are impatient with single modes of operation in data space. We search for synthesis of image, sound, text. We wish to incorporate human and artificial movements, environmental dynamics, and ambient transformations all together into a more seamless whole. We search, in short, for what I call, in German, Gesamtdatenwerk, or "integrated data work," echoing the Gesamtkunstwerk, or "total artwork," conceived by Richard Wagner.

Ascott continues to underline the philosophical implications of what such a cyberspace could be, firmly entwined in reality:

[...] computer networking provides for a field of interaction between human and artificial intelligence, involving symbiosis and integration of modes of thinking, imagining and creating, which, from the point of view of art, can lead to an immense diversity of cultural transformations, and which, in science and philosophy, can yield enriched definitions of the human condition. Computer networking, in short, responds to our deep psychological desire for transcendence—to reach the immaterial, the spiritual—the wish to be out of body, out of mind, to exceed the limitations of time and space, a kind of biotechnological theology.

[...] Our perception of space and time is not the frame of reality but an aspect of an undivided whole within which an infinity of separate realities, parallel universes, can endlessly be constructed. How quickly this science moves into metaphysics and brings us back to theology, mysticism, and mythology! It is in this richness of value systems, world models, cultural constructs, and virtual realities that the networking artist operates.

Another aspect worth highlighting from my early encounters with new technologies and programmed virtual realities is that it also seemed to me that these deeper experiences could change reality rules under a new technological strata, by proposing new ones, or attempting to emulate and play with known ones, and could educate and foster life changing experiences in the virtual that

[4] The term *Gesamtkunstwerk* first appears in Trahndorff (1827), *Ästhetik oder Lehre von Weltanschauung und Kunst*, although is more attributed to Richard Wagner of which he uses this same word-concept in his book *The Art-Work of the Future* from 1849.

would feedback in the user towards a better real. At the time of my first encounters with these technologies I knew of no traditional artists working on such fields. The possibilities mesmerized my senses since.

In the dawn of the commercial Internet I was able to research and experience VRML spaces,[5] early mathematical and software art, tutorials and coding tools which allowed me to learn the rudiments of programming languages, that I have been refining over the years. In the peak of these first technological encounters with game engine tools, they since shifted my interests as an artist from static traditional art experiences towards interactive processes and game spaces. Before approaching virtual space interactivity, and already with keen interests in video manufacturing and electronic sonic processes and music composition, yet in art school, I began experimenting with real-time sound and light installations, which led me to develop, since 1998 and ongoing, the *Struct* series of artworks.[6] It was yet in 1998 that I jumped into the virtual and started building a first interactive experience space for the final work of sculpture at art school. *0 0 255* (Sier, 1999)[7] was a first practical entry point into the arts I have studied, researched, presented works on, ever since.

Games, or the ludic sphere, are inherently present in many aspects of human activity. They are also a powerful tool to convey stories and other experiences which are usually outside a human's normal life. In the seminal work *Homo Ludens* (1939), Johan Huizinga applied game theory to different aspects of human life, outside of the ludic sphere, stating they could be used as tools to everyday aspects of human life. Roger Caillois (1958) built upon and disputed Hu-

[5] VRML stands for Virtual Reality Modeling Language, a precursor attempt to create a standard file format for representing 3 dimensional interactive graphics, designed in 1994 as a runner up to extending the World Wide Web to support virtual reality (Raggett, 1994, https://www.w3.org/People/Raggett/vrml/vrml.html accessed 10 October 2018).

[6] For a research article about the Struct series of artworks please refer to Sier, A. (2017), 'Structs for an aspatial quantum-now', TABOO - TRANSGRESSION - TRANSCENDENCE in Art & Science, Honorato, D., Giannakoulopoulos, A., (Eds), Corfu, Ionian University | ISBN: 978-960-7260-60-4 | URL https://avarts.ionio.gr/ttt/2017/en/proceedings/

[7] *0 0 255* was an interactive audio-visual browsable game space constructed with UnrealEd. The 3D environment offered the player navigation through a joystick in a constructed imaginary space with spatialized sounds and events. A precursor work into the many interactive 3D environments the author has constructed; some images can be consulted at https://andre-sier.com/piantadelmondo/0-0-255/

izinga's emphasis on competition in play, formulating four distinct categories of games: Agon, Alea, Mimecry/ Mimesis, Ilinx. The research I am undertaking focuses on electronic arts constructs and games fostering the disrupting of the human sense of self, thus falling on Caillois's *ilinxian*[8] game category, while trying to expand it to accommodate other distinct subcategories. This vertigo like game-state of ilixian category might be achieved via altering and disrupting the perception of self while engaging the user on a ludic construct, mediated through technology, algorithms, and custom human-computer interfaces.

Videogames are among the most elaborated software programs, which house a significantly large number of procedures in every displayed frame. Running in logical machinical substrates, which control-flow electricity as data information at dazzling speeds through labyrinthine electronic circuitry, following highly complex algorithms, which combine almost all computer's abilities at circa 60 frames per second, almost instantly, providing at human scale and their senses a feasible replica of reality, or engaging other realities. They are also a most effective mean by which, through simple interactive experiences (key stroking, mouse moving, sonic, visual, physical or other input interfaces), it is possible to engage in first-person played experiences, storytelling and even to achieve immersive otherness. "They feedback from life and have the potential to modify the self" (Sier, 2016b).

Videogames, by combining interactive content, become different from other media. Within this medium, like Espen Aarseth (1997) affirms, "nontrivial effort is required to allow the reader to traverse the text". He also states (2001):

Games are both object and process; they can't be read as texts or listened to as music, they must be played. Playing is integral, not coincidental like the appreciative reader or listener. The creative involvement is a necessary ingredient in the uses of games.

[8] Ilinx is a category of games and a kind of play Roger Caillois ascribes in his seminal 1958 book *Les Jeux et les Hommes* to a temporary disruption of perception capable of inducing alter perceptive experiences, like vertigo, dizziness, brief acute disorientation. This playful outer body experience resembles key elements of knowledge incorporation, change, Deleuze's foundation of differential ontology.

The interactive activeness remains an essential touchstone in the processes these new media allow: players dive in the imaginary yet tangible virtual worlds, and it is solely through their interaction with the world they progress or incorporate new knowledge. This essential new quality of videogames or deep interactive experiences is referred by Ian Bogost in his book *Persuasive Games* (2007), as equating videogames as a tool towards a new form of education through experimentation on the first person:

I call this new form procedural rhetoric, the art of persuasion through rule-based representations and interactions rather than the spoken word, writing, images, or moving picture. [...] In addition to becoming instrumental tools for institutional goals, videogames can also disrupt and change fundamental attitudes and beliefs about the world, leading to potentially significant long-term social change. I believe that this power is not equivalent to the content of videogames, as the serious games community claims. Rather, this power lies in the very way videogames mount claims through procedural rhetorics.

Learn by doing, learn through otherness near embodiment, or by experiencing the actions in our own flesh, virtualized or augmented, remains a powerful and deeper mechanism by which experiences can be shared in a more acute way. Now insert the tape, type Load "" and press play.

2. SWITCH (ROMS/PROGRAMS LISTING)

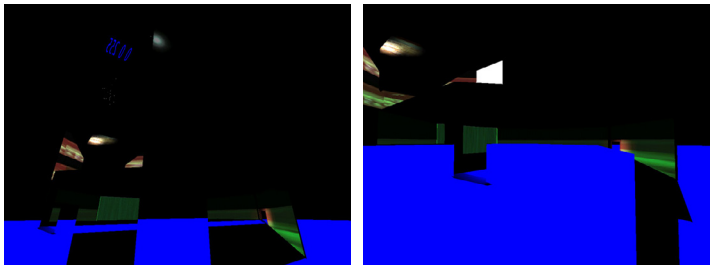
```
switch(game){
    case 00:    0 0 255                 1998/9  ;
    case 01:    747                     2001/2  ;
    case 02:    747.2                   2004    ;
    case 03:    747.3                   2006    ;
    case 04:    k.                      2007    ;
    case 05:    Space Race #1           2007    ;
    case 06:    Space Race #2           2008    ;
    case 07:    Space Race #3           2008    ;
    case 08:    32-bit Wind Machine     2009    ;
    case 09:    k.~                     2010    ;
    case 10:    747.5                   2010    ;
    case 11:    Eer                     2007/11 ;
    case 12:    0 255 0                 2011    ;
    case 13:    577Rhea                 2013    ;
    case 14:    TemporaryBabel2D        2013    ;
    case 15:    TemporaryBabel3D        2013    ;
```

```
    case 16:    747.7                   2014    ;
    case 17:    Skate.Exe               2014    ;
    case 18:    Draco.Wolfanddotcom.info 2015   ;
    case 19:    Atlantis (Sólon Interface) 2016 ;
    case 20:    Phoenix.Wolfanddotcom.info 2017 ;
    case 21:    Wolfanddotcom           2017    ;
}
```
[9]

3. DRAW(){

0 0 255 (1998/99)

This was the first (and only to this date) artistic experience constructed with a game engine editor (UnrealEd). With a title depicting the pure blue color, the work features an interactive audio-visual browsable game space, a constructed imaginary space with spatialized sounds and events, with streaks of abstract concrete space spawning from an endless blue background. It is a precursor work into the many interactive 3D environments constructed since and exploring audio-visual spatialized composition.



Figs. 1, 2
Two viewpoints into the *0 0 255* environment seen from its blue background.

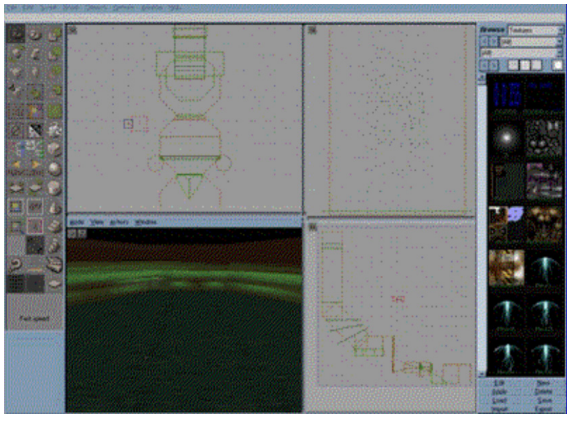


Fig. 3
Backstage view of the built program in Unreal Game Editor.

[9] The attentive programmer will notice int game might fall through due to no breaks;

747 (2001/2)

First work in the 747 series, made with Max/MSP/Nato and a custom C coded terrain external. 747 is an abstract interactive audio-visual flying machine experience, where the terrain is real-time sound generated from the amplified site-specific sounds of where the work is installed, and players must evade colliding with it, while the speeds increase.

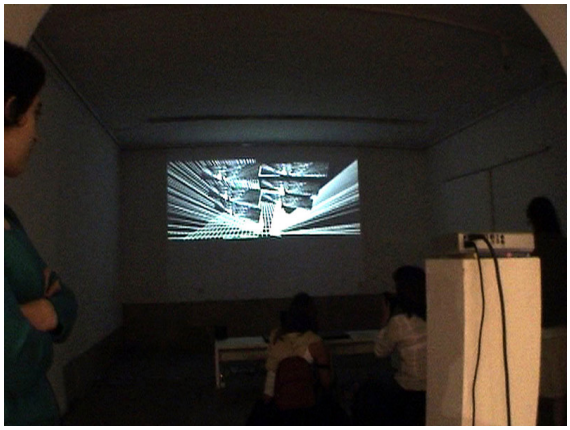


Fig. 4
747 installed at SoundVisions (2006), Sala do Risco, Lisboa.

747.2 (2004)

Second piece in the 747 series following the same game logic, this time with quadraphonic spatialized sound output and a couple of terrain spaces, above and below.

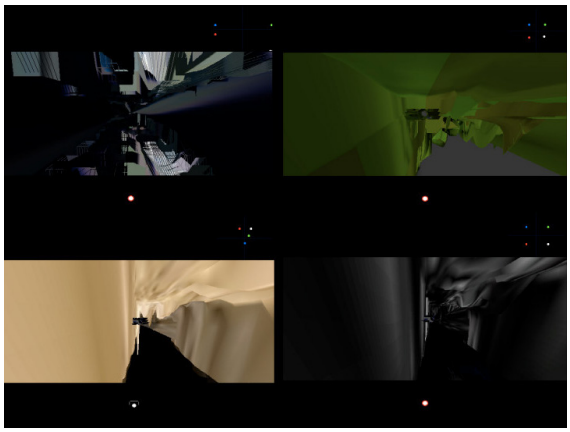


Fig. 5
4 screenshots of *747.2*.

747.3 (2006)

The third work in the 747 series features a custom computer vision tracking mechanism that is able to invisibly track a users' arms position. With this information from the custom self-built tracker I was able to transform flying human gestures into game commands.[10] Players interact simply by mimicking flying gestures in the active game area in front of the projection.

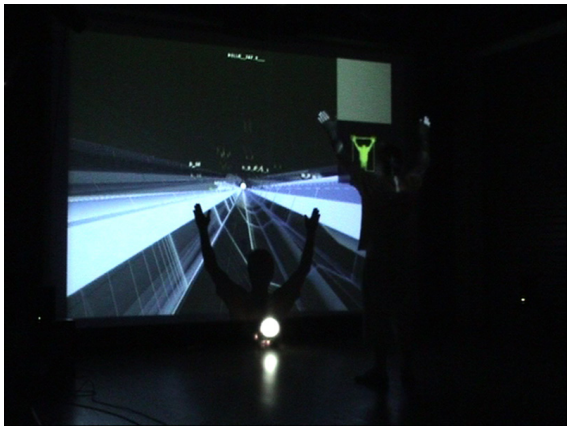
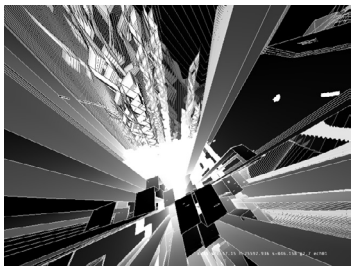


Fig. 6
747.3 installed at Lugar Comum, Oeiras.

k. (2007)

This is a procedural stochastic game with abstract graphics rooted in Franz Kafka's The Castle which attempts to provide the player a pseudo-infinite quest by placing the Castle structure, the player's goal, in only one of the 4,294,967,295 levels of the 32-bit precision random number generator. Game engine programmed from scratch in java/processing

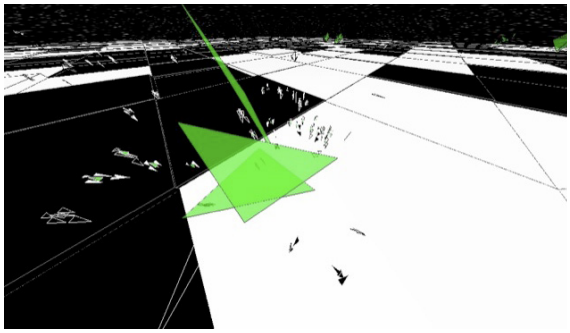


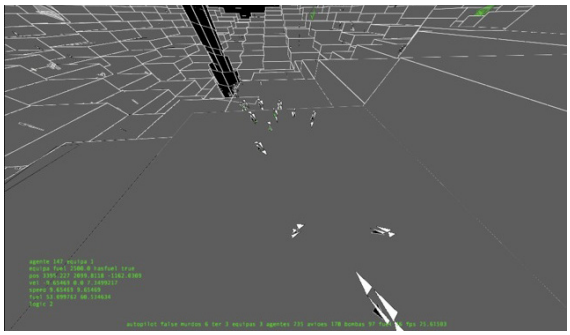
Figs. 7, 8
Screenshots from *k.*.

[10] The algorithm devised specifically for this work was implemented first in Max/MSP under the a-jit.human external (2006) and later in the Flob library for Processing and Openframeworks (2009). For more information see Sier, A. (2016a), 'Human dragons playing in cyberspace', Technoetic Arts: A Journal of Speculative Research, 15:3, pp. 283–96.

Space Race #1 (2007)

An autonomous self-playing electronic game, where the computer stochastically plays a selected number of computer agent teams which compete for fuel resources to transport them to other planets, within an endless loop.





Figs. 9, 10
Screenshots from *Space Race #1*.

Space Race #2 (2008)

An abstract game where the user is invited to play, using a joystick, fighting his way through hostile planets populated with autonomous agents that try to take his spaceship. Basically, it's Space Race #1 with high scores, where a human user competes endless hordes of computer teams.

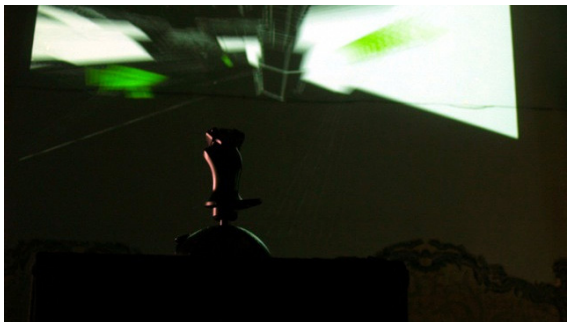
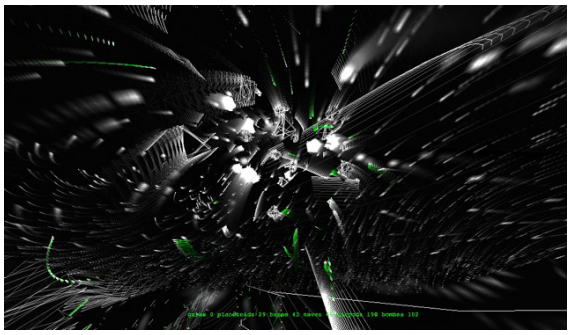
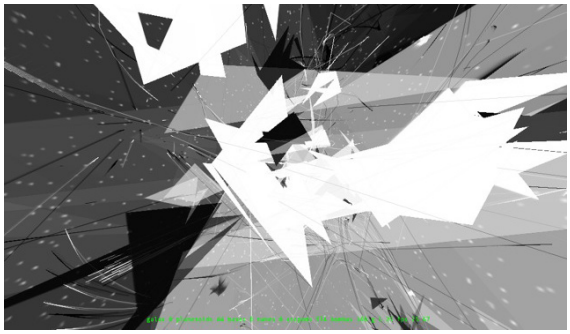


Fig. 11
Space Race #2 at Festival Eme, Teatro Ibérico, Lisboa (2008).

Space Race #3 (2008)

A 3d simulation where several simulated humanoid spaceships depart from different planetoids and search the universe in the quest of new worlds, plundering the ones they inhabit. A computer computer game, marks the end of the Space Race Trilogy, in an endless universal collapse.

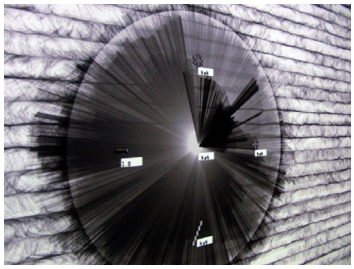


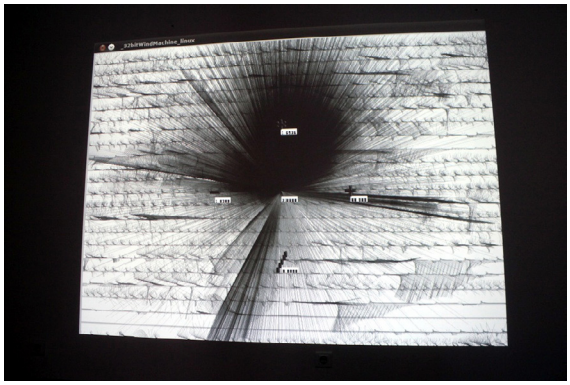


Figs. 12, 13
Space Race #3 screenshots.

32-bit Wind Machine (2009)

A visual mathematical game designed for wind and machine. A wind sensor analyses and emits to a computer the values of wind speed and wind direction. The wind values serve as input to an abstract game where 4 numbers relate with each other with the basic mathematical operations, stepping up as electronic cardinal directions (+, -, *, /). The machine pauses and restarts when the 32-bit limit of the floating point numbers is overflowed, while producing unique drawings.

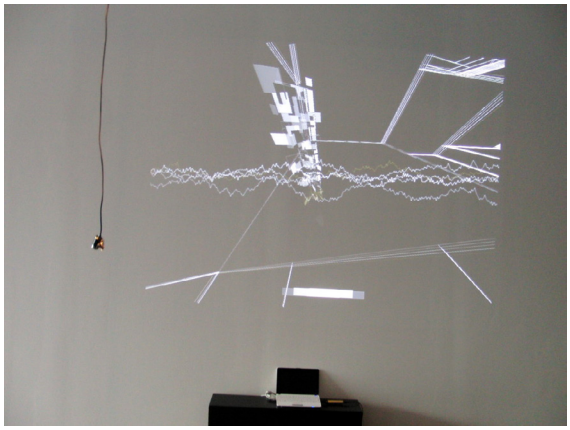


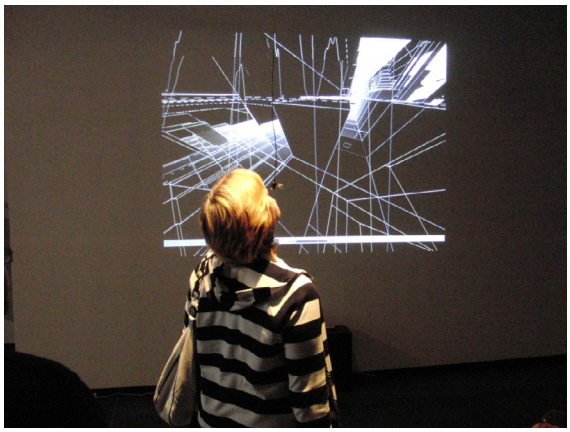


Figs. 14, 15, 16
32-bit Wind Machine sensor and visual output, at 64-bits (Who Gallery, Lisboa, 2011) (14,15) and at k.+uunniiv-veerrssee (CCCTV, Torres Vedras, 2012) (16).

k.~ (2010)

A sonic land-surveyor of infinite spaces. A three-dimensional voyage in continuous space through sound. A sonic adaptation of k. (2007) where the mouse and keyboard are replaced with a microphone and custom sound analysis algorithm. Users, making sounds above a silence threshold cause k. to move in the direction he is facing. No sounds cause continuous rotation about his axis. Hissing sounds makes him fly.

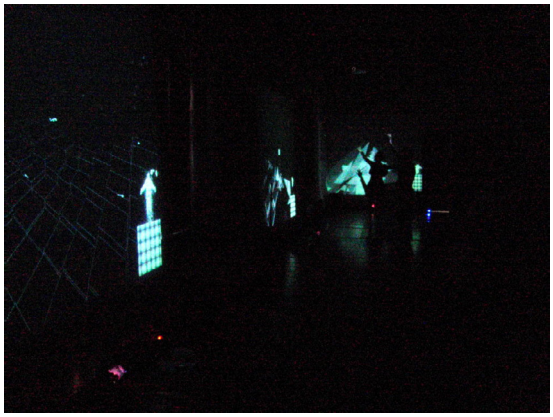




Figs. 17, 18
k.~ at Ape-x (NT Gallery, Lodz, Poland, 2010).

747.5 (2010)

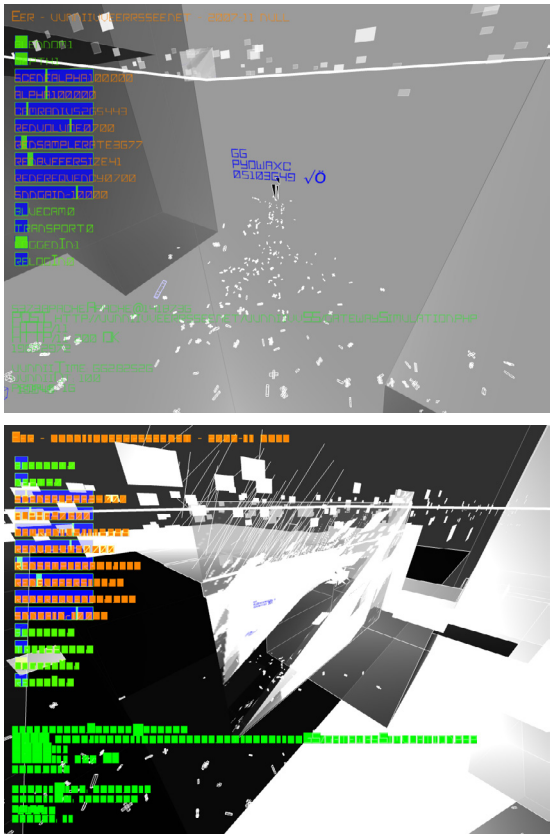
A real time simulation of free flight from the users' bodies; an audio-visual experience where several persons in a local network cross abstract stratospheric skies in a shared virtual space. Unlike *747.3* where players only move forward/sideways, here the virtual space is open and users can fly any direction and meet/crash with each other.



Figs. 19, 20
747.5 at O Espaço do Tempo, Montemor-o-Novo, 2010.

Eer (2007/11)

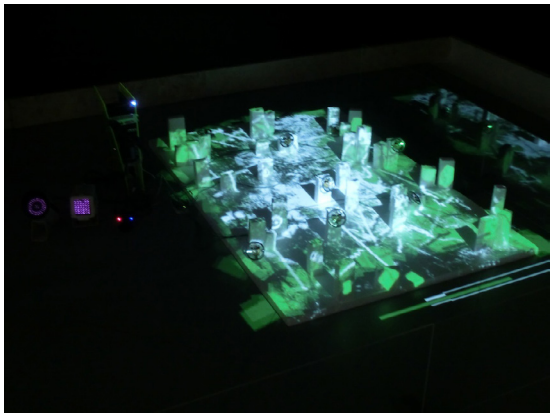
In *Eer* the user is invited, using keys or webcam, to err around the uunniivveerrssee in abstract 3d meta-spaces that gather the various online users, as well as elements of races living virtually inside the code and running in the processor cycles.

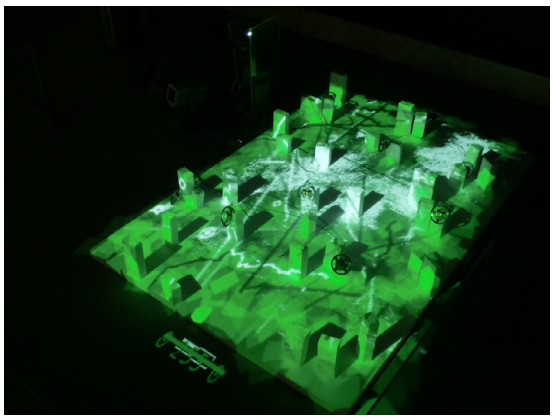


Figs. 21, 22
Eer screenshots.

0 255 0 (2011)

The piece alludes to 100% green, in RGB color components. It is a video mapping installation on the model of a city where an abstract simulation, an endless game between three teams takes place. Human movement, detected with computer vision, casts team elements on the simulation that tint the game.



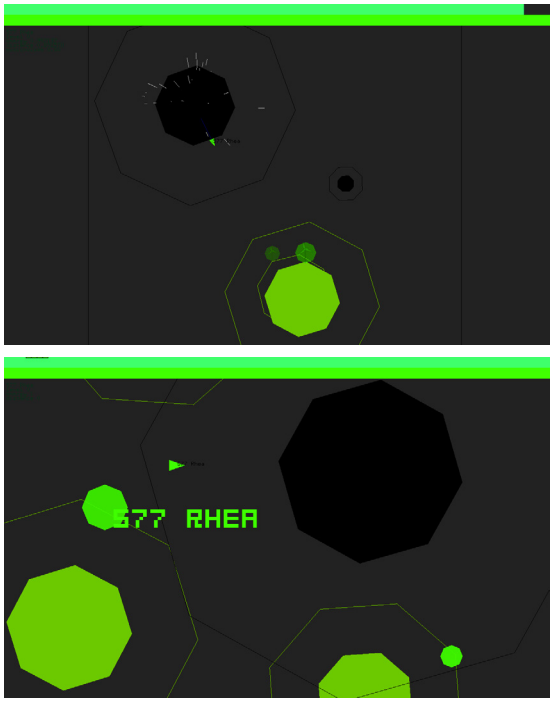


Figs. 23, 24
0 255 0 at Algoritmos Criativos, Pavilhão Ciência Viva, Lisboa.

577Rhea (2013)

Stochastic exploration space game, with smooth gravity physics.

You are your planet's last hope. Your corrupted planet explodes. You have to time-travel through blackholes with primordial essences to prevent the inevitable collapse of your home.



Figs. 25, 26
577Rhea screenshots.

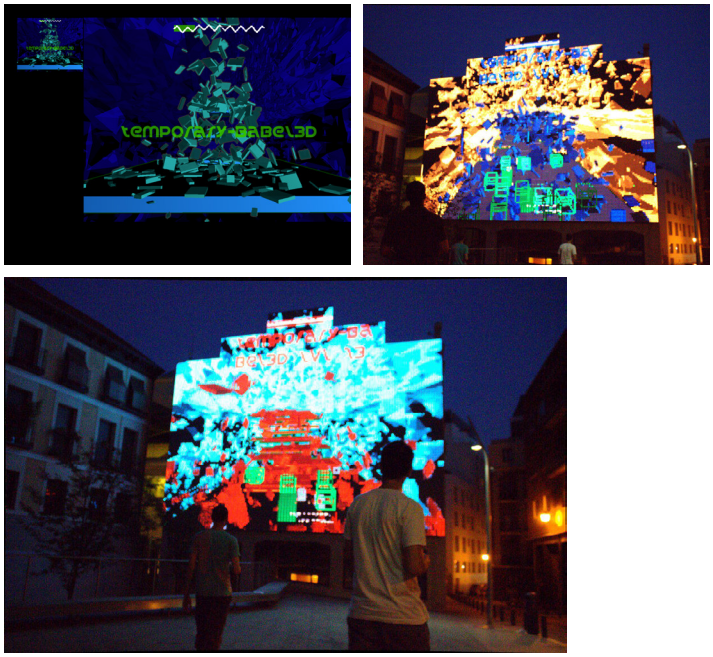
Temporary-Babel2D (2013)

An amusing and minimalist game, about libraries, time, temporary and permanent things. An interactive installation where you play in the mind-scape of the Babel Tower construction set, a space where time oscillates and perspective bends. You have 1h to reach the librarian at the top, guiding your avatars with joystick, mouse and microphone, through the several readers, hyperskates and book-shelves falling at the library, making the temporary architecture of Temporary-Babel2D.

Figs. 27, 28
Temporary-Babel2D at Festival Cidade Pre0cupada, 2013.

Temporary-Babel3D (2013)

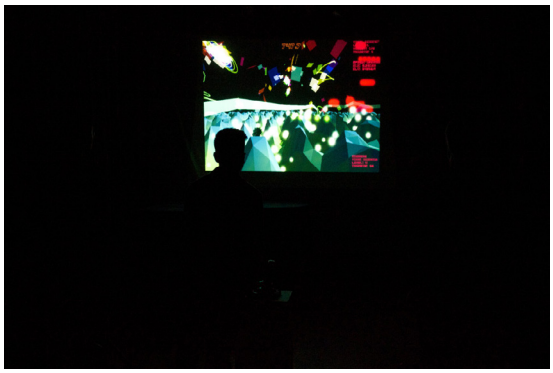
A networked computer tower-like construction game simulation is evolved from fluxes of movement by multiple real and virtual users. *Temporary-Babel3D* is an interactive game where you play in the mind-scape of the Tower of Babel construction set – a space where time oscillates and perspective bends; a space where real and virtual fluxes of movement by users carve building and destroying dynamics into the edification of an interactive community built game. This project synthesizes upon the archaeological movement of rebuilding the Tower of Babel, and how communities' movements shape transient and temporary virtual architectures within an engaging simple game environment.

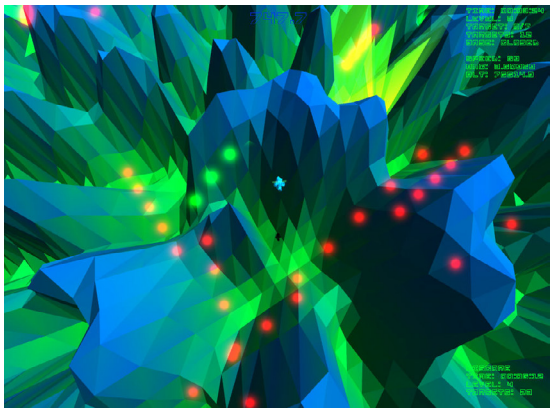


Figs. 29, 30, 31
Temporary-Babel3D at Solid Interfaces and Urban Games, Medialab Prado, Madrid, 2013.

747.7 (2014)

Stochastic, immersive, meditative war game space. *747.7* is a game and an abstract flight simulator populated with drones and autonomous agents which must be taken down in order to proceed to the next level.

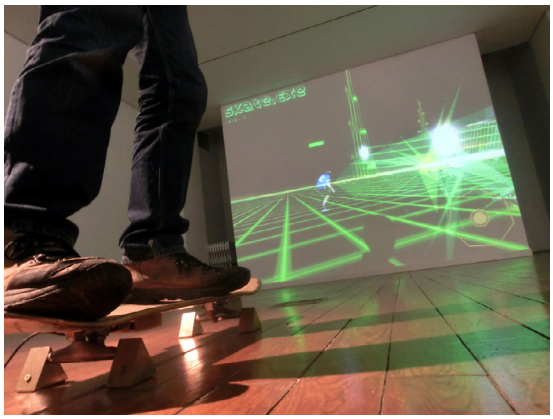


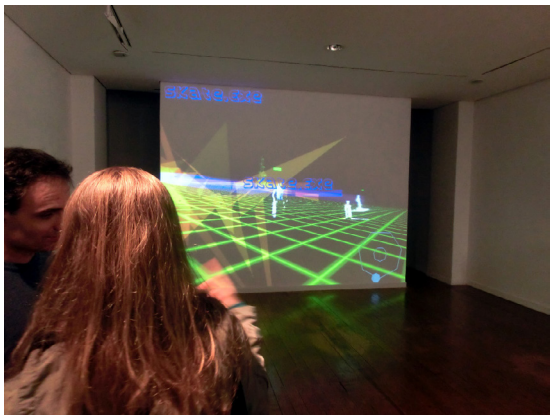


Figs. 32, 33
747.7 at Levantamento das Pestes, Casa da Zorra, Évora, 2014.

Skate.Exe (2014)

A game-installation where you can skate your way through infinite virtual space and endless levels of progressing difficulty using a skateboard connected to the computer. You play the hero and have to capture the princess-witch while evading her attacks, which leads you to the next level. Your dexterity on the skateboard will be tested in the land of disproportionate forces!

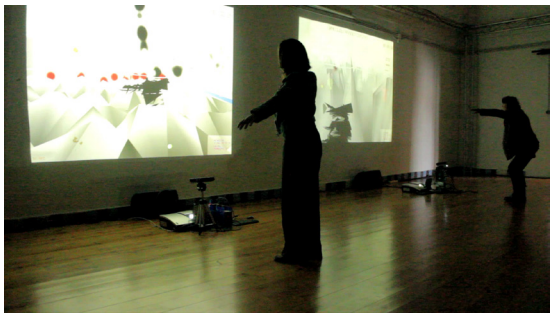


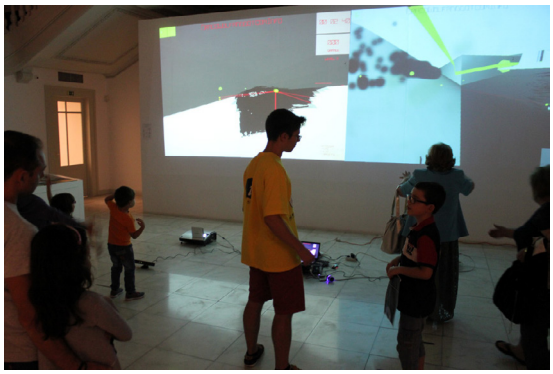


Figs. 34, 35
Skate.Exe at Galeria Luis Serpa Projectos, Lisboa, 2014-15.

Draco.Wolfanddotcom.info (2015)

Dragons returning to a 21st century overflowing with companies, dot-coms, humanoids, drones and dollars, about to experience the rage of these spiritual warriors. A local multiplayer audio-visual environment which abstractly stimulates its users to release their dragons, be transported and learn to fly in fantastic movement and destruction modes.

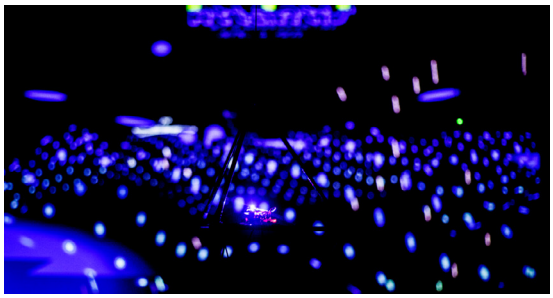


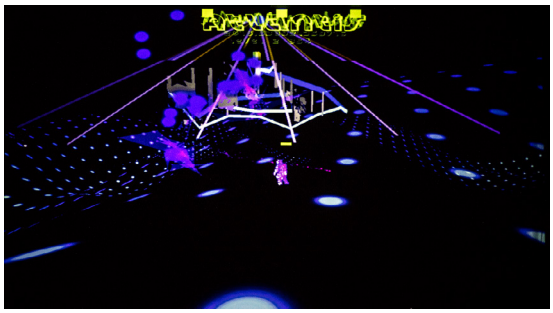


Figs. 36, 37
Draco.Wolfanddotcom.info at Espaço do Tempo, Montemor-o-Novo, and at Festival Aura, MU.SA, Sintra, 2015.

Atlantis (Sólon Interface) (2016)

An interactive suspended tetrahedron with electronics becomes the interface which allows users accompanied by Sólon's robotic voice to embark on a scholastic voyage of labyrinthine adventure in the quest of the lost city of Atlantis. By collecting oricalcum and taking it to the temple in the center of the tri-concentric city on the static seas, visitors appear to time travel backwards to what appears to be the original Atlantis.

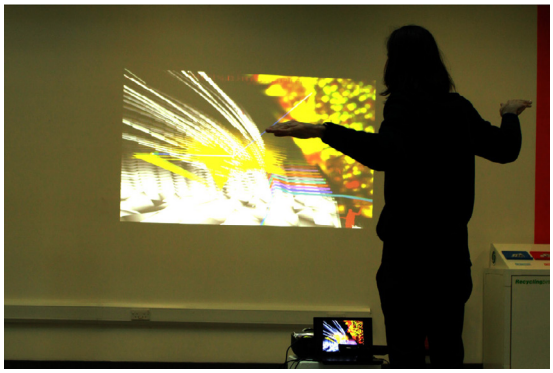


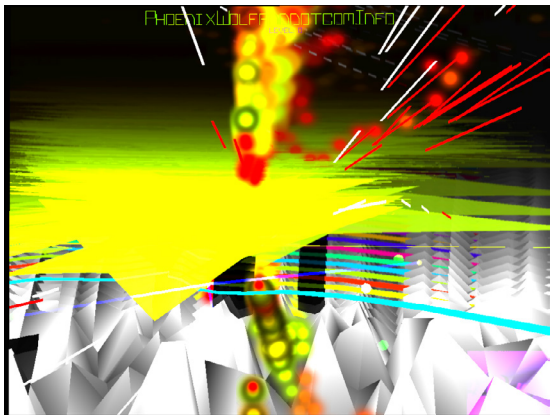


Figs. 38, 39
Atlantis (Sólon Interface) at Atlantis, Museu Nacional de Arte Contemporânea do Chiado (MNAC), Lisboa, 2016.

Phoenix.Wolfanddotcom.info (2017)

Immerse your body in an abstract phoenix embodiment art construct simulator. Fly, dive, crash, and set fire to a daunting perilous cathartic virtual path at the dawn of extinction. *Phoenix.Wolfanddotcom.info* is a videogame installation where users play and may become virtual mythological winged phoenixes, using full body invisible video interaction, within an environment over-populated with humans, obstacles, and scarce endangered organisms.

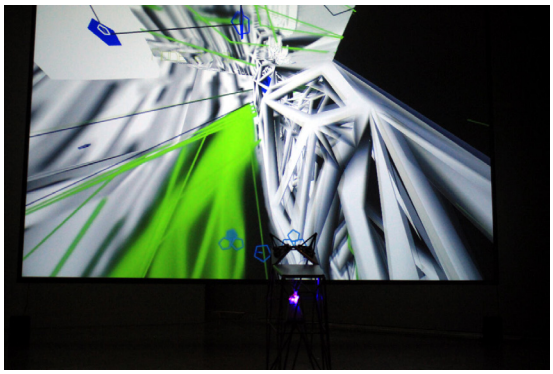




Figs. 40, 41
Phoenix.Wolfanddotcom.info at Balance Unbalance, Plymouth University, 2017.

Wolfanddotcom (2017)

Wolfanddotcom is a local networked ambient audio-visual videogame. Joystick-wolf-sculptures allow people to immerse as virtual wolves. The game is set in a post-human abstract environment synthesized from files and computer processes. Wolves are longing and racing to construct networks amongst themselves..



Figs. 42, 43
Wolfanddotcom at Sonae Media Art, MNAC, Lisboa, 2017.

4. REFERENCES (#INCLUDE <>/"")

Aarseth, E. (1997), Cybertext: Perspectives on Ergodic Literature, Baltimore, Maryland: The Johns Hopkins University Press.

Aarseth, E. (2001), 'Computer Game Studies, Year 1', in Game Studies, Volume 1, Issue 1, http://www.gamestudies.org/0101/editorial.html Accessed 1 October 2007.

Ascott, R. (1989), 'Gesamtdatenwerk', in Telematic Embrace: Visionary Theories of Art, Technology, and Consciousness, Shanken, E. (Ed), Berkeley: University of California Press.

Baudrillard, J. (1981), Simulacres et Simulation, Paris: Éditions Galilée.

Benedikt, M. (Ed) (1991), Cyberspace: First Steps, Massachusetts: The MIT Press.

Bogost, I. (2007), Persuasive Games: The Expressive Power of Videogames, Massachusetts: The MIT Press.

Burchill, L. (2007), 'The Topology of Deleuze's Spatium', in Philosophy Today, 51, pp. 154-160.

Caillois, R. (1958), Les jeaux et les hommes, Paris: Gallimard.

Deleuze, G. & Guattari, F. (1972), L'Anti-Oedipe: Capitalisme et Schizophrénie 1, Paris: Les Éditions de Minuit.

Deleuze, G. & Guattari, F. (1991), Qu'est-ce que la philosophie?, Paris: Les Éditions de Minuit.

Huizinga, J. (1939), Homo Ludens: Versuch einer Bestimmung des Spielelements der Kultur. Basel : Burg-Verlag.

Sier, A. (2016a), 'Human dragons playing in cyberspace', in Technoetic Arts: A Journal of Speculative Research, 15:3, pp. 283–96, doi: 10.1386/tear.15.3.283_1 | ISSN: 1477965X

Sier, A. (2016b), 'Artefactos da porta escondida da ponte ("Lançados para dentro de um Labirinto")', in Cibertextualidades. Porto. ISSN 1646-4435. 8 (2017) 57-70. URL https://bdigital.ufp.pt/handle/10284/6008

Sier, A. (2017), 'Structs for an aspatial quantum-now', in TABOO - TRANSGRESSION - TRANSCENDENCE in Art & Science, Honorato, D., Giannakoulopoulos, A., (Eds), Corfu, Ionian University | ISBN: 978-960-7260-60-4 | URL https://avarts.ionio.gr/ttt/2017/en/proceedings/

Sutherland, I. (1965), 'The Ultimate Display', in Proceedings of IFIP Congress, pp. 506–508.

Wagner, R. (1993), *The Art-Work of the Future and Other Works.* Lincoln and London.

Wiener, N. (1948), Cybernetics: Or Control and Communication in the Animal and the Machine, Paris: (Hermann & Cie) & Camb. Mass. (MIT Press).

PAPERS

Military confrontations simulator for the training of army officers

TIAGO PEREIRA,[1] PEDRO A. SANTOS[2]

ABSTRACT

In this paper we present a study about the requirements of a military simulator for officer training, together with an architecture for their implementation in existing commercial frameworks which are low-priced or free, and which allow for the development of a constructive simulator. The proposed system has the advantage of being more affordable than existing military simulators. To demonstrate the viability of using one of the studied frameworks to develop a military simulator, a prototype was developed and tested with the target audience (military personnel). From its tests in can be concluded that the developed prototype and consequentially the created model, can fulfil the proposed objective.

KEYWORDS

Military simulation;
Low cost simulation;
Wargame;
Warfare

[1] Instituto Superior Técnico / INESC-ID, Universidade de Lisboa, Portugal
pedro.santos@tecnico.ulisboa.pt

[2] Instituto Superior Técnico / INESC-ID, Universidade de Lisboa, Portugal
tiago.f.pereira@tecnico.ulisboa.pt

1. INTRODUCTION

As modern military training can be very costly in terms of time and resources, it must be as efficient as possible. A part of that cost comes from operating military equipment, like weapons and vehicles, during training. A way to reduce that cost is to combine realistic simulation with the usual forms of military training. In this work, a realistic simulator is one that has a behaviour that is close enough to its real counterpart for training purposes. While simulation does not completely replace training with the actual equipment, as it cannot emulate all of its particularities, it can reduce the time soldiers need to use the actual equipment to learn how to use it, saving both resources and time, since a simulator is always ready, but the environment may not always be favourable for training with the actual equipment. For officer training, simulators allow for the construction of environments where the various entities and realities of warfare are simulated. As such, these simulators allow for officers to experience the stress and pressure of those kinds of situations, without employing the actual equipment or spending the necessary resources and space to simulate them in the real world in military exercises.

Realistic military simulators are complex and costly to buy and maintain. For example, VBS3, one of these military simulators, has a cost of $3,000[3] per seat, disregarding the price of the computers to run the software. The prices for other simulators in the market are not public. Furthermore, their use implies that the military officers in charge of training must be familiarized with the simulator to be able to design and create training sessions with it. This paper attempts to demonstrate that it is possible to create a military simulator, with the required characteristics to be successfully used in the training of officers, relying only on cheap or free frameworks, lowering the cost of that simulator.

[3] While this price was obtained from the Bohemia Interactive store, the web page is not directly available from their website. The page's address is: https://store.bisimulations.com/products/VBS3-Seat-License, accessed on 7th of May

Some questions emerge: Which are the requirements of a military simulator for officer training? Is it possible to use an open framework or a game engine to create a more affordable simulator? And will that simulator be able to deliver a sufficiently accurate situation to be used for the training of military commanders?

In the present work we will:

- Make explicit the main attributes which create a realistic military simulation;
- Define the requirements of a virtual simulator to train officers;
- Suggest a possible system developed using free or cheap development tools which can be used to simulate war situations to train military officers;
- Describe the results of a Proof of Concept (POC) that was developed to demonstrate the capabilities of the studied tools and of the proposed model.

In Section 2 some theoretical concepts essential for the understanding of this paper will be explained. In Section 3, the requirements for a military simulation are presented. Section 4 explains the model which answers those requirements while Section 5 describes how the proof of concept was implemented, tested and validated. Finally, the document's conclusions are presented.

2. THEORETICAL BACKGROUND

There are several concepts that describe a military body's structure, its composition and behaviour. For composition, the military uses Tables of Organization and Equipment (TOE), which describe military units with regards to their mission, capabilities and internal structure in terms of units and equipment (Headquarters Department of the Army 1997). For a unified behaviour, the military defines its military doctrine, which specifies a framework for the various actions to be performed. A military doctrine usually comes from the core beliefs of the military, standardizing the conducted operations and providing a common lexicon for the various leaders and planners to use in their communications (Jackson 2017).

The second concept which must be studied is simulation. Simulation exists in three different variants: live, virtual and constructive. Live simulation involves real people operating real systems. For example, when a tank is equipped with a live simulation system, it uses laser pointers to determine where a fired shell would land, actual shells thereby not being spent. Virtual simulation is described as real people operating virtual systems. An example of virtual simulation is the use of a simulator with specialized controls (reproduction of the vehicle's cockpit). Finally, constructive simulation

consists in having simulated people operate simulated systems. An example would be an entire virtual scenario where every entity is controlled by a computer, according to pre-defined rules. In a military context, constructive simulation is used as a Decision Support System (DSS) to determine the best approach to a given situation (Santos 2012).

Although military simulators for the training of military officers are wargames, they differ from videogames because of their purpose: as they seek to create a realistic simulation, the duration of the sessions, with longer ones and the characteristics of the units, in terms of both their equipment and behaviour (their interactions with the environment and the tactics employed), will be analogous with reality. To study how these concepts are actually employed in simulators in use by military forces, we analysed three different simulators:

- Tac Ops4;
- Masa Sword;
- MÄK Combat Staff Training.

It could be gathered that these simulators share some of their characteristics, which we will describe in the next Section and make explicit the requirements of a military simulator.

3. MILITARY SIMULATOR REQUIREMENTS

The following requirements contribute to understanding what is to be expected of a military simulator. We have drawn both from the preliminary analysis of the requirements of a constructive simulator proposed by (Cunha 2011), and from our own interviews with the officers responsible for constructive and virtual simulators, conducted at the Portuguese Military Academy[4] at their simulation centre, and at the Institute for Higher Military Studies.[5]

3.1 ARCHITECTURE REQUIREMENTS

Architecture requirements deal with the general aspects of the simulator, discussing its purpose and main components.

The system should be designed to help train any officer, offering the possibility of being used by the different scales of command, as

[4] Responsible for the training of the lower echelons of military command.

[5] Responsible for the training of the higher echelons of military command.

it should be possible to change the scenario dimensions and the size of formations. The sessions should run in real-time with the possibility of manipulating the time scale in order to suit the session's needs and purpose. This way, the trainee can experience the pressure of a war situation and understand how timing is relevant in military decision-making.

In order to reduce deployment costs, the system should be distributed, with a server making the calculations and the clients sending commands to the server (through orders) and visualizing the simulation. As the system is distributed, only the server will require a bigger investment, as the solution should be lightweight for the terminals.

When connecting to a session, the new client can play different roles, in accordance with the training officers' needs.

The different roles are:

- **Officer** – plays the role of a commander, controlling part of the simulated forces;
- **Instructor** – umpire role. It can influence the scenario status (changing the timescale or other aspects of the session), can issue orders to all the forces and introduce new units at any time during the session;
- **Radio Operator** – does the mediation between the trainees and the high command (Trainer), requesting air or artillery support or sanitary operations. In this role, the user will not see the simulation.

It should be possible to record each session, integrating the orders taken by each faction, the evolution of the state of the simulation and the communications in the different channels. The information can then be selected to preview and export to a video file.

3.2 UNITS REQUIREMENTS

Units requirements determine how the simulated units should be designed inside the simulator. Since the purpose was to create a military training tool, the behaviour and equipment was based on armed forces around the world. The behaviour is based on the military doctrine, but it should be customizable via the Standard Operating Procedures (SOP), for either a subset or all the controlled units. For example, if the commander desires to place scouts near the front, they should not engage enemy units.

During the interview with military officers of the Military Academy, it was mentioned that it should be possible to configure areas where a given unit should open fire if it sees an enemy unit.

Engineering units should allow for changing the terrain by building bridges or entrenching a position, helping friendly units or hindering enemy units by deploying minefields or other obstacles.

Other orders that were considered to be important, for the infantry units, are their ability to garrison in structures, upgrading the unit's line-of-sight and resistance, and the possibility of boarding vehicles.

3.3 MECHANICS REQUIREMENTS

Lastly, mechanics requirements discuss general functionalities that the simulator should contain.

The scenarios where the simulation session takes place should be possible to create and edit. They should take place in real locations on the world and so the simulator should be able to import terrain information in order to create them. The generated terrain is one of the crucial parts of the simulator as it influences the unit's speed (some units cannot move in all kinds of terrain) and line of sight.

Another important system is the weather system as it affects the scenario as a whole, changing the unit's line-of-sight and movement capabilities. As with all other features, clients connected as an instructor can change the weather at any given time. Other features that should exist in the simulator are:

- Sanitary and logistic operations;
- Artillery and air missions;
- Malfunctions;
- Information operations;

Regarding sanitary and logistic operations, they should be represented from their inception until their end, there being the possibility of being disrupted by the enemy. This contributes to provide a realistic simulation as in the battlefield any units are subject to enemy fire.

Concerning the artillery, fire missions should distinguish between planned fire or non-planned fire, affecting the time that the artillery needs to fire and reflecting the calculations the artillery crew needs to make before firing. Besides the type of fire, it should also be possible to choose the munitions and the number of salvos of each fire mission. Air missions are to be configured in a similar manner.

Finally, regarding malfunctions, they could happen at either a unit level (vehicle malfunction, weapon jamming), which can disable or reduce the efficiency of the units or at the communication level.

Malfunctions can originate from either electronic warfare or from sabotage. Other features found to be required are:

- Stacking of the unit markers when they are near each other on the map, in order to reduce clutter. The various units contained in the stack are then accessed via the context menu when the stack is clicked.
- The generated map should display a grid over it, like military maps, so that trainees must calculate the positions to reference them. Instructors, however, can access the position calculations directly and can draw over the map, if needed.

The coming section presents our proposed architecture to satisfy the requirements identified.

4. SOLUTION ARCHITECTURE

This Section describes our proposed solution for a realistic military simulator. The requirements identified in the preceding section allow the system to provide realistic behaviour.

4.1 SOLUTION MODULES

Since the proposed system is complex, it was divided in different modules (as seen in Figure 5):

- **Simulation Interface** – this module will contain the code required to draw the interface through which the client interacts with the simulation. The interface changes depending on the user's role.
- **Simulation Database** – the system will keep the various types of information used by the simulator (Table of Organization and Equipment, Doctrines, Formations, military equipment, maps, scenarios) in a database;
- **Scenario Database** – module to be used by the trainers to create and store the scenarios for their trainees by combining the various types of information in the simulator's database;
- **Simulation server** – central module of the system which will do most calculations required by the simulation, like hit calculation and movement processing;
- **Voice Communications** – Voice-over-IP (VOIP) module which will guarantee voice chat between the different instances of the simulator, with the option of choosing between channels;
- **HLA/DIS Interface** – this module will implement the HLA and the DIS standards in order for the projected simulator to communicate with other compliant simulators;
- **Archives** – will offer the possibility of recording the played scenarios for after-action reviews, further enhancing the learning possibilities. The recording will display the orders given by the

different factions throughout the duration of the play, the communications between the different players allowing to see the action developing on the map.

They are connected in the manner shown in the following scheme:

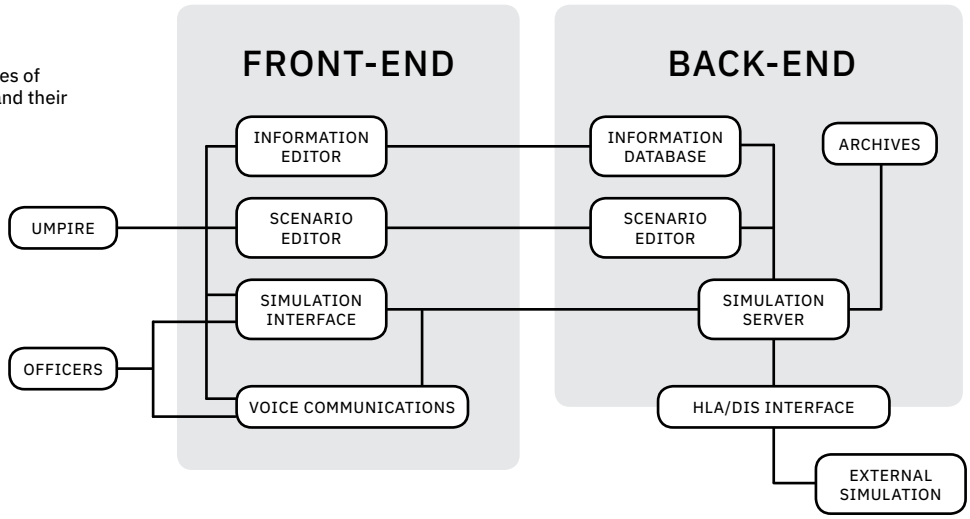


Fig. 1
Internal modules of the Simulator and their relationships.

The units will be kept in the information database and characterized by different attributes, depending on their type, for instance:

- Equipment used by the unit;
- Ammunition – kinds and quantities of ammunition currently in possession of the unit;
- Armor (divided into front, back, sides and top), when applicable;
- Movement capabilities in the different kinds of terrains.

In addition to these characteristics, the unit's experience, status (under fire, moving, standing still or others) as well as the terrain, both the one at the unit's location and the one crossed during the bullets voyage, will influence the capacity of the unit to engage effectively the enemy units.

The units are organized hierarchically by using an implementation of a TOE. More specifically, a TOE's internal structure is implemented using two types of nodes: Basic nodes and Composite nodes. Both nodes share the attributes derived from their representation during the simulation like their NATO symbol, size symbol and its type (combat unit, support unit). However, some attributes, like the unit's equipment or its soldier count, depend on the subunits that it is made of. More specifically, in a basic node, it is possible

to define directly the number of soldiers that the unit contains and the equipment it uses, as well as the attributes mentioned before. When creating composite units, it is not possible to define all the same attributes as in the basic units: their values will be automatically known by considering the subunits that are added to them. These subunits can be either basic nodes or other composite nodes.

As such, the person that is creating/ editing a TOE starts by defining the equipment that a unit can use, then the basic units and then the composite units using those basic units and other composite nodes, creating a tree like in a real TOE.

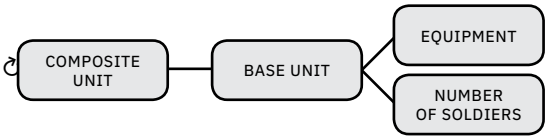
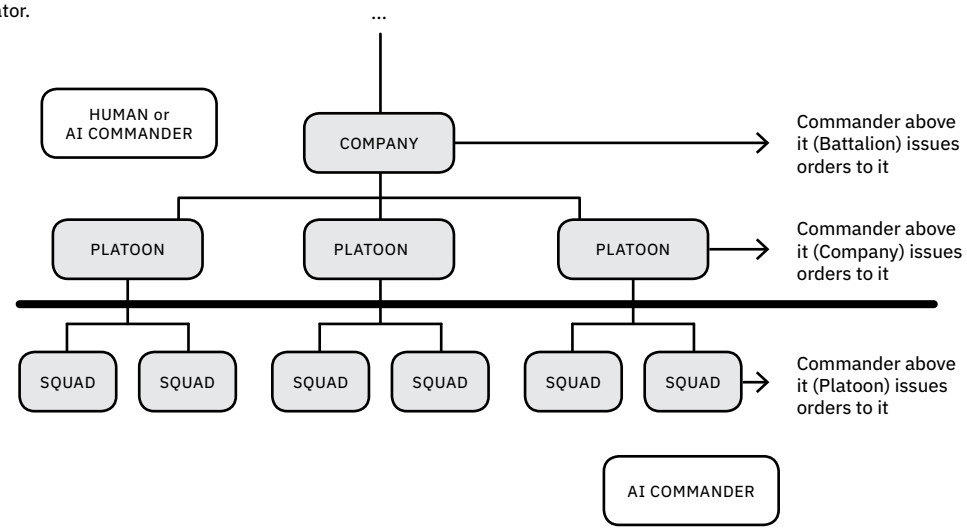


Fig. 2
Internal constitution of a TOE instance.

The internal components of a TOE can be seen in Figure 2. The TOE is used to define two other types of information: Formations and Doctrines. While TOE usually defines an abstract unit, Formations are used to define specific units, using as a base a specific TOE. For example, if we wanted to define an infantry company called the 4th Infantry Company, first we would have to define what is an infantry company, and then, by using that TOE as a base, we would construct a Formation with the desired name. A Formation allows us to create instances based on the units created in the TOE and so customize their characteristics, like their name, to create a unique unit. Formations are the entities that will be spawned and controlled by the commanders during a simulation and whose subunits are assigned orders by their commanders. For example, a company commander assigned to 1st Company as defined in Figure 3, will issue orders to all its direct subunits, the three platoons.

Fig. 3
Hierarchy and commanders in the simulator.



Doctrines are used to define the orders which are executed by each unit, as defined in a TOE. As such, the orders are hierarchical by nature. When a unit, controlled by an Artificial Intelligence (AI), receives an order, its doctrine will determine how it will be translated into orders that can be executed by the unit.

These orders are constructed using actions, which can be of three different types: basic, composite or general. Each action within an order is associated with a specific subunit.

Actions can be associated with an interrupt condition, which allows for them to have another way to be completed, allowing a greater control of the timing in which the subunits execute their orders. For example, if a movement order is issued to a given point but it has a condition of being near another determined unit, then this order will end either when the unit has reached that destination or if it is close to that pre-determined unit.

General actions are the ones which can be added to any level of the hierarchy. An example of such an action is the wait action. Basic actions are implemented on the units themselves, as they correspond to the actions that any trained soldier can execute and are used to construct the composite actions. They are associated to any echelon which is not associated with an officer, like squads or fireteams. Both general and basic actions are static in the sense that a user cannot add new actions of these types, only the developer by editing the simulator internal code.

Finally, composite actions are the ones which give the simulator flexibility by providing the users with the ability to construct any manner of orders, by applying together the various action types. Composite actions are built in any echelon which does not have basic actions and each one corresponds to an order that can be given to the unit during a simulation. When a user defines a new order, he can construct different action sets, which allows for the same order to be completed by the AI in different ways, depending on the conditions associated with each one. If there is more than one condition which is verified at a time, the action set is chosen from the restrictiveness of that condition. For example, if an order for movement was created for a platoon but the manner in which that platoon moves is dependent on expected danger during the order's fulfilment,[6] then different action sets would be created, each one with an appropriate condition, which would allow for the AI to have a behaviour similar to that of a platoon if it had been commanded by a human.

A doctrine uses the logic of a Hierarchical Task Network (HTN) (Russel e Norvig 2003) decomposer to construct a hierarchy of the orders:

1. Orders given to units above squad level are all composite orders (or composite tasks);
2. The doctrine describes how a composite order is decomposed into a set of orders belonging to the level below (either themselves composite or basic actions);
3. The decomposition ends when the given order has been transformed into a set of basic actions;
4. Each order can have attached to it constraints, which finish the order prematurely.

TOE, Doctrines and Formations, are related in the manner depicted in Figure 4.

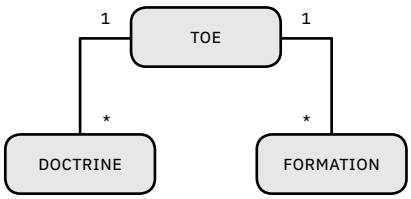


Fig. 4
Relations between the concepts of TOE, Doctrines and Formations

[6] The video "The Rifle Platoon Dismounted Movement Techniques", available on https://www.youtube.com/watch?v=-qdFd9Uh0N0, for instance, shows how an infantry platoon adapts their movement tactics depending on the contact probability.

Also contained in the database are the maps used to create the scenarios. These are loaded and interpreted by the simulation that defines 2D representations of the terrain (with a distinction between types of terrain and height) as the setting for the simulation sessions.

In addition to having the stacking behaviour described earlier, the units can be merged (if compatible) or separated as necessary. When there is a stack of independent units, there will be a visual cue informing of the situation.

As the proposed architecture is highly complex, a POC was developed. The following Section describes the POC that was developed to demonstrate the feasibility of creating a military simulator by using a cheap or free development framework and how that solution achieves the purposed objectives.

5. SOLUTION IMPLEMENTATION AND VALIDATION

This section describes the POC that was implemented to demonstrate the feasibility of the model described in the previous section. We will also describe how we tested our POC, how we prepared the tests, how they were conducted and their respective results. As the POC was created to show the potential that our proposal has, our tests were aimed to demonstrate that the current internal calculations of the simulation could be deemed as realistic.

Having analysed three different options to create a military simulator, what was chosen was *Unreal Engine*, justified by these facts:

- Using *Unreal Engine* allows for just focusing on the actual logic of the simulator instead of how to code it, because of the existence of blueprints. Without them, it would be necessary to reason what exactly would be the correct library to use or if it was necessary to code it.
- *Unreal*'s community is active, which eases the process of understanding the reason for any difficulty that emerges during development;
- There is a large quantity of *Unreal Engine* tutorials online;
- *Unreal Engine*'s documentation is extensive;
- Nodes were created by experts in both *Unreal Engine* and *C++*, which guarantees a certain level of performance when using them;
- *Unreal Engine* also has a marketplace where there are free plugins which extend the functionality of the engine;
- The client-server communications in *Unreal Engine* are close to the simulator's goal, where the server does all the calculations and the client shows the results from those orders.

Although some of these features are also present in other game engines, like *Unity*, we have chosen *Unreal Engine* due to previous experience in working with it.

This POC's objective is to implement a simplified version of the proposed architecture to demonstrate its potential to create a lower priced military simulator and the possibilities that a game engine such as *Unreal Engine* offers for this kind of project. The developed POC focused in implementing features of three of the modules discussed in Section 4.1, namely the Simulation Interface, the Simulation Server and the Unit Database.

5.1 SIMULATION SERVER IMPLEMENTATION

The Simulation Server was constructed by making sure that functions which have an impact on the gameplay are called in the Server version of the various entities in the game world, and so its code is spread across the various classes.

5.2 DOCTRINE

As stated in Section 6.1, the doctrine will be used to customize the behaviour of the AI controlled units, and so, separate the unit's implementation from its behaviour in the simulation.

In the POC, this was implemented by separating the functionality of a doctrine in separate classes, each one with a separate function within the overall functionality of our concept of a doctrine. The various classes are used sequentially during the decomposition of the orders. During the decomposition process, if there is an interrupt condition attached to the action, it is added to unit's blackboard, and is verified via a service in the behaviour tree, until either the condition is verified itself and the order is skipped, or the order reaches its supposed end.

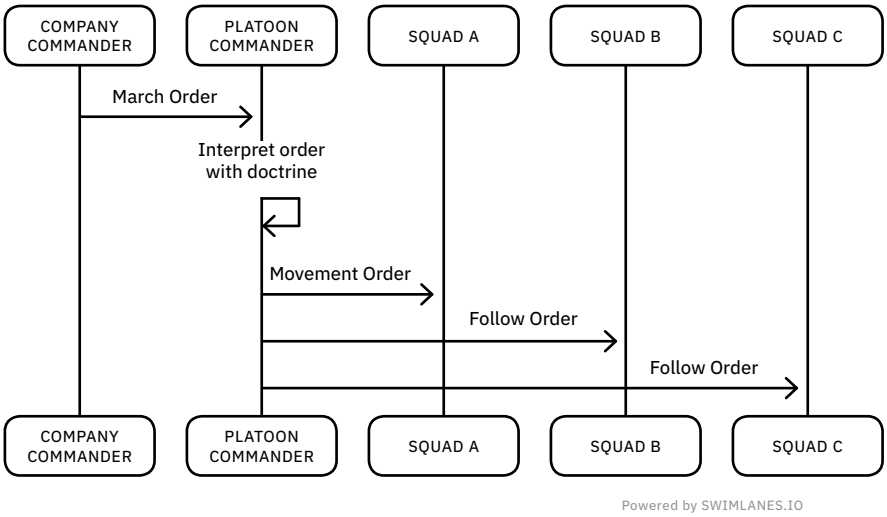


Fig. 5
Invocation of a composite order.

In Figure 5, it is possible to see an example of an invocation of a composite order. The commanders can either be human or an AI. If it is an AI-controlled commander, the doctrine will determine how the order is decomposed to be interpreted by the next echelon. If not, then the human commander must know how to decompose that order.

5.3 VALIDATION

In order to validate our prototype, we performed two sets of tests: one for the system usability, where we used the SUS (Brooke 2013), and another to evaluate its realism.

The first set of tests had the following results, scored from 1 to 100:

- 55 for the Information Editor;
- 56 for the Scenario Editor;
- 71 for the Simulation Editor;

These results point to serious problems with the system's usability, particularly on the Information Editor and the Scenario Editor. However, as the users who performed the tests were not the end-users for this system, these tests' results are not conclusive.

The second set of tests had the purpose of evaluating the realism that the current POC offers in terms of military behaviour and as such could only be performed by persons which had some degree of understanding of military tactics. More specifically, the tests were made by connecting 3 users to the simulator and having them play different roles, with 2 players occupying the roles of commanders and one occupying the position of the Umpire, alike the training done at the Military Academy.

We invited officers from the Military Academy to view the model and the developed prototype, to understand its state and receive feedback about its features.

After finishing the tests and the various officers having taken part in the exercise and demonstrations, the officers focused on the following points:

- The program is simple to understand and manipulate, reinforcing that understanding of military concepts is important to understand the program's interface and the flow of the program. Therefore, the interface and usability were considered adequate by the end-users.
- The program can integrate with other tools in a seamless way. For example, its ability to use real terrain information and having that terrain information directly translated into the simulated world. One of the major disadvantages of the current systems used by the military is the lack of interoperability between the various tools that exist. For terrain information, the military has a tool which allows to export all the relevant information about the terrain, such as, where does the terrain give cover and where do the different units are able to navigate.
- Despite being very basic in the POC, the unit's AI behaviour follows a doctrine, which is very important in a simulator.

However, the officers also pointed out some errors in our model and POC:

- Usually, the Platoon commanders do not micro-manage the infantry squads as was implemented. They manage the support squads (like those with mortars or machine guns) directly, but they command the infantry squads in a more general way. For example, it should be possible to define itineraries for those squads to follow instead of ordering them directly.

In the next Section, we present the conclusions of the developed work.

6. CONCLUSIONS

In this paper, a proposal for an architecture of a realistic military constructive simulator was presented. However, given the high quantity of requirements defined and the relative short time for development, only a proof of concept of this system could be constructed, in order to demonstrate the possibilities of low-cost development software to create traditionally costly software. To construct the proof of concept, *Unreal Engine* was used, as it allows for the rapid development of prototypes via the blueprint system.

The major contributions of this work, in terms of the requirements described in Section 4, are related to the architecture and units'

requirements: by creating units through TOE as described in Section 4, it is possible for the units to belong to any echelon and thus different scales of command can be simulated. The adaptable behaviour that the units should have is supported with a doctrine as described in Section 4. More specifically, this implementation allows for the creation of orders for any unit (from platoon level to the upper echelons) by defining orders for a given unit, using the orders defined for the units it is composed of. For example, if an infantry platoon is constructed from three infantry squads, the orders for the infantry platoon will be defined according to the orders available to the infantry squads. Besides the actions associated with each unit, the system chooses the most appropriate actions according to conditions associated with each set of actions.

A game engine, like *Unreal Engine*, offers the server-client architecture that is required. Regarding the mechanics requirements, by using a game engine, we are offered the AI functionalities required to differentiate the types of terrain and to create an influence map. Although *Unreal Engine* offers a great set of built-in features, these are skewed for a certain type of games. It was therefore necessary to work against the original purpose of the engine's features in order to repurpose them to a different type of creations, like the one discussed in this paper.

Note that by having the simulation engine built, new scenarios are relatively easy and fast to create, as all the previously used units can be repurposed for the new scenario. One just needs to import the physical terrain into the simulator and place the appropriate units to create a new training situation.

The programming work to produce this POC was 5 man-months. The results obtained from the tests demonstrate that our hypothesis (that it is possible to develop a realistic military simulator for the training of army officers using a cheap or free development framework) can be fulfilled by the model which we created. Furthermore, it can also be conjectured that if the proposed system is executed without assigning human players any position, the simulation can run by itself, transforming an otherwise virtual simulator into a constructive simulator.

6.1 FUTURE WORK

While it was possible to create a POC which demonstrates the potential of the proposed model, future work in implementing it should be done in code, as only then will it be possible to access the total potential of *Unreal Engine*. By using code, the simulator will become more efficient, more portable as well as more stable. As stated above, we focused mainly on the architecture and the unit's re-

quirements, as they were more important for our purposes, further requirements being left for future work. An engine like *Unity* would have had a better support for these types of programs, as users usually have to implement their own versions of features which are offered by *Unreal Engine*, making *Unity* more flexible.

We predict that to produce a first deployable version one would need about 18 man-months for the simulation implementation and 6 man-months dedicated solely to the interface.

AKNOWLEDGMENTS

We would like to thank all the army officers who collaborated with us during the development of this work. We also acknowledge the support of the Unreal Engine's community, particularly Victor Burgos, for helping with understanding the system's inner workings. This work has been partially supported by national funds through Fundação para a Ciência e a Tecnologia (FCT) with reference UID/CEC /50021/2013;

REFERENCES

Brooke, John. 2013. "SUS: A Retrospective." *Journal of usability studies* 8 (2): 29-40. Accessed 05 08, 2018. https://usabilitygeek.com/how-to-use-the-system-usability-scale-sus-to-evaluate-the-usability-of-your-website/.

Cunha, André. 2011. *O emprego do sistema de simulação constructiva como ferramenta de apoio à decisão; uma proposta ao exército brasileiro*. Master Thesis, São Paulo: Escola de comando e estado maior do exército.

Global Security. n.d. *Global Security*. https://www.globalsecurity.org/military/library/policy/army/toe/toenum.htm.

Headquarters Department of the Army. 1997. "Force Development and Documentation - Consolidated Policies." Washington, DC.

Jackson, Aaron P. 2017. "The Nature Of Military Doctrine: A Decade of Study in 1500 Words." *The Bridge*. 15 November. Accessed April 7, 2018. https://www.realcleardefense.com/articles/2017/11/15/the_nature_of_military_doctrine_a_decade_of_study_in_1500_words_112638.html.

Russel, Stuart J., and Peter Norvig. 2003. *Artifical Intelligence: A Modern Approach*. Person Education.

Santos, João. 2012. *A Simulação. Contributos para a formação e treino.* Master Thesis, Lisboa: Academia Militar. Direção de Ensino.

U.S. Department of Health & Human Services. n.d. "System Usability Scale (SUS)." *usability.gov*. Accessed May 08, 2018. https://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html.

Wayman, Erin. 2012. "What is War Good For? Ask a Chimpanzee." *Slate*. Outubro. Accessed December 6, 2016. http://www.slate.com/articles/health_and_science/human_evolution/2012/10/chimpanzee_wars_can_primate_aggression_teach_us_about_human_aggression.html.

Game design for environmental awareness — the case of "Invasive Plants"

LILIANA SANTOS,[1] **ANTÓNIO COELHO,**[2] **RUI NÓBREGA**[3]

ABSTRACT

Invasive species are a major environmental problem affecting Portugal and the rest of the world. As such it is important to promote scientific literacy and environmental awareness on this topic. In this article we present a serious game for environmental awareness, *Invasive Plants*. The game's goal is to eliminate several invasive species using the appropriate methods. Through engagement with the game, we intend to promote awareness for the resolution of an environmental problem caused by invasive species. Usability tests have revealed that this prototype has educational potential, however, improvements are still needed, such as how the information and mechanics of the game are presented and extending the content.

KEYWORDS

Serious games;
Pervasive games;
Location-based games;
Environmental awareness.

[1] INESC TEC / Faculty of Engineering, University of Porto, Porto, Portugal — l.a.rocksaints@gmail.com

[2] INESC TEC / Faculty of Engineering, University of Porto, Porto, Portugal — acoelho@fe.up.pt

[3] INESC TEC / Faculty of Engineering, University of Porto, Porto, Portugal — ruinobrega@fe.up.pt

1. INTRODUCTION

Scientific dissemination can take place in many ways, but all aim to convey a scientific message to the general public. Nowadays, the way people acquire knowledge has changed, as well as their openness to digital media. There are several theories that focus on what motivates a person to consume a particular media product or the media in general. Gamification techniques and games have proved to be effective in motivating and engaging people with media content. It is no surprise they were adopted for purposes other than mere leisure. Serious games have a goal that goes beyond entertainment and can be used for educational and awareness purposes, among others (Michael & Chen 2006; Marsh 2011).

In this technology age, smartphones are multipurpose portable platforms (Santos et al. 2016), which include an increasing number of functionalities (Pereira 2013). In addition, they have been massively disseminated through society and can be an adequate means of promoting scientific dissemination *in loco*.

Current technology allows us to overcome the barriers of space. Location-based serious games enable players to explore the real world around them while playing a game that is meant to educate them on some subject or make them aware of some real problem. There are several games that provide these types of experiences for urban contexts, under the theme of cultural heritage. Likewise, games can also be an asset in the creation of new experiences in spaces of nature, helping to promote a place's natural heritage and fostering environmental awareness (Santos et al. 2016).

We live in a society of digital information, knowledge and social interactions, which have changed the way people seek experiences and acquire knowledge (Santos 2017). Consequently, the way in which content is produced for different areas has also been changing in order to respond to this demand. In addition, while the latest generation of smartphones has unprecedented potential to change the way we interact with others and the environment (Jepson & Ladle 2015), this transformative power, and their potential for educating people on nature and its topics, have not yet been fully explored.

As the use of pervasive games on mobile devices reveals a great potential for environmental awareness, and given the limited number of published studies on this field, this topic becomes relevant, needing further investigation. Spreading awareness about natural heritage through the use of information and communication technologies is, therefore, a challenge to the scientific literacy of the postmodern world, as well as a need (Santos 2013). For this reason, it is considered relevant to contribute to the exploration of new

ways of communicating science, with contents of environmental awareness contained in the form of location-based games, an area that although not new, still needs more study (Weber 2016).

The object of this paper is integrated in a digital media doctoral project, on the use of the serious pervasive games for the scientific dissemination of natural heritage. In this article, we present one of the minigames developed over the course of this research: *Invasive Plants*. This game was designed for the general public but, since it's still in its early stages of development, it was tested by a sample of game developers. The reason is to gather more informed feedback and suggestions for future improvements. That way, after the technical problems are solved, we will be able to focus more on the game's message efficiency.

This paper will begin with a brief literature review on serious games and location-based games and their importance, with emphasis on their use for educational purposes, scientific dissemination and awareness for nature and environmental issues. Some examples of mobile applications with this type of games are also discussed. Afterwards, the game *Invasive Plants* is presented, as are its technical specifications, gameplay, mechanics and objective. Afterwards, the game evaluations and their results are presented. At last, we conclude with a discussion and conclusion about the user tests results.

2. LITERATURE REVIEW

The following literature review intends to provide a general background about serious games for nature dissemination and environmental awareness in society.

In today's media culture, digital games, gamification, pervasive games and serious games enable new forms of gameplay and lead to what Raessens (2010) calls "ludification of culture". Like other forms of media, games have the potential to be more than just entertainment (Michael & Chen 2006), as they can also pass on a message, teach something or provide an experience (Michael & Chen 2006; Marsh 2011).

2.1 SERIOUS GAMES, PERVASIVE GAMES AND PERVASIVE SERIOUS GAMES

When digital games have the ability to take game experience from the virtual world into the real world, they are called pervasive games (Benford *et al.* 2005; Viana *et al.* 2014; Jantke & Spundflasch 2013). In the case of location-based games, the experience is adapted based on the information the device receives about the physical location of the player, usually by means of a GPS sensor, allowing the player to access location-specific information, such as maps (Jacob & Coelho 2011).

1. INTRODUCTION

By combining the physical and virtual world, pervasive games promote new types of game experiences (Kuehn & Sieck 2009; Baptista *et al.* 2015), which extends Huizinga's traditional "magic circle". With the development of positioning technology in mobile devices, this type of games found a gateway into the mobile market (Pereira 2016). The most well-known example of a pervasive game is *Pokemon Go* (2016), developed by the video game producer Niantic and published by Nintendo. However, not every location-based game has entertainment as their main goal. Location-based games that have an intended goal of educating people on a certain theme or promoting awareness on a real issue can be called serious pervasive games. For example, the *Savannah* game allows learning about lions' behavior through collaboration among players, thus exploring a more educational component (Benford *et al.* 2004).

Many of these games were designed for urban environments and museums, and are associated with spreading awareness about Cultural Heritage and address issues related to History, Architecture, Art and Culture. One example from Portugal is *TravelPlot Porto*, an urban tourism application with a location-based game for mobile devices, which consists of a treasure hunt through the city of Porto, having several monuments and relevant points of the city as a reference (Ferreira & Alves 2012).

Serious pervasive games can now be used for scientific dissemination (Santos *et al.* 2016; Santos *et al.* 2017) as a way of motivating contact with scientific knowledge in a given context. In this way, it is believed that it makes sense to apply the serious pervasive games in natural environments for the dissemination of Natural Heritage.

2.2 PERVASIVE SERIOUS GAMES FOR NATURE DISSEMINATION AND ENVIRONMENTAL AWARENESS

Pervasive technology allows amplifying and enriching the experience of visiting natural spaces, since a layer of digital information is placed over the real world, highlighting contextual information about these spaces.

Mobile applications in the context of nature tourism in Portugal typically have a map of the region with routes and trails, information related to points of interest and, sometimes, information on local fauna and flora (Santos *et al.* 2017). The authors give as exam-

ples the *National Parks Wildlife Guide*[4] application, which shows the wildlife of the North American parks, and the *National Parks*[5] application from National Geographic, which presents an interactive guide and maps of the most visited parks of the United States of America. Some examples from Portugal are the *Trekking BioRia*[6] application which recreates the walking and cycling routes of Estarreja and the application for Pico's Natural Park, which presents the landscape of the this island's vineyard culture and its Natural Park. However, Santos *et al.* (2017) concluded that in these applications, gameplay is not explored.

Awareness-raising games linked to nature are scarce. In the area of school education, however, we can mention the application *EduPark* (Rodrigues *et al.* 2017), which allows one to know more about the Infante D. Pedro Park, in Aveiro, Portugal, through questions triggered by augmented reality.

Serious location-based pervasive games have a potential for education and communication of any area of knowledge. We believe that Natural Heritage and environmental awareness are very relevant themes for creating contents for this type of games, applied in natural spaces. Since the gaming experience is related to the real and physical world, it is believed that location-based games can make users more aware of the environment around them and more open to environmental issues addressed in the content of these games. However, further studies are needed to confirm this hypothesis.

3. METHODOLOGY

We developed an environmental awareness game about invasive species. The following methodology describes the chosen theme, the technical specifications of the game's development and the data collection process.

[4] National Parks Wildlife Guide, available at: https://play.google.com/store/apps/details?id=com.enature.guides.npca2&hl=pt_PT, 2018

[5] National Parks, available at: http://www.nationalgeographic.com/mobile/apps/national-parks-by-national-geographic/, 2018

[6] Trekking BioRia, available at: http://www.bioria.com/newstext.php?id=222, 2018

3.1 GAME DEVELOPMENT TECHNICAL SPECIFICATIONS

The game is designed for Android mobile devices and to be played in a horizontal (or landscape) position. The Unity 3D game engine was used. All visual elements were drawn through the use of the Adobe Illustrator vector drawing software. For the sound effects a search of sounds (fire, explosion, dry leaves, end of the game, among others), was carried out in open source databases and later edited with Audacity.

3.2 EVALUATION OF PROTOTYPES/ PROTOTYPE TESTING

After the development of the first prototype, an initial evaluation of its usability was carried out, during an event aimed at game developers. Three Android mobile devices were used with the application previously installed. Thirty-three users participated in this experiment, each test having an average duration of ten minutes. Each user was encouraged to explore the application. For data collection, a questionnaire survey methodology was adopted, in which, after each test session, the participants were asked to complete a questionnaire about their experience.

After analyzing the results of this first evaluation, some changes were made to the game's prototype. Following these improvements, the prototype was re-evaluated through a second test phase. This also took place during an event of game developers. Once again, three Android mobile devices were used with the application previously installed. Thirty users participated, each test having approximately the same duration. The experiment protocol was the same as in the first phase of testing. The questionnaire survey was also the same, except for an additional question that was asked to see if the user had already participated in the first testing phase.

Eight of the analyzed issues have made use of a Likert scale, adapted for a semantic scale ("I strongly disagree", "I disagree", "I have no opinion", "I agree" and "I fully agree"). In addition to age and frequency with which they use mobile applications, participants also had to answer if they felt the need for an instruction manual or tutorial, if the application responded quickly to the user and if the game responded as expected to input, if they noticed the game's purpose and message, as well as their opinion about the game's educational component's effectiveness and if they found it entertaining. They were also asked if they would like to play more levels, whether they liked the game's visual aspect, which age groups they considered most appropriate for the application and, finally, they were encouraged to write comments and suggestions.

4. THE GAME *INVASIVE PLANTS*

In this section, we present the theme, the game purpose, the interface and the game description.

4.1 THEME AND GAME PURPOSE

The chosen theme was invasive species, as it is a major environmental problem affecting Portugal and the rest of the world. The game's main objectives are to promote scientific literacy and raise awareness about the environmental problem caused by invasive species. Through this game we intend, although in a purposefully simplified and caricatured way, that the player learned to identify some invasive species, as well as learning methods for their control and eradication. The game's idea is to destroy invasive species with the appropriate methods. Several levels were considered (see figure 1), each containing an invasive species, with the combination of multiple invasive species being a possibility for later levels. However, due to limitations of resources and time, only the first level was developed, concerning the invasive *Eichhornia crassipes*, known as water hyacinth.

Water hyacinth[7] is an aquatic floating herb, with swollen leaves and very showy blue-violet flowers. Originally from South America, this plant represents a very high level of ecological risk, as it multiplies quickly forming a thick carpet that floats and spreads in all directions, causing the fish to eventually die from asphyxiation due to a lack of oxygen. Several techniques have already been attempted to eradicate water hyacinths, such as the use of dynamite, flamethrowers, floating harvesters, among others, but all these have been ineffective.

4.2 INTERFACE AND GAME DESCRIPTION

The *Invasive Plants* game prototype was structured according to the wireframe seen in figure 1. The prototype starts with the initial menu with four options: "Play", "Information", "Credits" and "Exit game" (see figure 2).

[7] This description was based on the Website http://invasoras.pt/, the Portuguese resource of scientific information for Invasive species in Portugal. The Website also explains that the Water hyacinth is listed in Annex I from the Portuguese Decree-Law No 565/99 of 21 December and is included in the list of species of concern in the European Union by Regulation (EU) 1143/2014 of the European Parliament and of the Council of 22 October 2014, because of its level of ecological risk.

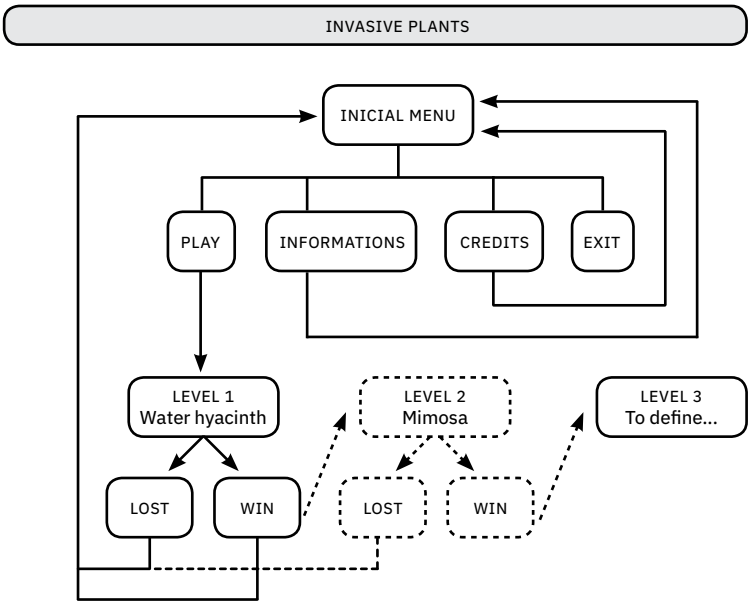


Fig. 1
Invasive Plants game prototype menus wireframe

Fig. 2
Menu interface with "Play", "Info", Credits" and "Exit game" buttons

By touching the "Info" button, the player has access to more information about the water hyacinth, how to eliminate it and the game rules. In "Credits" the list of elements of the game design and development team is presented. When you touch the "Play" button, the game starts with the first level. If the player loses, a game over screen appears and the player is returned to the initial menu. If the player wins, a victory screen appears, and the player can continue the game on the second level. This logic is repeated as many times as the number of implemented levels. Due to time constraints, it was only possible to develop the first level. This level starts with a

lake's scenery, with some fish, aquatic plants at the lake's bottom and water hyacinths. These float on the lake's surface, distributing themselves horizontally with their roots under water. After some time, they reproduce naturally, regardless of the player's actions. The vertical bar on the right symbolizes the "health" of the player, this being the amount of oxygen in the lake, which is influenced by the number of invaders. The larger the number, the less health the player has, and the murkier and darker the lake's water becomes. Thus representing its eutrophication, until when the life bar becomes empty and the player loses. The number of water hyacinths also affects the fish, which can die if there are a high number of plants in the lake. The scenario also includes an inventory with four tool options, which the player can use to attempt to eradicate the water hyacinths: a bomb, a net, fire, and an axe. These tools were not chosen randomly. The dynamite, for example, has already been used in real life in an attempt to eliminate these plants with disastrous effects. The tools available at each level will not be exactly the same and will depend on the actual methods of eradication for each invasive species. When dragging an object from the inventory, it will exert its effect on the water hyacinths (see Figure 3): the bomb causes an explosion that multiplies the water hyacinths; the fire and the axe are not effective because the plants are in the water, leaving the net as the only effective option. If a bomb bursts at the beginning of the game or at the maximum health level, the player's health drops substantially, but not to the point of ending the game.

The player must drag the net in order to remove the water hyacinths from the lake and allow them to dry. After a second, the water hyacinth is dry (see Figure 4) and disappears. As soon as the player eliminates all water hyacinths, (s)he completes the first level and a victory screen appears. In more advanced levels, the player will have to be careful not to destroy indigenous species otherwise he will lose "health".

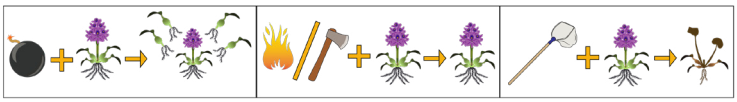


Fig. 3
Tool effects on water hyacinth: bomb, fire/axe and net

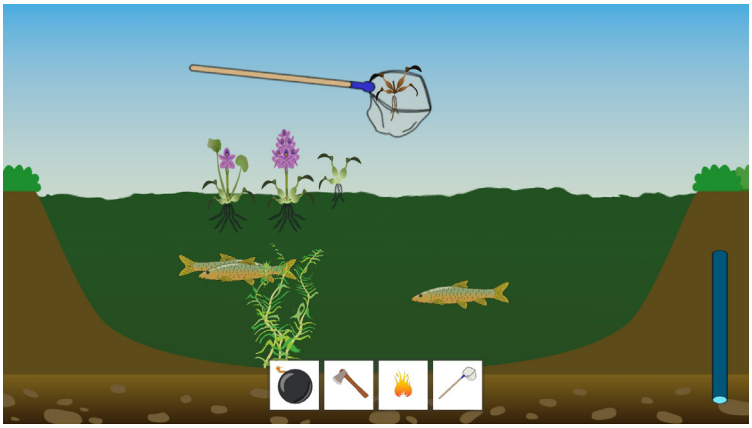


Fig. 4
Game interface after collecting a water hyacinth using the net

The game mechanics are not location-based but the game itself will be. The idea is for this game to be unlocked in a place inside the Gaia's Biological Park that is dedicated to environmental awareness on the subject of exotic and invasive species. Nonetheless, it has the potential to be an isolated app without the location-based component.

In future levels, there will be different invasive species and upper levels could even have a mix of species. The tools and mechanics would be adapted to each species. Some of them can also have more complex mechanics of elimination. For instance, for a mimosa tree it would be necessary 2 steps: first, to peel its bark so that the tree could dry out, and after, to chop it with an axe. The level of life of the player could be measured by the amount of water on a nearby spring. The idea of these levels is to recreate the mechanics of real life in an educational and gamified way.

5. RESULTS

In this section, we present the results obtained via the used data collection instruments. It is important to note that since the sample is not representative, the results do not allow definitive and generalizable conclusions to be drawn.

There were 33 users on the first phase of the test and 30 on the second. The users' age from the first round of tests varies between 15 and 47 years, with a mean of 29.8 years. On the second test phase, the participants' age ranged from 22 to 45 years, with a mean of 29.6 years. According to the results, most respondents from both phases of testing use mobile applications frequently. The results to the questionnaires referred in section 3.2 are summarized on Table 1. The results present the percentage of users that "agree" and "fully agree".

Table 1
Results from the 1st and 2nd phases of testing

QUESTION	1ST PHASE	2ND PHASE
Need an instruction manual or tutorial.	58%	50%
The application responded quickly.	76%	93%
The game responded as expected to the controls.	51%	74%
The purpose of the game was easy to understand.	54%	60%
I understood the game message.	75%	83%
The game has an effective educational component.	76%	80%
I thought the game was fun.	48%	80%
I would like to play more levels.	88%	96%
I liked the visual aspect of the game.	85%	84%

As shown in Table 1, the need for an instruction manual or tutorial decreased 8% in the second phase, compared to the results obtained during the first phase. Participants considered that the application responds quickly. In other results, the percentage of disagreement with the sentence declined by 15% in the second phase of testing and the percentage of fully agreeing with the claim rose by 34%. Practically half of participants in the first phase agreed that the game responded as expected to input and there was a 23% increase of positive responses in the second phase of testing. Regarding the clarity of the game's goal, the general opinion is divided both in the first and in the second phase, although it presents some improvements in the second phase. Nonetheless, it was found that they were more consensual in their opinion regarding the clarity of the game's message. The percentage of users who perceived the message rose from 75% on the first phase to 83% in the second phase of testing. In general, participants considered that the game had an effective educational component. The percentage of users who considered the game to have an effective educational component increased from 76% to 80%. There was a significant increase from 48% to 80% in those who found the game to be fun. The vast majority of participants in both phases of testing expressed that they would like to play more levels, with an 8% increase in the second phase, from 88% to 96% of positive responses. The visual aspect of the game was highly praised in both phases of testing (85% and 84%). Also, the majority of participants considered that this game would be more suitable for a young age group, under 18 years old (88% in the first phase of tests and 90% in the second phase of tests). As the age group increases, the percentage of responses decreases. It was found

that 27% of the users of the second test phase had already participated in the first phase.

The survey included an open answer question, allowing participants to write comments and suggestions regarding the prototype and their gaming experience. Several comments expressed the participants' willingness and desire to play more levels and more variety of game content. Several comments from both test phases pointed to the lack of information and instructions in the game. It was suggested that before the player starts the game, they would be presented with information regarding their goals, the invasive species and the effects of each tool. Gameplay and mechanics problems were also pointed out in the first phase of tests, as well as suggestions for improvement, such as the fish being affected by the player choices (such as the bomb), adjustments to the game's difficulty and to improve feedback from user interactions. These and other improvement suggestions were taken into account during the second iteration. Among them: changes to the controls in order to allow the player to drag the tools; the adjustment of some values, such as the number of plants with which the game starts; the number of water hyacinths that spread with the explosions, as well as their influence on the "health" level; fish eventually dying as "health" dwindles; correction of some bugs; inclusion of more sounds; general aesthetic improvements. In the second testing phase, some comments were collected which indicate that when a water hyacinth is in the lake's right corner, it is a little difficult to collect it due to the net's length. One suggestion is for the net to be guided by a central axis so that it is possible to guide it to the left or to the right.

In the first phase of tests, some correlations were found between liking the visual aspect of the game, wanting to play more levels and finding that the application responded quickly to the user. Other correlations have been found such as between finding that the game needs a tutorial or instruction manual correlating with not realizing the goal of the game or thinking that it responded as expected to input. Other correlations found in the first phase were finding that the game has an effective educational component and perceiving its message, as well as finding it fun. In the second phase of testing, both perceiving the game's message and wanting more levels are correlated with liking the visual aspect and finding that the game has an effective educational component. In addition, the perceived message of the game also correlates with finding that the application responded quickly to the user as well as understanding the game's goal. Understanding the game's goal,

in turn, has a negative correlation with feeling the need for a tutorial or instruction manual. There was also a correlation between finding that the game responded as expected to input and finding it fun.

6. DISCUSSION AND CONCLUSION

Invasive species are a major environmental problem affecting Portugal and the rest of the world, so it is important to promote scientific literacy and environmental awareness on this topic. For this reason, the game *Invasive Plants* was developed. For the moment, the game prototype only has one level, focused on the invasive species *Eichhornia crassipes* or water hyacinth. The first usability tests provided clues on how to improve the game mechanics and dynamics in the second game iteration, and the second tests also provided clues for future improvements.

Taking into account that these are the first prototypes, it was considered relevant to gather the opinions of an audience with expertise in the areas of game design and development (developers) although both samples are not representative and do not match the target audience (park visitors). This way, with the project in an early stage, it is easier to make improvements and create a new prototype, more complete and refined, to be tested in the future by the target audience.

The results showed that more than half of the participants in the first test phase and half of the participants in the second phase felt the lack of an instruction manual or tutorial and part of the comments and suggestions obtained in the open answer question precisely referred to this topic. Although instructions and more information were added on the information screen in the second iteration of the game, they required that the player would consult them before playing, which rarely happened because of the participants' willingness to start playing, so not all participants realized the goal of the game. This can be solved by including in-game information before the game starts.

The effective educational component was one of the strengths pointed out by the participants. By having the freedom to explore the game mechanics, the users realized the effects that each method had on the water hyacinths, as well as how to eliminate them. The message was perceived by most users, especially in the second phase of testing, and in a fun way. However, about half of the participants in the first phase and slightly less than half of the participants in the second phase did not claim to find the game fun. This result points out toward a need to review the game mechanics and explore more options to make the game more engaging. It should

be taken into account that user tests were not carried out with the target audience, but mostly with creators and consumers of entertainment games, so there may have been some bias in the results. The fact that tests did not take place in the Biological Park of Gaia, where the game should trigger, may also have some influence on users' appreciation.

The results revealed that the vast majority of participants expressed that they would like to play more levels. These results are reinforced by the submitted comments, in which one portion suggested the addition of more levels and variety of contents. On one hand, this is considered a positive result, since it could mean interest, curiosity and motivation to continue playing and, consequently, greater knowledge acquisition or more opportunities for environmental awareness. On the other hand, it may also mean that the game still needs more content to become interesting, appealing and/or fun for some players. The graphical aspect was highly praised during the user tests, which is confirmed in the results obtained. Since most participants liked the game's visual aspect, it can be considered that this result provides clues as to which type of graphics should be chosen for games of this nature: simple, 2D, with easy to identify sprites based on their real-world counterparts.

To conclude, the obtained results were positive and provided clues that contribute to the game's future improvement and its adoption after the conclusion of this research work. Some of these improvements include the addition of in-game information and tutorials, the implementation of more involved mechanics, and some bugs' correction, which were not possible due to time constraints. It can also be considered that the evaluation tests, when performed with a more representative sample of the target audience would be more conclusive and illustrate more clearly the qualities and problems present in the prototype. In the future, we intend to do new user tests on a Biological Park with the target audience in order to test the usability. When the game becomes location-based we will study how the inclusion of the location component affects the user experience. The idea is for this game to be unlocked in a place inside the Gaia's Biological Park that is dedicated to environmental awareness on the subject of exotic and invasive species. The game mechanics are not location-based but the game in itself will be. Although this game can be played anywhere and be an app by itself, we believe that being part of a bigger app with a set of serious games, unlockable in places that have something to do with the subject of each game, will enrich the game experience.

REFERENCES

Baptista, R.; Nóbrega, R.; Coelho, A.; Vaz de Carvalho, C. *Location-based Tourism in-game Certification*. 9th International Technology, Education and Development Conference, 3602-3610. 2015.

Benford, S., Rowland, D., Flintham, M., Hull, R., Reid, J., Morrison, J., ... & Clayton, B.. *Savannah: Designing a location-based game simulating lion behaviour.* In: International conference on advances in computer entertainment technology. 2004

Benford, S., Magerkurth, C., & Ljungstrand, P. *Bridging the physical and digital in pervasive gaming.* Communications of the ACM, 48(3), 54. 2005. http://doi.org/10.1145/1047671.1047704

Ferreira, S., & Alves, A. P. *Location based transmedia storytelling : The travelplot Porto experience design.* Revista Turismo Y Desenvolvimiento, 17/18, 95–99. 2012.

Jacob, J. T. P. N., & Coelho, A. F. *Issues in the development of location-based games*. International Journal of Computer Games Technology. 2011. http://doi.org/10.1155/2011/495437

Jantke, K. P., & Spundflasch, S. *Understanding pervasive games for purposes of learning.* CSEDU 2013 - Proceedings of the 5th International Conference on Computer Supported Education, (May), 696–701. 2013.

Jepson, P., & Ladle, R. J. *Nature apps: Waiting for the revolution.* Ambio, 44(8), 827–832. 2015. Retrieved from: http://doi.org/10.1007/s13280-015-0712-2

Kuehn, E., & Sieck, J. *Design and implementation of location and situation based services for a pervasive mobile adventure game.* In: Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications, 2009. IDAACS 2009. IEEE International Workshop on (pp. 640-644). IEEE. 2009.

Marsh, T. *Serious games continuum: Between games for purpose and experiential environments for purpose.* Entertainment Computing, 2(2), 61–68. 2011.

Michael, D., & Chen, S. *Serious Games: Games That Educate, Train, and Inform.* Boston: Thomson Course Technology PTR, 2006.

Pereira, P. M. dos S. B. *Os dispositivos móveis no apoio a visitas a museus.* PhD Thesis. University of Aveiro. 2013.

Pereira, D. B. *Jogo Baseado na Localização para a Otimização da Experiência Turística.* Dissertação de Mestrado Integrado em Engenharia Informática e Computadores, Faculdade de Engenharia da Universidade do Porto.

Raessens, J. *Homo Ludens 2.0. The Ludic Turn in Media Theory,* 37. 2012.

Rodrigues, A. R.; Carvalho, M.; Pombo, L. & Neto, T. *Tecnologias da Informação em Educação Tecnologias da Informação em Educação.* Indagatio Didactica, 9(4), 211–226. 2017.

Santos, L., Pereira, D., Beça, P., Nóbrega, R., & Coelho, A. *Aplicação móvel para divulgação do património natural no turismo.* Revista Turismo & Desenvolvimento, 1(27/28), 1461-1473. 2017.

Santos, L.; Pereira, D.; Nóbrega, R.; Beça, P.; Coelho, A. *Jogos sérios digitais para a promoção do património natural – o caso de um jogo de exploração*

de um parque na busca dos seus animais. Atas da Videojogos 2016 - 9ª Conferência de Ciências e Artes dos Videojogos. Universidade da Beira Interior. 2016.

Santos, L. A. da R. *Parques Urbanos: uma proposta de atividades de Divulgação Cientifica para o Parque da cidade do Porto*. 2013.

Viana, J. R. M., Viana, N. P., Trinta, F. A. M., & Carvalho, W. V. de. A *Systematic Review on Software Engineering in Pervasive Games Development.* Brazilian Symposium on Computer Games and Digital Entertainment, 51–60. 2014. Retrieved from: http://doi.org/10.1109/SBGAMES.2014.16

Weber, J. *Designing engaging experiences with location-based augmented reality games for urban tourism environments* (Doctoral dissertation, Bournemouth University). 2016.

Extended Play at Faraday Museum

JOÃO BARRETO,[1] RUI PRADA,[2] PATRÍCIA GOUVEIA[3]

ABSTRACT

Taking advantage of augmented reality technologies this paper proposes a solution to enhance human-machine interaction with museums. People are rarely able to manipulate objects in classical object-oriented exhibitions or when it is possible, they do it with constraints. Museums can use augmented reality technologies more often in a playful way to enhance interaction and deliver new content among their public. This project was created for Faraday Museum (FM) at Instituto Superior Técnico in Lisbon. In order to increase the amount of interaction inside and outside Faraday´s Museum exhibitions, we created and developed a gaming application that uses augmented reality technologies named *Extended Play at Faraday Museum*. Using this application, the user/player can learn content about real objects allowing her/him to interact with digital replicas of the original pieces. Our goal is to provide interactive experiences in Museums questioning the relationship between users/players and objects to understand if people connect more deeply with the available content and learn through the process of interacting with digital augmented content.

KEYWORDS

Augmented Reality;
Interaction Design;
Applied Gaming;
Player/User Experiences;
Museum Experiences.

[1] Instituto Superior Técnico / INESC-ID, Universidade de Lisboa, Portugal
joao.cardoso.barreto@tecnico.ulisboa.pt

[2] Instituto Superior Técnico / INESC-ID, Universidade de Lisboa, Portugal
rui.prada@tecnico.ulisboa.pt

[3] Faculdade de Belas Artes, Universidade de Lisboa, Portugal
p.gouveia@belasartes.ulisboa.pt

1. INTRODUCTION

Museums are eager to engage people in deeper ways in their exhibitions by using gaming technologies, virtual and augmented reality devices, robot guides, among other possibilities. The purpose of this paper is to present an experimental gaming experience named, *Extended Play at Faraday Museum*. This game takes advantage of augmented reality technologies in order to enhance the user/player experience of manipulating digital replicas of the original museum objects. The main goal of this research is to question if it is possible to cut or avoid some constraints in the relationship between visitors and museum artefacts with the usage of augmented reality devices. Making visitors feel like they are really engaging with the real objects presented at the museum, receiving knowledge about it in the process of playing the game, can help solving some interaction problems and enhance the overall player experience. Since the majority of time we are not allowed to touch museum artefacts due to their fragile structure or uniqueness this application aims to contribute to the field of gaming and interaction design applied to museums. We would also like to contribute to new forms of interactivity in museums. Peter Weibel once described the shift from the passive spectator to the active participant. According to this author,

> *"if there are any social aspects at all in modern art, then they must involve the spectator. We want to arouse the spectator's interest, to liberate him, to relax him. We want him to participate. We want him to seek interaction with other spectators. We want to develop together with him enhanced perception and action. A spectator who is aware of his power and tired of so many falsities and mystifications will be enabled to make his revolution in art and to follow these signs: act and cooperate."* (Weibel, 2007: 48)

2. BACKGROUND

According to ICOM (International Council of Museums),[1] "a museum is a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment" (ICOM, online).

[1] http://archives.icom.museum/definition.html (accessed September 2018).

Chris Christou considers virtual reality as some type of a computer simulation where we find an environment to walk around objects and simulated people, commonly known as avatars (Christou 2010). Normally, this environment is a 3D replica of the real world, but we can also find imaginary spaces or building blocks games or sand boxes. One possible example of a 3D simulation of a real world was developed by Carvalho and Raposo in 2013. They developed a virtual reality replica with the purpose of simulating a museum cloister in Aveiro, Portugal.

Lanier (2017), founding father of a pioneer VR Company called VPL Research, considers, in his first VR definition, among many other dispersed in the book, *Dawn of the New Everything, A Journey Through Virtual Reality*, the field as "a twentieth-first-century art form that will weave together the three great twentieth-century arts: cinema, jazz, and programming." (Lanier 2017: 3) Virtual reality, as Lanier states in the above quoted book, is a powerful medium involving visceral sensations, haptic feedback and body perception and it contrasts with augmented and mixed reality. Following Lanier, we can consider that with virtual reality we can create new worlds and sensations to be explored in a first- or third-person perspective, this trend is common in gaming applications that take advantage of immersive strategies and technologies. In contrast, augmented reality is all about exploring and appreciating the real world in new ways. Pokémon Go[2] is a good example of merging the actual world with the digital one assembling, in a gaming space, real data with digital creatures.

Faraday Museum is already using some sort of Augmented reality. By using QR (quick response) codes they let the visitors learn more about objects that have those codes on them. However, the solution that will be presented is more than simple data acquired by pointing a Smart-phone to those codes. In the project *Extended Play at Faraday Museum* we will use augmented reality in the sense that our goal is not to merge immersive and hot virtual reality with headsets, gloves and other similar gadgets but more cold (McLuhan 2003 [1964]) and disembodied technologies like mobiles and tablets.

[2] https://pokemongolive.com/en/ (accessed September 2018).

In this sense we consider that mix reality would be a hybrid technology between virtual and augmented reality, allowing the user/player to be immersed in digital information, with the possibility to interact directly with it, without losing focus of the real world. Some work done by Birchfield *et al.* (2008) shows that it is possible to interact with the virtual object by using two external controllers with the aspect of glowing balls. Other authors, like the above quoted Jaron Lanier, consider that these days mixed reality is equivalent to augmented reality technologies, but we decided to also take into consideration the classical Paul Milgram (1994)[3] definition of a "virtuality continuum" between digital and real data to open the discussion concerning mixed reality in a broader perspective. In *Extended Play at Faraday Museum* we will use augmented reality to enhance human-machine interaction to further develop user/player experiences.

We can consider the usage of other technologies to enhance human-machine interaction in museums such as the robot guides presented in the New York Times article, "Let a Robot be Your Museum Tour Guide". As Carvajal (2017)[4] states, the author of the above-mentioned text, "a robot walking in a museum gallery, becomes its own exhibition, inciting curiosity and people´s imagination" (Carvajal 2017: online). This robot is available at the Museum of the Great War in France and it shows a screen where people can see how it was the military life in the trenches of the World War I.

Since the solution that we propose will be a game with some learning purposes it can be included in the category of a serious game. A serious game is a game that has as its main purpose teaching something about a certain concept. According to Alexiou *et al.* (2012) "these software applications aspire to bring into the world of learning, those elements of digital games that stimulate, immerse and engage players" (Alexiou *et al.* 2012: 1243-47). An example of a serious game is *Treme-Treme*[5] (Barreto *et al.* 2014) a game that teaches children, from 7 to 9 years old, how to survive

[3] http://etclab.mie.utoronto.ca/people/paul_dir/IEICE94/ieice.html (accessed November 2018).

[4] https://www.nytimes.com/2017/03/14/arts/design/museums-experiment-with-robots-as-guides.html (accessed September 2018).

[5] http://www.treme-treme.pt/en/treme-treme-pt (accessed September 2018).

in an earthquake and its aftershocks.

Other games were analysed during the process of creating a game for Faraday Museum with the aim of enhancing users or players interaction experience. *Parthenon Frieze*[6] is an online game with mini-games with mechanics such as dragging, solving puzzles, detecting differences between images and so on. Smithsonian American Art Museum's *Meet me at Midnight*[7] is a game where the narrative guides the player through the experience, in order to learn about three objects from the museum. This game design approach is structured, which means that the player can only go to where the narrative allows. *Rugged Rovers*[8] is a game where the player constructs a rover, placing its wheels where she/he wants in order to check how long it takes to travel with that setup. The gaming application *Blockworks: Recreation of the great London fire of 1666* uses Minecraft "to build a detailed virtual model of the 17th century London – and then burn it down" (Blair 2016). In this game the player can walk in London in 1666[9] when the fire took place. *Minecraft Infinity Project*[10] is a game that uses cooperation in order to build popular pieces of art. Finally, *Labours of Hercules* (Antoniou 2015) is a game that teaches about the myth of Hercules in a playful way. Players learn about the myth while they are playing the game in a structured design in which the player can only go to where the narrative allows. This is a game design option that we will not use in our gaming application *Extended Play at Faraday Museum*. In our case we can select objects randomly freely without a pre-determined order.

In terms of augmented reality applications, we can quote as our main guides some medical surgery usage of robots with the help of augmented reality (Aparicio 2012) which overlaps digital content with the real world in order to precisely know where veins are. *ATTech* (Chantzi 2013) was used to learn about specific biology content

[6] http://www.parthenonfrieze.gr/play (accessed September 2018).

[7] htttp://2.americanart.si.edu/exhibitions/online (accessed September 2018).

[8] http://www.sciencemuseum.org.uk/games-and-apps (accessed September 2018).

[9] htttp://www.museumoflondon.org.uk/discover/great-fire-1666 (accessed September 2018).

[10] http://www.biennial.com/minecraft-infinity-project (accessed September 2018).

with the help of image marks that showed 3D models of an embryo. *Augment*[11] is an application where the user can upload its specific content in order to show it to clients or friends. *Reblink*[12] is an augmented reality experience where users or players view specific portrait art, making the inside of the portrait alive with augmented reality help.

Location-based augmented reality game demonstrated by (Rubino 2015) is a game where the player plays pieces of the play differently if she/he is located in different museum rooms. Finally, we can quote the example of an augmented reality game teaching about boats inside the naval museum of Ílhavo (Costa 2013). This game detects if the player is at a specific location when she/he points the smart phone's camera to the correct place in the museum in order to show info about boats.

Fig. 1
One of Faraday Museum's Rooms and Gower-Bell telephone.

3. GAME DESIGN, METHODOLOGY AND DEVELOPMENT

The created application, *Extended Play at Faraday Museum*, is an augmented reality game for a public with 12 years old and up with basic Portuguese and English knowledge and skills. The augmented reality game asks museum visitors to create an object-oriented collection as a way to engage them in the available museum content. The player will be able in the future to choose up to 9 specific objects from the museum but to do so he needs to be in the room where the objects are in order to detect them with a mobile phone.

[11] https://www.augment.com/ (accessed September 2018).

[12] https://ago.ca/exhibitions/reblink (accessed September 2018).

However, now, in our stage of research it is only possible to select one object, which is the Gower-Bell telephone (fig. 1). If the visitor selects it the application will show information about the telephone and the possibility to play a mini game where she/he has to do mandatory things to earn stickers to her/his book collection of objects. Afterwards players can show it to their family and friends.

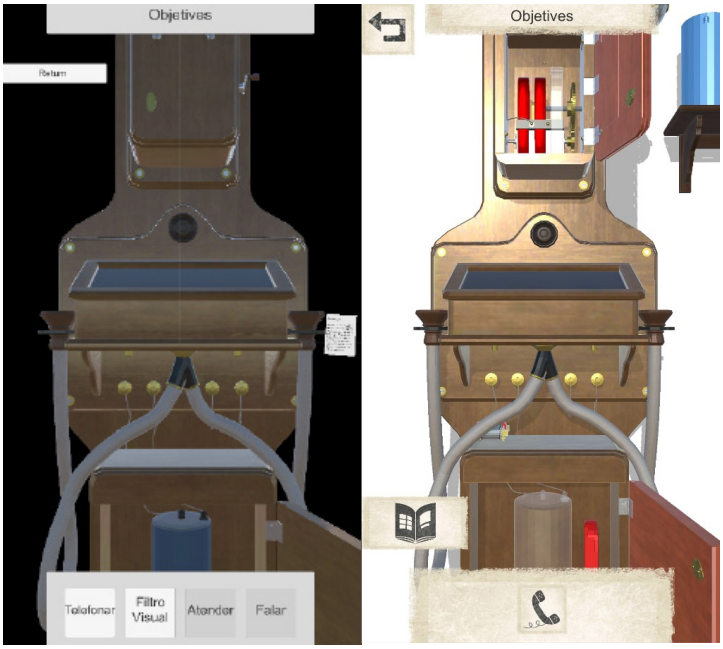


Fig. 2
Different stages of the game graphical interface.

In this first mini game, players should finish some missions about the Gower-Bell telephone. The first one is discovering why the object is not working properly. By using actions such as, grabbing, dragging, touching, zooming, listening and rotating they should find a missing object and introduce it into one of the telephone compartments (cf. fig. 2). This compartment has 3 magnets that produce electric energy if a lever is rotated and the player should put the third one in the correct place. Like that players will learn that in the past this was necessary in order to send an electric pulse to a telephone central for the operator to know that the person who rotated that lever wanted to dial again. After doing this challenge the player can try to call the digital phone but it still sends smoke from other places. Players need to find a microphone box and, finally, after exploring the Gower-Bell telephone doors and features players need to recharge a battery and "dial a number", in this case to

click a button. To charge the battery players need to touch it five times but they finally solved the problem and can make a call with success and, if she/he does pick the earphones, a specific sound is played. With this mission accomplished the player can return to the book where she/he earned a special sticker connected to the Gower-Bell telephone (figs. 3 and 4).

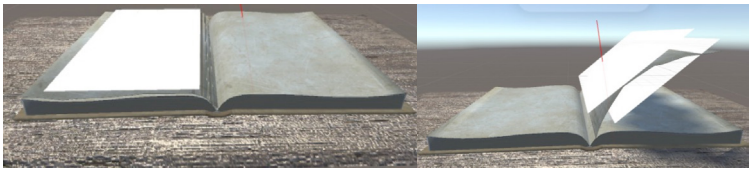


Fig. 3
Collectors book page animation

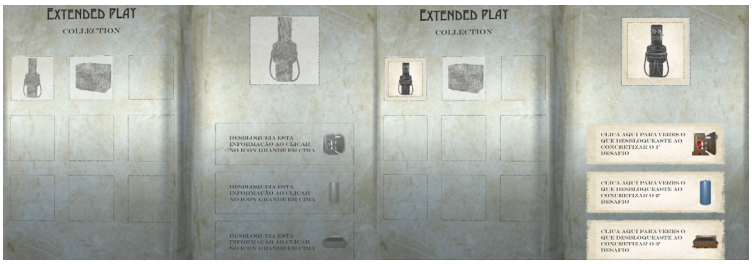


Fig. 4
Collection book - earned sticker in golden texture

The creation and development of the game application *Extended Play at Faraday Museum* had several implementation steps. The first one was to find the team of engineers and artists involved in the game creation. Two groups of people, from two different faculties, Instituto Superior Técnico (IST) and Faculdade de Belas-Artes (FBA), both from Universidade de Lisboa, were involved in the process of creating the gaming experience. The 3D work was made by Rafael Miranda, and the 2D graphic design was done by Camila Reis. The second step was to test diverse augmented reality APIs such as ARToolKit+, Kudan, Vuforia, ARCore e Wikitude. The next step involved several meetings with the artists and the museum curators in order to debate ideas and see if the development of the game was going according to the curator's ideas and concepts. Low fidelity 3D model prototypes were made in order to test game mechanics until one of the artists ended the 3D model. The next step was to show the game, still in development, at IST Alameda in the national museum's day at May 18th, 2018 in Portugal.

Few days after the national museum's day the game was tested in a public game's exhibition at IST-Taguspark with a cardboard replica (figure 5) made for the event. After that event some interface and

interaction problems were solved considering the constructive feedback we received. Next step was to try different techniques to detect the player's location in relation to the position of where the 3D object will appear. In this phase we tested the use of image targets, multi-image targets, scanning real world objects and using CAD information to detect real world objects. For this purpose, we used the following software: Game Engine, plugins and APIs Game engine – Unity[13] using C# language; SDK – Vuforia.[14] The choice to use Vuforia was inspired by a study done by Marto (2017). For the creation of the 2D graphic interface environment we used Photoshop[15] and Gimp.[16] In terms of 3D Software, we used Blender[17] to make all the 3D objects, including the first prototype.

The development and implementation process took several steps. First, we did a low fidelity prototype where we could test mechanics such as grabbing the telephone doors and dragging objects to the correct places along with the first challenge that the player would face and the visual particles that would be used to send visual feedback of where the problems in the telephone reside.

The second stage was making the low fidelity interface in order to test it later in the public event (fig. 6) and knowing how to export it to an Android platform. Then, we exchanged the low fidelity telephone prototype into the final version made by the artist along with its textures (Color, Specular and Normals). We also ended mechanics concerning answering the phone along with the first version of particles to simulate electricity passing through places where it is supposed to pass and the sound that would pass in the earphones.

After the public event, we changed the in-game interface according to the feedback received in 28 usability and player interaction questionnaires (please cf. conclusions and future research for further information about this questionnaires) and we ended the beginning screen and the low fidelity collection book. This book has the

[13] https://unity3d.com/pt (accessed September 2018).

[14] https://developer.vuforia.com/ (accessed September 2018).

[15] https://www.adobe.com/pt/products/photoshop.html (accessed September 2018).

[16] https://www.gimp.org/ (accessed September 2018).

[17] https://www.blender.org/ (accessed September 2018).

tutorial in its two first pages and the player can turn pages left and right, finding different objects to play inside the museum (figs. 3 and 6).

Our next goal was altering the low fidelity visual interface with the final version, where the position of the interface is right, and finding a way to save data between scenes and even after the game has been turned off. This was made with the use of an XML file that has information about each object. This file can be changed by the museum curators if they need to do it without an external programmer.

Then, we started building the second challenge of the game and the final version of the collector's book by exchanging the low fidelity version by all the work done by the artists. We changed the visual aspect of the interface inside the telephone game and we ended the final version of the electricity, where we used 3D models to show an animated texture instead of a Bézier curve with particles.

Finally, we did the third game challenge and worked in code optimization like reducing the number of calls of certain expensive methods per frame. We proceed with visual optimization like having big images with different images inside it or having different images for each different image, in order to reduce draw calls, making a shadow catcher to simulate shadow in the museum wall. Since this is an augmented reality game, the 3D object will be overlapped with reality, since the real object is in a museum wall, this will turn the experience even more realistic.

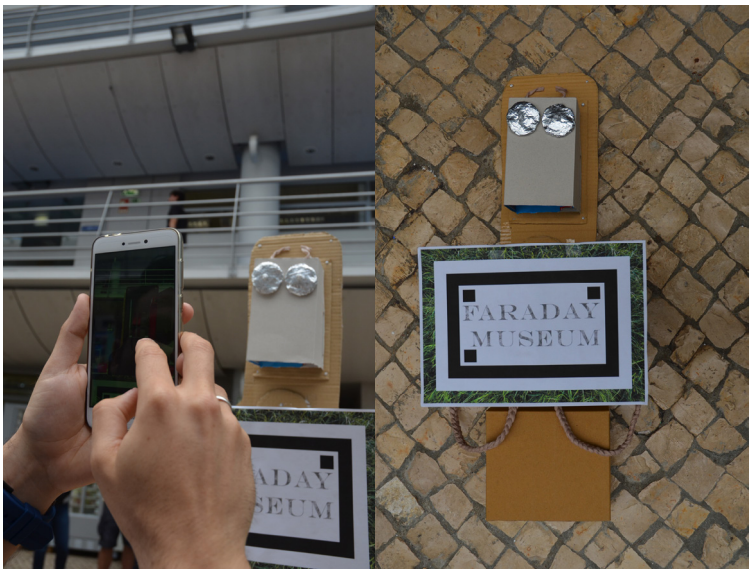


Fig. 5
Cardboard replica of the Gower-Bell telephone for usability tests at public game exhibition, May 2018.

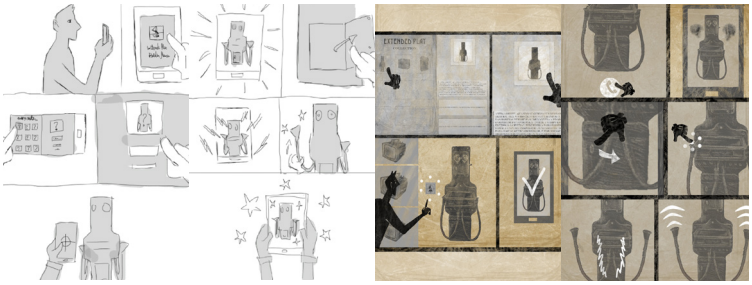


Fig. 6
Storyboards for the game tutorial animation.

A few months after the MOJO event, the game had a final test. This test involved 30 persons, 19 male and 11 female users/players. This test had the purpose of finding if the users/players felt a deeper connection with the Gower-Bell Telephone in terms of interaction. We also wanted to find if this game is a possible solution for acquiring knowledge about this object. In order to know if the interaction was good, a usability test was done. The usability test used was the UEQ.[18] This test evaluates the game in six dimensions, attractiveness, perspicuity, efficiency, dependability, stimulation and novelty. According to the authors of the UEQ, a positive value is > 0.8 for the mean, and if we watch the mean results, every scale was positive however, the perspicuity had a standard deviation of almost the mean value, and the confidence interval shows that this scale has a lot of values < 0.8. But the other results were good, the best one was the attractiveness, stimulation and novelty, which means that the users liked this game a lot.

Users were asked to make an auto-guided visit to the museum, specifically for the Gower-Bell telephone, in order to test if this game was a good way to teach information about this object. Then they had to fill five questions about the telephone. After this, the player would play the game and then, after playing it, she/he would answer the same 5 questions again in order to compare the acquired knowledge.

[18] https://www.ueq-online.org/ (accessed November 2018).

UEQ SCALES	MEAN	CONFIDENCE INTERVAL
Attractiveness	1,872 ± 0,603	1,657 to 2,088
Perspicuity	0,933 ± 0,912	0,607 to 1,260
Efficiency	1,367 ± 0,923	1,036 to 1,697
Dependability	1,317 ± 0,512	1,133 to 1,500
Stimulation	1,858 ± 0,694	1,610 to 2,107
Novelty	1,917 ± 0,744	1,651 to 2,183

Table 1
Usability test results

The questions were:

1. If you had this telephone at home, and lived in the 19th century, how would you dial to another person?
2. Where is located this telephone's microphone?
3. Does this telephone need any battery to work?
4. Is the battery needed to any component? if so, which one?
5. How can you answer the telephone?

The results were as shown in the table 2. "Before" means the number of users that answered correctly before playing the game. "After", the number of users that answered correctly. Finally, "Changes" means the difference between "Before" and "After"

QUESTION	BEFORE	AFTER	CHANGES
1	0%	77%	77%
2	10%	77%	67%
3	73%	93%	20%
4	13%	47%	34%
5	43%	90%	47%
MEAN	27.8%	76.8%	49%

Table 2
Knowledge acquired results

Even if some changes are low, for example, in questions three, four and five. This happens because the "Before" result was already high. So, it is also important to see the "After" column because it shows a great 76.8% of knowledge acquisition. The "Changes" also tell that the results were good because we had a 49% overall increase in acquired knowledge. Users' opinions about the overall experience were consistent, as one said,

"The game revealed a level of interaction with the equipment that would be impossible (or rather unlikely) given its condition that, even if it were well maintained, would be impossible in real situations. I have to say that I enjoyed it, it is a promising and modest beginning that keeps your ideas not only in learning important pieces in the history of telecommunications but also, in its conservation for future generations of visitors."

5. CONCLUSIONS AND FUTURE RESEARCH

During the public game exhibition (MOJO), we did 28 users/player interaction questionnaires to evaluate user or player experience with the Gower-Bell telephone augmented reality application *Extended Play at Faraday Museum*. Ten female and eighteen male players fulfilled the questionnaires. Twenty players found the game easy to understand but eight found it difficult to manage. The majority of players said they would go more often to a museum if they could interact with similar devices. After that iteration it was possible to enrich the application to enhance users/players experience and to continue our technical research in terms of future achievements. The gaming application was also tested by the museum curators at Faraday Museum and in informal gatherings of higher education student groups. After these tests we did major and minor changes to the game and we did a final *in situ* game test at Faraday Museum. Users/players played the game while aiming with a smartphone to the real Gower-Bell Telephone. The results, in terms of interaction showed that the way the game presents the objectives to the player could be improved. However, players really liked the game, and everyone played it till the end without much effort. The results also showed that this game was a good solution for learning museum content, but we did not used other means of acquiring knowledge to compare with. In this context, the only conclusion we can get is that this is a possible solution to acquire museum content in a playful way. Users opinions and observations also demonstrated that this was a good solution to interact with an object in a museum environment. The development of this game will be continued, and it is predicted that it will have more 8 objects to interact inside the museum with different ways of interacting with them. It might be possible to take photographs with the augmented reality system and use the game at home after acquiring the object inside the museum in users/players smartphones. It is important to say, that this is a starting point to be extrapolated to other museums.[19]

[19] Final video presentation available here: https://youtu.be/sCwpNK1iZfo (accessed November 2018).

AKNOWLEDGMENTS

This work was supported by national funds through Fundação para a Ciência e a Tecnologia (FCT-UID/CEC/500 21/2013). We would also like to thank Faraday Museum curators, Prof. Moisés Piedade and Prof. Carlos Fernandes, for their guidance and scientific support and Faculdade de Belas-Artes (Fine Arts Faculty) artists Rafael Miranda (animations and 3D objects design and development) and Camila Reis (graphical interface and storyboard illustrations).

REFERENCES

Alexiou, Andreas and Michaéla Schippers, Ilan Oshri. "Positive Psychology and Digital Games: The Role of Emotions and Psychological Flow in Serious Games Development". PSYCH Journal, pp. 1243-47, 2012.

Antoniou, Angeliki and George Lepouras, Stavroula Bampatzia, Hera Almpanoudi. "An Approach for Serious Game Development for Cultural Heritage: Case Study for an Archaeological Site and Museum". PSYCH Journal, 2013.

Antoniou, Angeliki and Jamie O´Brien, Tiphaine Bardon, Andrew Barnes, Dane Virk. "Micro-augmentations: situated calibration of a novel non-tactile, peripheral museum technology". ACM Proceeding of the 19th Panhellenic Conference on Informatics. 2015.

Birchfield, David and Brandon Mechtley, Sarah Hatton, Harvey Thornburg. *Mixed-Reality Learning in the Art Museum Context*. Proceedings of the 16th ACM international conference on Multimedia, 2008.

Blair, Joshua. "Great Fire 1666: The Great Fire of London in Minecraft". In https://www.museumoflondon.org.uk/discover/great-fire-1666 (accessed September 2018).

Carvajal, Doreen. "Design Museums Experiments with Robots as Guides". In https://www.nytimes.com/2017/03/14/arts/design/museums-experiment-with-robots-as-guides.html, 2017. (accessed September 2018).

Carvalho, Ruben and Rui Raposo. *Proposta de uma visita virtual 3D ao claustro do museu de Aveiro*, Ria, Repositório Institucional da Universidade de Aveiro, 2013. In https://ria.ua.pt/handle/10773/12182?mode=simple Education (accessed November 2018).

Chantzi, Athanasia and Charikleia Plessa, Lason Gkanas, Dimitrios Tsolis, Athanasios Tsakalidis. "Design and Development of Educational Platform in Augmented Reality Environment using Gamification to enhance Traditional, Electronic and lifelong Learning Experience". Local Papers of the Balkan Conference in Informatics, 2013. In http://ceur-ws.org/Vol-1036/Education (accessed November 2018).

Christou, Chris. "Virtual Reality in Education". In ResearchGate. 2010. In https://www.researchgate.net/publication/272677840_Virtual_Reality_in_Education (accessed November 2018).

Costa, Luís. *A realidade aumentada aplicada ao conceito de caderneta de cromos*. Unpublished Master Thesis. SIGARRA U. PORTO. 2015. In https://sigarra.up.pt/reitoria/pt/pub_geral.pub_view?pi_pub_base_id=35705 (accessed November 2018).

Irene Rubino, Claudia Barberis, Jetmir Xhembulla, Giovanni Malnati. "Inte-

grating a Location-Based Mobile Game in the Museum Visit: Evaluating Visitors Behaviour and Learning". ACM Journal on Computing and Cultural Heritage. Volume 8 Issue 3, 2015.

Lanier, Jaron, *Dawn of the New Everything, A Journey Through Virtual Reality*, The Bodley Head, London, 2017.

Marto, Anabela, "Realidade Aumentada Móvel num Contexto de Herança Cultural," Repositório Aberto da Universidade do Porto, Faculdade de Engenharia. In https://repositorio_aberto.up.pt/handle/10216/105980PORTO, 2017. (accessed November 2018).

McLhuan, Marshal, *Understanding Media, the Extensions of man*, (ed.: by W. Terrence Gordon), Ginko Press, Corte Madera, CA. 2003: [1964].

Milgram, Paul and Kishino, Fumio, "A Taxonomy of Mixed Reality Visual Displays". *IEICE Transactions on Information Systems, Vol E77-D, No.12 December 1994*. In http://etclab.mie.utoronto.ca/people/paul_dir/IEICE94/ieice.html (accessed September 2018).

Pedro Barreto, Rui Prada, Pedro A. Santos, Mónica Amaral Ferreira, Hugo O'Neill, Carlos Sousa Oliveira. "Treme-treme - A serious game to teach children earthquake preparedness". Proceedings of Videojogos 2014 – Sétima Conferência de Ciências e Artes dos Videojogos, Barcelos, Portugal, 2014.

Romualdo, Sofia. "Curating the Arcade: Strategies for the Exhibition of Videogames". Proceedings of Videojogos 2017. In https://docplayer.com.br/84273244-Videojogos-videogames-as-an-art-form.html (accessed November 2018).

Weibel, Peter. *It is Forbidden Not to Touch: Some Remarks on the (Forgotten Parts of the) History of Interactivity and Virtuality*. In *MediaArtHistories*. Ed.: Oliver Grau. Cambridge, Mass.: MIT Press, 2007.

Mise-en-jeu: A Framework for Analysing the Visual Grammar of Platform Videogames

JOÃO PEDRO RIBEIRO,[1] MIGUEL CARVALHAIS,[2] PEDRO CARDOSO[3]

ABSTRACT

This paper proposes a framework that addresses the lack of a visual grammar in videogames, providing designers, artists and academics with tools for the analysis of the aesthetics of *mediated space* in videogames. Such systematic description of the visual grammar of videogames' *mediated space* is crucial for understanding the medium itself. Our proposal is based on an analysis of the key-concepts of film's *mise-en-scène*, from which we were able to pinpoint the key-aspects of the visual grammar of the mediated space in videogames, the *mise-en jeu*. The framework presents eight variables: LIGHTING KEY, CAMERA PROXEMICS, CAMERA PERSPECTIVE, SHAPES, AREA OF PHASE SPACE, DEPTH OF FIELD, HORIZON OF INTENT and SETTING. Our method for testing and validating its functionality consisted on a detailed empirical analytical analysis of 36 case studies, all platform videogames from 1980 to 2013. Our research allowed us to find 6 distinct design patterns, proving the efficiency of the framework. For future research we aim towards an understanding of the effects that *mise-en-jeu* has on the player's experience and across diverse videogame genres, provided that a qualitative analysis of the patterns is conducted.

KEYWORDS

Game Studies;
Mediated Space Design;
Mise-en-jeu;
Visual Design.

[1] Porto, Portugal — jprs.22@gmail.com

[2] INESC TEC / Faculty of Fine Arts, University of Porto, Porto, Portugal — mcarvalhais@fba.up.pt

[3] INESC TEC / Faculty of Fine Arts, University of Porto, Porto, Portugal — pcardoso@fba.up.pt

1. INTRODUCTION

This paper[4] addresses the aesthetics of videogames, a component that is used to describe "the desirable emotional responses evoked in the player, when she interacts with the game system" (Hunicke *et al.* 2004, 2).[5] It takes into consideration Michael Nitsche's five planes theory for the analysis of videogame spaces (2008), especially the *mediated space*, which Sercan Sengün interprets and describes as consisting "of the visual outlet of the game and mostly breeds cinematic and visual studies" (2015, 186-7).

Previous studies include theories on the production of space (Lefebvre 1980; Manovich 2002), videogame spaces (Nitsche 2008; Aarseth 2000; Murphy 2004), game design and development (Wolf 2001; Hunicke *et al*. 2004; Chang & Hsieh 2017), game criticism (Konzack 2002), technical game research (Hunicke *et al*. 2004; Winn 2008), videogames as art and culture (Kuhn & Schmidt 2014), film studies (Giannetti 2014), and cinematography (Logas and Muller 2005).

In an approximation to how film and theatre have *mise-en-scène, mise-en-jeu* has been suggested by Ivan Girina (2013, 53) and by Victor Potier (2014). However, these authors only present terminology and the contents it could address, pointing to cinema as an example. Videogames and cinema, however, are very distinct media. Our framework fills that gap by providing a model that is structured and defined by the specificities of videogames.

In order to answer to our core question — What is the visual grammar of the videogame medium? — we have adapted the variables of *mise-en-scène* to the videogame medium, while adding new variables, native to videogames, and testing these with case studies. These were performed by means of a qualitative analysis with a sample of over 100 scenes from 36 videogames.

The first section of this paper provides an abridged review of the main literature. It is followed by an overview of the methods used to conduct the research. We then propose a framework, all the variables it includes, and demonstrate the patterns we were able to find. We conclude with a summary and a description of this research's limitations, and suggestions for future work.

[4] This work is a summary of our dissertation *Let's Play the Visual Trail: A Framework for the Analysis of the Mise-en-jeu* (Ribeiro 2018).

[5] Although we reviewed other elements of videogame design.

2. BACKGROUND

Videogame designers often strive to provide mechanically well-developed experiences, with a comprehensive set of game designs and artefacts. The *MDA framework*[6] (Hunicke *et al*. 2004) has been proposed in order to help videogame designers with the tools to conceive those experiences. Its authors define the terms of the framework as:

- *Mechanics* describes the components of a game at the level of data representation and algorithms. They are analogous to the rules of a videogame, and we need to look at them as the machine-driven executions of which a videogame depends when functioning.
- *Dynamics* describing the run-time behaviour of the mechanics acting on player inputs and each other's outputs over time. The dynamics of a videogame are the idiosyncrasies that become a consequence of the implementation of a videogame's mechanics as a constraint of player action. They are the result of this interaction and necessitate symbiosis between the player and the machine.
- *Aesthetics* describing the desirable emotional responses evoked in the players when they interact with the game system (ibid., 2). They are set from a player perspective and are related to the tone of the videogame. In relation to this component, the authors of the framework start by asking "What makes a game fun?" Afterwards they conclude that the word fun is too limited and that it is not always what a designer sets out to achieve with a videogame, and so they created a taxonomy with 8 elements.

To arrive at these concepts, the authors researched what the main elements of videogames are and reached a conclusion: Rules, System and "Fun", and from there they established their design analogues: Mechanics, Dynamics and Aesthetics, respectively. The paper describing the MDA Framework concludes by informing us that player experience is constructed from more than the rules, and that videogame designers only design the mechanics, even when their goal with that is to influence the dynamics and consequently the aesthetics.

[6] MDA stands for Mechanics, Dynamics, and Aesthetics.

In addition to the MDA framework, we need to understand the basic concepts of the production of space, before moving on to the production of space in videogames. Henri Lefebvre's *La présence et l'absence: contribution à la théorie des representations* (1980) presents a model of spatial structure analysis that came before the theories of Mark Wolf (2001) and Michael Nitsche (2008), which we will discuss ahead, and introduced the concept of *dialectics of triplicity*. It distinguishes three types of spaces: *objective space, conceived space*, and *lived space*. Edward Soja refines Lefebvre's concepts into what he defines as *trialectics*. According to Soja, the *lived space* "never stands alone, totally separate from its precedents or given absolute precedence on its own" (1996, 70). Soja's model defines the concept of third space and maintains that the third space comprehends the previous two. In the third space, all spaces gather together (ibid., 65).

Before Nitsche, Wolf included a very comprehensive analysis of the different characteristics of space (among other categories) in various videogames in *The Medium of the Video Game* (2001). In that work, he remarks that "many games have spaces so elaborate that spatial navigation becomes an important part of gameplay. Navigation is an interaction with space itself, a space through which one actively makes choices to find one's way around. Navigation involves freedom of movement and connected spaces, the connections of which are explored and learned through navigation" (ibid., 433).

Despite Wolf's description, Nitsche (2008) introduced what we believe to be a better paradigm, and on which we based our work. He presents 5 different spaces: the *rule-based space*, which is "defined by the mathematical rules that set, for example, physics, sounds, AI, and game-level architecture" (Nitsche 2008, 15); the *mediated space*, which is "defined by the presentation, which is the space of the image plane and the use of this image including the cinematic form of presentation" (ibid., 16); the *fictional space*, which "lives in the imagination" of the player, "in other words, the space imagined by players from their comprehension of the available images" (ibid.); the *play space*, in which players act within the rules of, not only the game but also, the physical devices that accommodate the play experience (ibid.); and the *social space*, which is "defined by interaction with others, meaning the game space of other players affected" (ibid.).

Although we follow Nitsche's model, we also recognise that it does not take into to account previous models such as those by Wolf, the *MDA framework*, or Lars Konzack's *Computer Game Criticism:*

A Method for Computer Game Analysis (2002).[7] The examples Nitsche provides throughout his book can sometimes depend in excess on film studies, and he focuses exclusively on 3D spaces, not describing elements of the 2D plane, such as the side-scrolling camera. The importance of *trialectics* is mostly recognizable here, as it promotes unidirectional exchange of information between all spaces, something we believe should be present in Nietsche's model.

To deepen our knowledge on the mediated space, we also considered the *Eye Space Framework* (Chang & Hsieh 2017), in which the authors propose a taxonomy of the compositional elements and their respective importance and significance within a given frame. This model contains four categories: *primary subject, distractions, backdrop*, and *guiding information*. We also analysed Heather Logas and Daniel Muller's *Mise-en-scène Applied to Level Design: Adapting a Holistic Approach to Level Design* (2005), that makes a distinction between cinematic and cinematography in videogames, demonstrates the application of the *mise-en-scène* in the *mediated space* and on level design, and establishes the importance of colour values in videogames.

Girina (2013) and Potier (2014) identify the need of a *mise-en-jeu* framework, similar to how film and theatre have *mise-en-scène*. However, there has not been a sharp focus on providing a framework that successfully adapts cinema's analytical tools to the videogame medium, taking in consideration its specificities. For that adaptation to happen, we first need to know how *mise-en-scène* works in film, and for that we referred to Louis Giannetti's *Understanding Movies* (2014). He tells us that "the phrase refers to the arrangement of all the visual elements of a theatrical production within a given playing area — the stage" (47). The author refers that in movies, this terminology is more ambiguous and is used to describe "a blend of the visual conventions of the live theater with those of painting" (ibid.). He provides us 15 variables for the analysis of the *mise-en-scène*: DOMINANT, LIGHTING KEY, SHOT

[7] Konzack's paper defines a method to examine videogames. The analysis process is based on videogames principally, although it is inspired by other types of analysis approaches from varying disciplines (Konzack 2002, 89). He argues that videogames consist of two different levels: the virtual space, and the playground. Those levels can be used to the describe the game (90).

AND CAMERA PROXEMICS, ANGLE, COLOUR VALUES, LENS/FILTER/STOCK, SUBSIDIARY CONTRASTS, DENSITY, COMPOSITION, FORM, FRAMING, DEPTH, CHARACTER PLACEMENT, STAGING POSITIONS, and CHARACTER PROXEMICS.

3. METHODS

We studied platform videogames because the genre has a long history and well-documented conventions. We analysed 36 videogames, with the selection being based on the works of DeMaria & Wilson (2002) and Stanton (2015).

To collect and analyse the data, we have created tables and visualization graphics.[8] During the collection process, we have listed in a table the variables of the framework and acknowledged all the possible results for those variables. We only provided an orientation on the possible results for the HORIZON OF INTENT and the SETTING, due to the volatile nature of those variables. Adopting the methodology used by Skolnick (2014) for videogames, the analysis was based on the three-act structure, so we analysed three pivotal scenes from each case study, and in each scene, we analysed all variables at three distinct moments.

We started by testing the application of film's *mise-en-scène* to videogames, in order to find out what was incompatible and what challenges we would have ahead. Gradually, this evolved into the current method of analysis.

Having divided the table correspondent to the analysis of a scene in three moments, representing its beginning, middle and end (Fig. 1), we didn't always analyse just those three distinct moments of a scene. In order to increase the granularity of the analysis, whenever needed, we have created expanded tables in which we have described the scene in more detail and distribute that analysis into more moments. We have converted all the expanded tables into histograms to make data visualization clearer (Fig. 2).[9]

[8] Which can be found in the dissertation (Ribeiro 2018).

[9] However, we didn't create histograms for the variable HORIZON OF INTENT because we considered our analysis of it to be too biased and in need of triangulation to improve accuracy.

Value	Beginning	Middle	End
Lighting Key	HK	HK	HK
Camera Proxemics	Long Shot	Long Shot	Long Shot
Camera Perspective	Side Scrolling	Side Scrolling	Side Scrolling
Shapes	S, C	S, C	S, C
Area of Phase Space	Large	Large, Small	Large
Depth of Field	N/A	N/A	N/A
Horizon of Intent	A3, B1, B2, B3	B1, B2, B3	B1, B2, B3, C1
Setting	Exterior	Exterior	Exterior

Value	Beginning	..	..	Middle	..	..	End
Area of Phase Space	Large	Large	Large	Small	Small	Small	Large
Horizon of Intent	A3, B1, B2, B3	B1, B2, B3	B1, B2, B3	B1, B2, B3	B1, B2, B3	B1, B2, B3	B1, B2, B3, C1

Fig. 1
Example of an analysis table, and a correspondent expanded table.

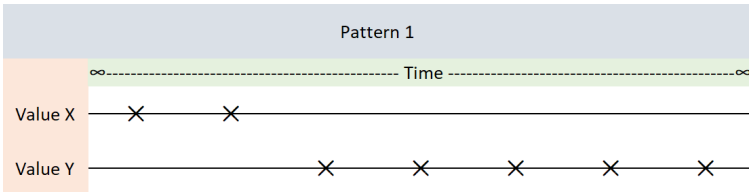


Fig. 2
Example of a data visualization histogram.

Some variables have results that are mutually exclusive and are never present at the same time at any given moment in the scene, while others present results that sometimes develop into mixed outcomes.

4. A MISE-EN-JEU FRAMEWORK

By examining crucial ideas of the *mise-en-scène* in film, we were capable to identify the most important features of videogames' *mediated space*, from which we considered 8 variables for the analysis of the *mise-en-jeu*: LIGHTING KEY, CAMERA PROXEMICS, CAMERA PERSPECTIVE, SHAPES, AREA OF PHASE SPACE, DEPTH OF FIELD, HORIZON OF INTENT and SETTING. We recognised the possible values of these variables by considering the ones from film we thought to be appropriate for videogames, by resorting to other ac-

ademics' studies,[10] and by means of our own deductions based on empirical knowledge on videogames and through analytical play.

4.1 LIGHTING KEY

Similar to what happens in film, in videogames is possible and important to examine lighting, as simulations/representations of light are manipulated in order to create a certain kind of mood in the scene. There are three key-categories to consider: *high-key, low-key* and *high-contrast lighting* (Fig. 3). *High-key* lighting endorses intense, uniform light and few apparent dark locations. *Low-key* lighting supports shadows that are scattered across the scene and large hazy regions of light. *High-contrast lighting* favours a mixture of sharp beams of light and sudden hints of dark.

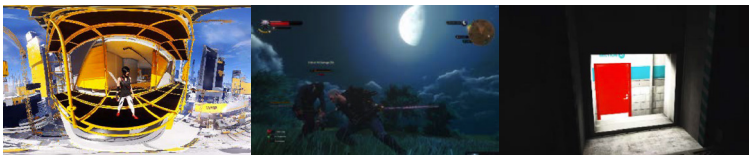


Fig. 3a, 3b, 3c.
Differences between *high-key, low-key* and *high-contrast lighting*, respectively. *Mirror's Edge* (2008) on the left and on the right, *The Witcher 3: Wild Hunt* (2015) in the middle.

4.2 CAMERA PROXEMICS

Videogames can employ a virtual camera, that can either move in response to players' movements in the game world or be controlled directly by them. The distance relating the camera to the primary subject is practically always contextual and changes in response to player action and narrative. The shot distance and proxemics in videogames are similar to film, which means that we have six basic types: the *extreme long shot*, the *long shot*, the *full shot*, the *medium shot*, the *close-up*, and the *extreme close-up* (Fig. 4).

Fig. 4a, 4b, 4c, 4d, 4e, 4f
Differences between the *extreme long shot*, the *long shot*, the *full shot*, the *medium shot*, the *close-up*, and the *extreme close-up*, left to right and top to bottom. *INSIDE* (2016) (4a), *Everybody's Golf 6* (2011) (4b), *Carnival Games: Mini-Golf* (2008) (4c), *Persona 3: Dancing Moon Night* (2018) (4d), *Shin Megami Tensei IV: Final* (2016) (4e), and *Danganronpa: The Academy of Hope and the High School Students of Despair* (2010) (4f).

[10] Which we make reference to on the appropriate subsection.

4.3 CAMERA PERSPECTIVE

Due to the lack of montage in videogames as we know it in film, camera angles vary depending upon narrative circumstances, or when a controllable camera is present, or in correspondence to player action. Rather, videogames have another component that is of supplementary importance and is innate to the medium: CAMERA PERSPECTIVE. In videogames, the following five CAMERA PERSPECTIVES exist for examination, according to Anjin Anhut (2011): *Side Scrolling, Isometric, Third-person, First-person*, and *Over-the-shoulder*. However, we added a sixth perspective – *Side Static*[11] – because in videogames like *Donkey Kong* (1981), even though we see characters from a side perspective, the camera doesn't scroll (Fig. 5).

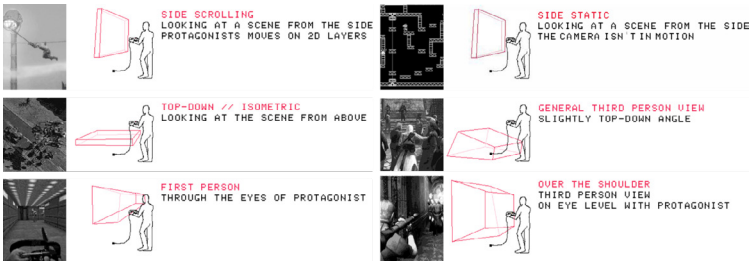


Fig. 5a, 5b, 5c, 5d, 5e, 5f.
An illustrative comparison between *Side Scrolling, Isometric, Third-person, First-person, Over-the-shoulder* (Anhut 2011), and *Static* perspectives.[12]

4.4 SHAPES

In *The Aesthetics of Game Art and Game Design* (2013), Chris Solarski surveyed the behaviourism of SHAPES in videogames. He points out that following SHAPES are associated with the subsequent aesthetic concepts in art: the *circle* is associated with innocence, youth, vigour and femininess; the *square* is associated with maturity, stability, balance and inflexibility; and the *triangle* is related with aggression, masculinity and power. This indicates that, like how we observed in film, they are a key element of the *mise-en-jeu*.

[11] In future studies we also need to consider other perspectives, such as *Top Static,* as found in *The Legend of Zelda* (1986).

[12] Changes have been made to the image in raster graphics editing software.

4.5 AREA OF PHASE SPACE

In *The Aesthetic of Play* (2015), Brian Upton uses the concept of *Phase Space* from physics and introduces it in the field of videogame studies by defining it as the bounds that restrain character movement, and calls it the *horizon of action*. Essentially, the conceivable positions on a given space to which a character can go. In film, *Framing* can be either tight or loose, and a similar description can be used in videogames, but instead of *Framing*, we analyse the *phase space*, and take it contextually, since in videogames it is constantly progressing.

4.6 DEPTH OF FIELD

In the field of videogames, DEPTH OF FIELD is not an element native to the medium but a simulation of the effect we see occurring innately in photography in a virtual camera. Knowing this, when examining DEPTH OF FIELD in videogames, we must first confirm if the effect is present at any given moment or not; and if it is, we need to reflect on why it might be present in some situations instead of being put into action throughout the whole game.

4.7 HORIZON OF INTENT

As we explored Upton's work (2015) we described the concept of *horizon of action*, saying that it comprises a character's possible moves. However, he provides us with the idea of HORIZON OF INTENT as well, which represents the players' set of desirable moves, the ones they are more likely to feel the impulse to make. We need to determine which is the player's HORIZON OF INTENT within any given scene in a videogame, and in that regard, we have confidence that one approach to analyse this consists on using a orthogonal grid coordinate system (Fig. 6).

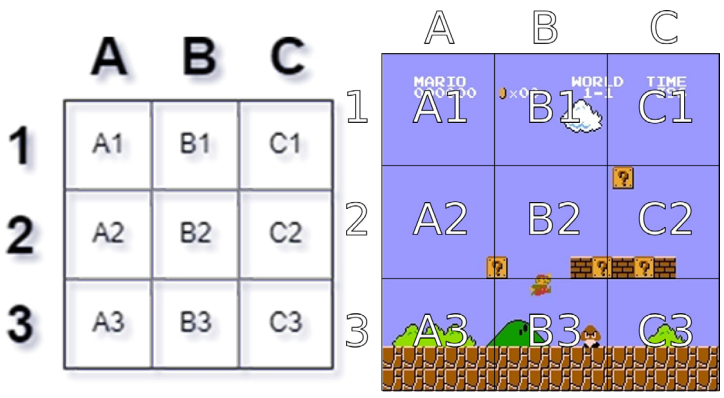


Fig. 6a, 6b.
Grid used to map the position of an object in space and an example of its application.

4.8 SETTING

In narratology, SETTING denotes a space of action and is shown by static descriptions or by indirect references in the narrative. Place imagery can be vastly ambiguous, or a character can provide a very detailed account of the SETTING (Lutwack 1984, 74). Therefore, we believe that in videogames it's imperial that SETTING strives to address principally interrogations regarding location. How detailed that description is, however, is completely contingent on the scope of the researcher and the necessities of the research in hand.

MISE-EN-JEU								
	VARIABLES							
	Lighting Key	Camera Proxemics	Camera Perspective	Shapes	Area of Phase Space	Depth of Field	Horizon of Intent	Setting
POSSIBLE VALUES	High-key	Extreme Long shot	Side Scrolling	Circle	Tight	Existent	Can be represented with a geometrical coordinate system.	Descriptive, with depth changing depending on scope.
	Low-key	Long Shot	Isometric	Square	Loose	Non-existent		
	High-contrast	Full Shot	Third-person	Triangle				
		Medium Shot	First-person					
		Close-up	Over-the-shoulder					
		Extreme Close-up	Side Static					

Table 1
Summary of the variables and their possible values, in the *mise-en-jeu* framework.

5. PATTERNS

To understand patterns, first we resorted to Mark Garcia's definition of patterns, which states that they are "a sequence, distribution, structure or progression, a series or frequency of a repeated/repeating unit, system or process of identical or similar elements" (2009, 8). They are a key-element in spatial design, and the interactions between multiple systems in space result in various effects of different aesthetical representation (ibid., 8-9).

In videogames, we can also find behaviours of design in the mediated space, which can then be compiled and compared, with the resulting comparisons giving origin to patterns when their graphical representation or behaviour is similar. Patterns are, therefore, the generalization of a behaviour that might manifest in the same manner across different variables.

When conducting our study, we identified various patterns by comparison. This comparison was made between all the histograms of all the different variables, meaning that each pattern is comprised by

the accumulation of the results from various variables. We quantified the repetition of visual outlines in histograms and identified the patterns. In the following sections, we describe them, theorize their significance, and question their existence.

5.1 PATTERN 1

Pattern 1 was located in 36 occurrences:[13] 25 times on the AREA OF PHASE SPACE; 6 times on the SETTING; 3 times on the CAMERA PERSPECTIVE; Once on the LIGHTING KEY; Once on the DEPTH OF FIELD.

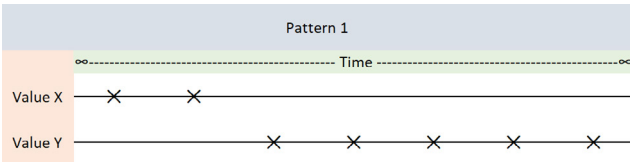
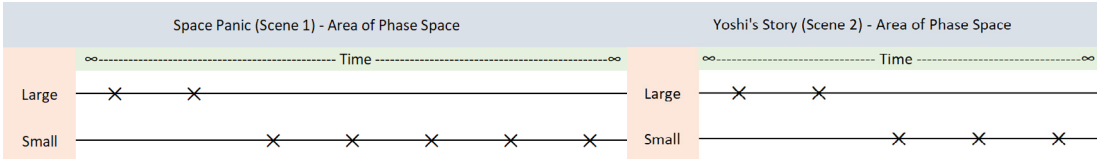


Fig. 7
Representation of Pattern 1.

Essentially, what ensues in Pattern 1 is that the variable exhibits one value consecutively, and then changes to another value that remains the same until the end. It might have to do with the creators' level design choices by, e.g., increasing or decreasing the space the player has available to move, and consequently increasing or decreasing the complexity of the level.

On the first scene of *Space Panic* (1980) that we analysed, this happens because at the beginning of the level the player doesn't have to face enemies, but from a certain point until the end of the level, enemies are always surrounding the player, and in the second scene we analysed of that same videogame, the same thing happens — although the time that the player is left without being challenged by enemies is shorter. On the second scene of *Yoshi's Story* (1997), the AREA OF PHASE SPACE starts by being large but then changes to small until the end, likely in order to increase the challenge in the platforming sections of the game.

Fig. 8a, 8b
Representations of the patterns applied to the examples above.



[13] The occurrences are the moments in which the visual pattern is identified in a histogram.

5.2 PATTERN 2

Pattern 2 was discovered in 13 occurrences: 5 times on the SETTING; 3 times on the CAMERA PERSPECTIVE; 3 times on the AREA OF PHASE SPACE; Once on the LIGHTING KEY; Once on the DEPTH OF FIELD.

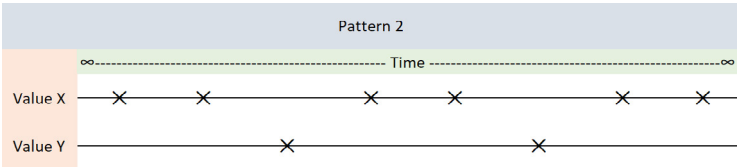


Fig. 9
Representation of Pattern 2.

What occurs in Pattern 2 is that the variable displays one value most of the times, some shifts to another value happen at odd periods, and immediately after it returns to the most constant value. These sudden shifts may exist to allow designers to, e.g., introduce the player to new locales, or to put them in starting locations that then expand into a larger traversal area. This type of change in lighting, e.g., may also be related to a sudden change in order to make navigation more difficult.

On the second scene (*Elec Man* level) of *Mega Man* (1987) that we tested, the CAMERA PERSPECTIVE is mainly *Side Static,* along with a very small AREA OF PHASE SPACE, due to the constant threat of adversaries and platforming risks, but there are two middle points in the level in which it switches to *Side Scrolling*, alongside a larger AREA OF PHASE SPACE. In the test of the second scene of *Mirror's Edge* (2008), we found this pattern on the AREA OF PHASE SPACE variable as well, which is mostly Small but has small spikes to Large whenever the SETTING changes from the *Interior* to the *Exterior*, with the results of the two variables being correlated, probably due to the designers' intent to have *interior* spaces offering a more difficult challenge in platforming.

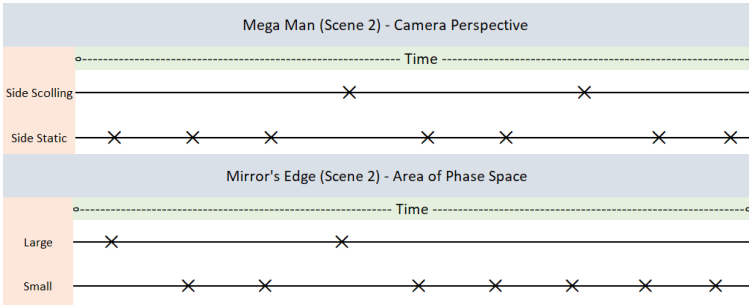


Fig. 10a, 10b
Representations of the patterns applied to the examples above.

5.3 PATTERN 3

Pattern 3 was unearthed in 12 occurrences: 9 times on the AREA OF PHASE SPACE; 2 times on the LIGHTING KEY; Once on the CAMERA PERSPECTIVE.

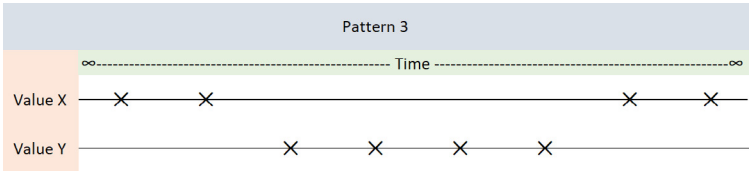


Fig. 11
Representation of Pattern 3.

What happens in Pattern 3 is that there is an initial value for a short period of time, changing to another value for a longer period, and ends with the initial value for an equal short period of time. This design might be related with the tendency that platform videogames have for presenting wide and easy to navigate locations at the start and the end of a level. In two scenes (*Labyrinth Zone* and *Final Zone*) of *Sonic the Hedgehog* (1991) and in two (*Bomb Omb Battlefield* and *Dire, Dire Docks*) of *Super Mario 64* (1996) the AREA OF PHASE SPACE is large at the beginning and at the end of the levels. It is nevertheless small at middle of those levels, moments in which we notice a higher level of difficulty during play. So, this seems to be a design pattern that lets the player observe the level and plan their actions at the beginning in order to prepare for the more difficult moments that will be experienced afterwards, and then cool down when closer to the end.

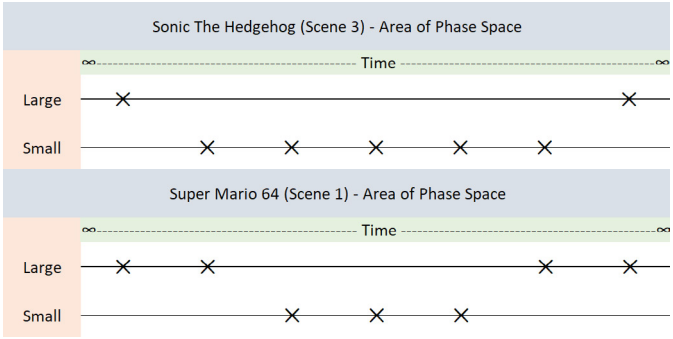


Fig. 12a, 12b
Representations of the patterns applied to the examples above.

5.4 PATTERN 4

Pattern 4 was found in 11 occurrences: 9 times on the SHAPES; Once on the LIGHTING KEY; Once on the CAMERA PROXEMICS.

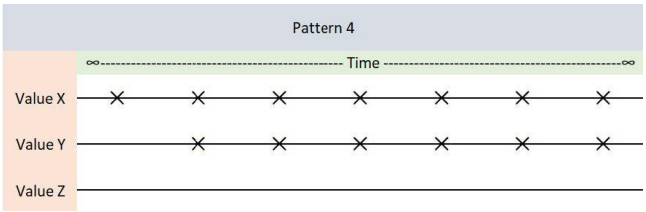
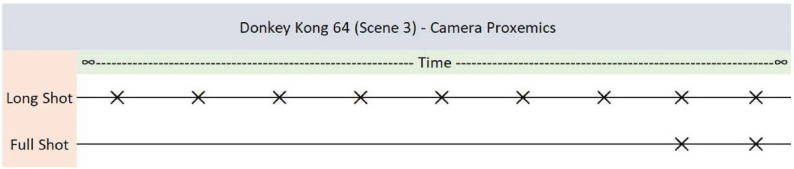


Fig. 13
Representation of Pattern 4.

Pattern 4 presents variables with continuous values from beginning to end, with one value that emerges at either the beginning and halts its presence in the middle, or begins just in the middle and stays visible until the end. While we could consider this to be two different variables, graphically they are very similar, only with the starting point being changed with the end point as the critical point defining the pattern.

On the third scene (*Final Boss*) of *Donkey Kong 64* (1999) we examined, the player merely gets *full shots*, parallel to the *long shots*, in the CAMERA PROXEMICS variable, at the end of the level since that's when they're close to defeating the last boss of the videogame, and that crucial moment is emphasized by changing the CAMERA PROXEMIC'S to a value significantly more intimate, which is the *Full Shot*.



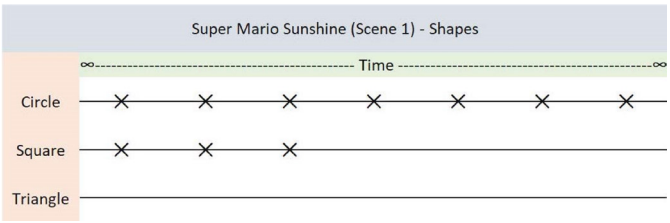


Fig. 14a, 14b
Representations of the patterns applied to the examples above.

Pattern 4 can also be verified throughout all the scenes of *Super Mario Sunshine* (2002) we analysed. In SHAPES, there are always *square* shaped platforms at the start of the level, a design that makes it easier for the player to learn new mechanics, but the shape is never present from midway through the end of the scenes, since the

player is more comfortable with the rules by then and can take more risks with the platforming elements of the game.

This might be attributed to, e.g., the variation of locations within the same level, as they may present different characteristics.

5.5 PATTERN 5

Pattern 5 was located in 9 occurrences: 5 times on the SHAPES; 2 times on the CAMERA PERSPECTIVE; 2 times on the CAMERA PROXEMICS.

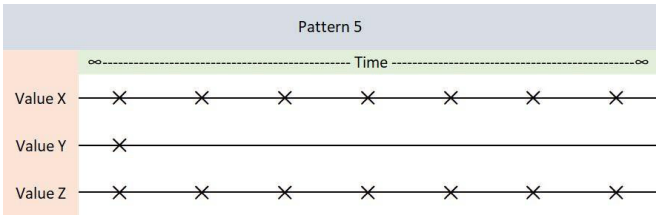


Fig. 15
Representation of Pattern 5.

Pattern 5 is constituted by three parameters, presenting constant values throughout the whole scene, instead of one that becomes null shortly after the beginning. Since the values are consistent from start to finish, with the exception of that on particular moment, it presents itself as a deviation of whatever we might consider the scene's general *mise-en-jeu* is. We believe that this may occur due to the introduction of a visual element that is exclusive to a precise instant of a level. As an illustration, on the *Shape* variable of the first scene (*Spiral Mountain*) of *Banjo-Kazooie* (1998) we analysed, rectangular tiles exist on the floor at the start of the level, but those are never revealed again in the scene, appearing to be restricted to the player character's house.

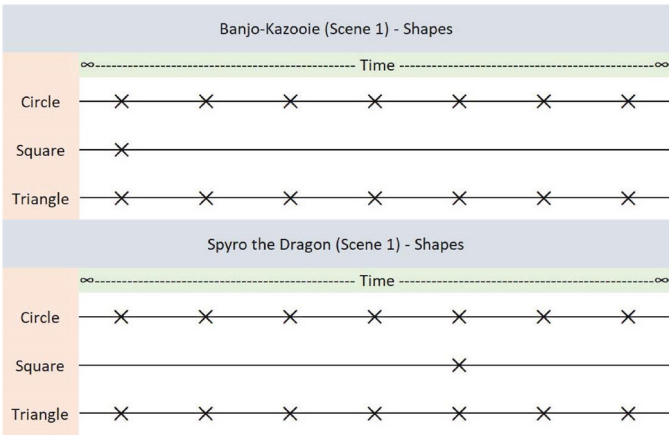


Fig. 16a, 16b
Representations of the patterns applied to the examples above.

The same thing happens on the first scene of *Spyro the Dragon* (1998) that we analysed, in which there is a small transition area with square tiles that the player must go through to access another area, but never sees again in that scene.

5.6 PATTERN 6

Pattern 6 was discovered in 2 occurrences: Once on the SHAPES; Once on the CAMERA PROXEMICS.

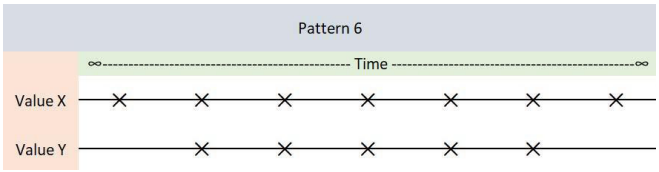
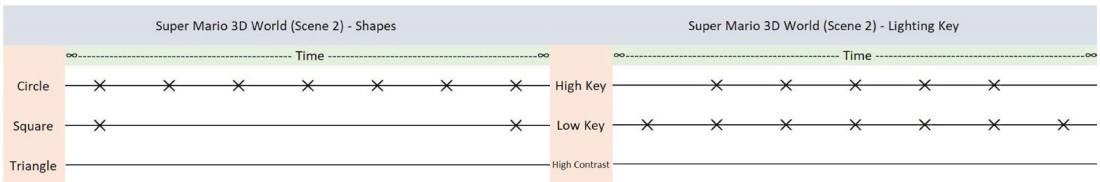


Fig. 17
Representation of Pattern 6.

What happens in Pattern 6 is similar to what we see on Pattern 3, but the variable being analysed consists of three parameters with not mutually exclusive values. There is one parameter that presents a positive value at the beginning or at the end of the scene or solely in the middle when in reverse, creating a pan appearance in the histogram (as observable in Fig. 17). Visually, while this might be recognized as two different patterns, we consider it as one since they are visual inversions of one another. Both occurrences are on the second scene of *Super Mario 3D World* (2013) that we analysed and are linked. What happens there is that whenever there are square-shaped elements in the scene, *high-key lighting* is never present, and when that sort of lighting is present the *square*-shaped elements are not. This happens because the scene consists mostly of a level boss, in which players are introduced to the level in a location where they can be stationary while planning their actions, move to the boss arena in a second stance, and then move onto an area similar to the one in the beginning of the level — where they can rest — and go for the flag that allows them to conclude the level.

Fig. 18a, 18b
Representations of the patterns applied to the examples above.



5.7 OTHER PATTERNS AND RESULTS

Besides the six patterns were able to discover, we found other results we are confident to be of peculiar interest. Many of these are the result of the combination of two or more of the previously designated patterns, e.g. there is a scene in *Earthworm Jim* (1994) in which we observed a break of a pattern's outline midway, for another different result to be momentarily shown, which is similar to what happens in Pattern 3, but with a variable that has non-mutually exclusive results.

We provide some examples of other results in the dissertation, and a complete list of the graphics is annexed to it, but since none of them are repeated through the analysis, none of them can be considered a pattern, and therefore, isn't of consideration in this summary.

6. CONCLUSIONS AND FUTURE WORK

There is no established model that allows us to make a generalized description of the *mediated space* in videogames. Therefore, our study is of critical importance in contemporary game studies. This work not only confirms the need for a *mise-en-jeu*, something already indicated by the research of Girina (2013) and Potier (2014), as it advances our comprehension of it, providing a fundamental basis of framework for its analysis and description, by means of 8 variables we propose. Those variables were built on the foundation of, and proved, the adaptability of film's *mise-en-scène* to the videogame medium's mediated space, with the notion that some aren't applicable to videogames, and that new variables native to videogames are an essential requirement. The variables in our model were tested with case studies of 36 videogames of the platform genre. The case studies showed us that it is possible to use the *mise-en-jeu* framework as a tool for detecting visual design patterns in videogames, and a qualitative analysis of those patterns might result in new knowledge of the mediated space in videogames, since it is a method we didn't apply.

Since at this time we were only able to conduct a particular quantitative research, our results do not directly allow us to evaluate the effect of the mise-en-jeu in player experience. And since we focused our study solely on platform videogames, cannot prove that this framework can is able to describe the *mise-en-jeu* of other genres of videogame, however we see that much of the results we obtained are able to serve such purposes.

Another limitation consists on the fact that we did not involve players other than ourselves, and for that reason the results of the SETTING and HORIZON OF INTENT variables need triangulation, so

that we can eliminate researcher bias,[14] despite our reiteration that this was a postpositivist analysis, allowing for some acceptance of the influence of our previous knowledge on the subject matter.

With this in mind, we propose future research to study other videogame genres, in an attempt to have an overall view of the medium's *mise-en-jeu*. In order to complement that and to build a deeper understanding on the subject matter we will also need qualitative research on the perceived effect that the mise-en-jeu has on player experience. This mixed methodology of quantitative in a first instance, and then qualitative research on the second phase will allow us to more profoundly understand the diversity of the *mise-en-jeu* and its effects on player experience and how to design it.

We didn't address sound, as it isn't certain that it should be part of the *mise-en-jeu*, or a separate field of study. We questioned its place in our framework because in other media, like film and theatre, there is no agreement on sound as part of the *mise-en-scène* nor on its role as part of the diegesis of film (Hackley 2013, 8). It's vital to verify its place on the diegesis of the videogame medium and, consequently, determine whether it can be part of the *mise-en-jeu*, in what terms, and how can it be analysed.

Some variables we believe to be critical in colour studies were left out since they were beyond the scope of our study, due to the working timetable.[15]

It is imperative that upcoming revisions of the framework also triangulate the data of the HORIZON OF INTENT variable, since our analysis doesn't have enough data sources to be valid as a definitive examination of it. Other than our own input, which was based on an empirical observation, future studies must gather data from multiple players and an opinion from videogame designers on what the values of the HORIZON OF INTENT variable might be in any given scene.

Since the HORIZON OF INTENT and SETTING variables cover sepa-

[14] Assumptions about the intended result that are based on our cultural lens and empirical knowledge.

[15] We recommend reading Erik Geslin et al.'s How Color Properties Can Be Used to Elicit Emotions in Video Games (2016) and Doug Stewart's Color in Video Games: How to Choose a Palette (2017), as those texts describe the complexity of the effect of colour on videogame design and player involvement, and we recommend that those hypotheses can be employed as a basis for critical discussion on the subject.

rate methodologic considerations from the other variables, it's likely that their results won't coexist in the same structure without flaws, in its current state, since their mapping method is different, something that has to be considered and resolved in forthcoming research.

We also think that temporal expression as a phenomenon accessible to observation must be resolved, so that the passage of time can also be graphically represented and that the moments of a scene can be properly connected by lines that visually exemplify those temporal processes. This can lead to a better foundation for qualitative research on the topic.

Finally, we've seen that some patterns are present across diverse variables in distinct scenes. Future work must also relate the patterns that are visually equal to different variables, where they're present, and examine why two different variables on the same scene share the same or similar behaviours. We must also understand the dynamics and how the variables guide one other, and ultimately how that shapes players' experience.

REFERENCES

Aarseth, Espen. 2000. "Allegories of Space: The Question of Spatiality in Computer Games." *Cybertext Yearbook 2000*, 152–171.

Anhut, Anjin. 2011. "A Look inside – Evaluating Camera Angles For Immersion." Gamasutra. 2011. https://www.gamasutra.com/blogs/AnjinAnhut/20110410/89304/A_Look_inside__Evaluating_Camera_Angles_For_Immersion.php. Accessed on 23/09/18.

Chang, Yu-Ching, and Chi-Min Hsieh. 2017. "Eye Space: An Analytical Framework for the Screen-Mediated Relationship in Video Games." *Art and Design Review* 05 (01). Scientific Research Publishing:84–101. https://doi.org/10.4236/adr.2017.51007.

DeMaria, Rusel, and Johnny L. Wilson. 2002. *High Score!: The Illustrated History of Electronic Games.* 1st ed. McGraw-Hill/Osborne.

Garcia, Mark. 2009. *Patterns of Architecture*. 1st ed. Wiley.

Geslin, Erik, Laurent Jégou, and Danny Beaudoin. 2016. "How Color Properties Can Be Used to Elicit Emotions in Video Games." *International Journal of Computer Games Technology* 2016 (January). Hindawi:1–9. https://doi.org/10.1155/2016/5182768.

Giannetti, Louis D. 2014. *Understanding Movies*. 14th ed. Pearson.

Girina, Ivan. 2013. "Video Game Mise-En-Scene Remediation of Cinematic Codes in Video Games." In *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 8230 LNCS:45–54. https://doi.org/10.1007/978-3-319-02756-2_5.

Hackley, Chris. 2013. *Marketing in Context: Setting the Scene*. 1st ed. Palgrave Macmillan UK.

Hunicke, Robin, Marc LeBlanc, and Robert Zubek. 2004. "MDA: A Formal Approach to Game Design and Game Research." *Workshop on Challenges in Game AI*, 1–4.

Konzack, Lars. 2002. "Computer Game Criticism: A Method for Computer Game Analysis." *Proceedings of the Computer Games and Digital Culture Conference Tampere*, Finland, 89–100.

Kuhn, Markus, and Johann N. Schmidt. 2014. "Narration in Film." The Living Handbook of Narratology. 2014. http://www.lhn.uni-hamburg.de/article/narration-film-revised-version-uploaded-22-april-2014. Accessed on 23/09/18.

Lefebvre, Henri. 1980. "La présence et l'absence contribution à la théorie des représentations." Casterman. https://philpapers.org/rec/LEFLPE-3. Accessed on 16/10/17.

Logas, Heather, and Daniel Muller. 2005. "Mise-En-Scène Applied to Level Design: Adapting a Holistic Approach to Level Design." *DiGRA 2005 Conference Changing ViewsWorlds in Play*, April. http://summit.sfu.ca/item/190.

Lutwack, Leonard. 1984. *The Role of Place in Literature*. 1st ed. Syracuse University Press.

Manovich, Lev. 2002. *The Language of New Media*. Reprint ed. MIT Press.

Monterescu, Daniel. 2015. *Jaffa Shared and Shattered: Contrived Coexistence in Israel/Palestine*. Cambridge University Press.

Murphy, Sheila C. 2004. "'Live in Your World, Play in Ours': The Spaces of Video Game Identity." *Journal of Visual Culture 3* (2):223–38. https://doi.org/10.1177/1470412904044801.

Nitsche, Michael. 2008. *Video Game Spaces: Image, Play, and Structure in 3D Game Worlds*. 1st ed. MIT Press.

Potier, Victor. 2014. "Mise en jeu de la production aux usages d'un jeu sérieux. Le cas d'une entreprise du secteur du jeu vidéo." *Sciences Du Jeu*, no. 2 (October). Laboratoire Experice. https://doi.org/10.4000/sdj.329.

Ribeiro, João P. S. 2018. "Let's Play the Visual Trail: A Framework for the Analysis of the Mise-En-Jeu." Universidade do Porto. https://repositorio-aberto.up.pt/handle/10216/113412.

Sengün, Sercan. 2015. "Why Do I Fall for the Elf, When I Am No Orc Myself? The Implications of Virtual Avatars in Digital Communication." *Comunicação e Sociedade* 27 (0):181. https://doi.org/10.17231/comsoc.27(2015).2096.

Skolnick, Evan. 2014. *Video Game Storytelling: What Every Developer Needs to Know about Narrative Techniques*. Trade Paperback ed. Ten Speed Press.

Soja, Edward. 1996. "Thirdspace: Journeys to Los Angeles and Other Real-and-Immagined Places." Blackwell.

Solarski, Chris. 2013. "The Aesthetics of Game Art and Game Design." Gamasutra. 2013. http://www.gamasutra.com/view/feature/185676/the_aesthetics_of_game_art_and_.php?print=1. Accessed on 23/09/18.

Stanton, Richard. 2015. *A Brief History of Video Games: From Atari to Virtual Reality*. 1st ed. Hachette UK.

Stewart, Doung. 2017. "Color in Video Games: How to Choose a Palette." Gamasutra. 2017. https://www.gamasutra.com/blogs/DougStewart/20170411/295806/Color_in_Video_Games_How_to_Choose_a_Palette.php. Accessed on 23/09/18.

Upton, Brian. 2015. *The Aesthetic of Play*. 1st ed. The MIT Press.

Winn, Brian M. 2008. "The Design, Play, and Experience Framework." In *Handbook of Research on Effective Electronic Gaming in Education*, 1010–24.

Wolf, Mark J. P. 2001. *The Medium of the Video Game*. 1st ed. University of Texas Press.

Wolf, Mark J. P. 2012. *Encyclopedia of Video Games: The Culture, Technology, and Art of Gaming*. 1st ed. ABC-CLIO/Greenwood.

LUDOGRAPHY

Alex Kidd: The Lost Stars. 1986. Sega.

Banjo-Kazooie. 1998. Rare. Nintendo.

Braid. 2008. Number None.

BurgerTime. 1982. Data East.

Carnival Games: Mini-Golf. 2008. Cat Daddy Games. Global Star Software.

Chuckie Egg. 1983. A&F Software.

Commander Keen in Invasion of the Vorticons. 1990. id Software. Apogee Software.

Crash Bandicoot. 1996. Naughty Dog. Sony Computer Entertainment.

Danganronpa: The Academy of Hope and the High School Students of Despair. 2010. Spike.

Donkey Kong. 1981. Nintendo R&D1. Nintendo.

Donkey Kong 64. 1999. Rare. Nintendo.

Donkey Kong Country. 1994. Rare. Nintendo.

Donkey Kong Jr. 1982. Nintendo R&D1. Nintendo.

Earthworm Jim. 1994. Shiny Entertainment. Interplay Entertainment.

Everybody's Golf 6. 2011. Clap Hanz. Sony Computer Entertainment.

Fez. 2012. Polytron Corporation. Trapdoor.

Ghosts 'n Goblins. 1985. Capcom.

INSIDE. 2016. Playdead.

Jak and Daxter: The Precursor Legacy. 2001. Naughty Dog. Sony Computer Entertainment.

Jet Set Willy. 1984. Software Projects.

LittleBigPlanet. 2008. Media Molecule. Sony Computer Entertainment.

Manic Miner. 1983. Matthew Smith. Bug-Byte.

Mega Man. 1987. Capcom.

Mirror's Edge. 2008. EA DICE. Electronic Arts.

New Super Mario Bros. 2006. Nintendo EAD. Nintendo.

Persona 3: Dancing Moon Night. 2018. P-Studio. Atlus.

Pitfall!. 1982. Activision.

Portal. 2007. Valve Corporation.

Shadow of the Beast. 1989. Reflections Interactive. Psygnosis.

Shin Megami Tensei IV: Final. 2016. Atlus.

Sonic Adventure. 1998. Sonic Team. Sega.
Sonic The Hedgehog. 1991. Sonic Team. Sega.
Space Panic. 1980. Universal.
Spyro the Dragon. 1998. Insomniac Games. Sony Computer Entertainment.
Super Mario 3D World. 2013. Nintendo EAD Tokyo. Nintendo.
Super Mario 64. 1996. Nintendo EAD. Nintendo.
Super Mario Bros. 1985. Nintendo.
Super Mario Galaxy. 2007. Nintendo EAD Tokyo. Nintendo.
Super Mario Sunshine. 2002. Nintendo EAD. Nintendo.
Super Metroid. 1994. Nintendo R&D1. Nintendo.
The 3-D Battles of WorldRunner. 1987. Square.
The Legend of Zelda. 1986. Nintendo R&D4. Nintendo.
The Witcher 3: Wild Hunt. 2015. CD Projekt Red.
Yoshi's Story. 1997. Nintendo EAD. Nintendo.

Development of a Serious Game to Improve the Teaching of Chemistry

HIGOR SOARES,[1] **JORGE AIKES,**[2] **FAUSTO MOURATO**[3]

ABSTRACT

It is very common the lack of interest and focus of the students in the learning process. In chemistry, due the abstraction to understand concepts involving microscopic entities, the disinterest may become more o recurrent if the students don't stay focused and motivated to learn. To motivate and try to make learning fun, we have developed the World of Chemistry, a playful platform, where students test their knowledge of chemistry while exploring a virtual world in order to improve the teaching of chemistry. The platform was tested with 30 volunteers to analyze its motivational and playful impact, which had a great performance and acceptance. It was also possible to analyze the usability of the platform and thus propose improvements.

KEYWORDS

Serious Games;
Learning;
Virtual Reality;
MDA Framework.

[1] Polytechnic Institute of Setúbal, Setúbal, Portugal — utoliveira@live.com

[2] Federal University of Technology - Paraná, Foz do Iguaçu, Brazil — Jorgeaikes@gmail.com

[3] Polytechnic Institute of Setúbal, Setúbal, Portugal — Fausto.mourato@estsetubal.ips.pt

1. INTRODUCTION

Disinterest and attention deficit have great recurrence in school education (Leal *et al*. 2011). This fact can be associate to the poor teaching materials, as appointed by (Laranjeira *et al*. 2009), and agreed by (Aparecida *et al*. 2009), in the diversification of the classes. Many of the chemistry concepts have their explanation based in microscopic entities, requiring focus and attention to simplify this abstraction, a fact that makes learning more susceptible to disinterest (De Quadros *et al*. 2011). As an alternative to encourage students to concentrate and motivate them in the learning process, it has become common to apply playful elements in teaching.

According to (Giasolli *et al*. 2006) immersing a student in a virtual environment with similar characteristics to the real world, allowing the student to test hypotheses and prove that they are true is one of the most effective ways to teach. Applying gamification in a virtual environment, it is possible to transform the frustration of failure into necessary part of gaining knowledge (Lee, and Hammer 2011), a feature that makes Serious Games an interesting alternative to improve teaching in classroom.

Serious Games are a branch of games and can be defined as productive games, which focus on transformations instead of just fun. The transformations can be applied to skills improvement, adaptation to the environment, and with the focus on teaching: the understating of phenomena (Mouaheb *et al*. 2012). Serious Games cover a wide variety of applications. In health, there is *Gameterapia* as example: the practice of physiotherapy using a ludic platform that immerses the participant in a virtual environment, through the use of the Kinect, a motion capture tool; thus, using fun to ease the discomfort of therapy (Alflen *et al.* 2016).

As a free playful solution with motivational aspects, the *World of Chemistry* platform was developed. The main goal of *World of Chemistry* is to provide a knowledge test to be applied in the classroom, in order for the player to review the contents of chemistry learned, and to improve and to diversify the learning process at chemistry classes. The purpose of this paper is to describe the *World of Chemistry* platform, its game design process and how it behaved by means of an initial study.

2. GAME DESIGN

Game Design is a decision-making process that occurs throughout the Game Development. This process is more present in the planning stage, where it is necessary to define and mature the structure of the game. It is important that the Game Design process of a Serious Game respects a transformation context, which in this study is

2.

divided into three aspects:

1. Purpose: Improve the teaching of chemistry by a playful and diversified solution;
2. Approach: A knowledge test of the contents learned previously in the classroom;
3. Contents of Chemistry supported: Isomerism, Structural Theory, Chemical Bonding, and Molecular Geometry.

To support the Game Design process of the *World of Chemistry*, the MDA Framework was applied. This Framework has the purpose to facilitate the design process by understanding the games through three aspects: aesthetics; dynamics; and mechanics. According to (Hunicke *et al.* 2004), the aesthetics are the emotional responses of the player when interacting with the game, the dynamics are the interactions which promote the aesthetics and the mechanics are the components of the game that allow the dynamics. Based on the transformation context, the established aesthetics are:

- Sensibilization: The emotional state of the student is very important in the learning process (Lima *et al.* 2011). In this way, it is proposed that the player be sensitized through a narrative to encourage him to fulfill his goals;
- Immersion: Focus is an important aspect of the flow state (Schell 2013), which is the state responsible to disconnect the player from reality and immersing him in the game (Zichermann *et al*. 2011). To encourage the player to keep his focus and avoid real-world distractions, the platform stimulates a feeling of immersion in the virtual environment;
- Progress: Students performance in testing their knowledge is directly related to their progress on the game. Stimulating the feeling of progress may encourage them to improve their performance in case it is not going well (Werbach *et al.* 2012);
- Danger: It is one of the most common feelings in games. Danger can be considered as a negative motivator due the possibility of stimulating bad feelings as anxiety and frustration due the failure (Chou 2015). However, if stimulated with caution, it can enhance the player's attention;
- Conquest: The feeling that the player is making good progress is an important motivator (Zichermann *et al*. 2011); thus, its aim is to stimulate the player to perform well by achieving defined goals.

Having the aesthetics defined, the Serious Game can be matured by defining the dynamics and so the mechanics. The dynamics and

1. INTRODUCTION

mechanics incorporated to the Serious Games will be explained in the next section as the platform is introduced. Besides MDA, it was defined by Game Design that the test of player's knowledge would be realized by the interaction with challenges through the game experience.

The challenges were defined by using the brainstorming technic in analysis of a set of questions of chemistry contents selected from Brazilian higher education ingress tests. The analyses consisted in refining the similar characteristics between the questions on the same contest and adapting them into regular game challenges. All the Game Design process regarding chemistry concepts were developed with the support of a Chemistry Teacher to guarantee the consistence of the concepts.

The experience of using a Serious Game is characterized as a human-computer interaction and can be analyzed through usability tests (Barbosa *et al*. 2010). All the components developed by the Game Design were tested in two ways. First, in a critical analysis of the usability on a single component by a person involved in the planning process. Second, in the game flow with all the components integrated, which consisted with the participation of two testers without previous contact with the game. After all the detected usability problems were corrected, another usability test of the game flow was realized with the participation of a chemistry teacher involved, in order to guarantee that the game was ready to be applied. After the verdict of the teacher, the game was applied in the initial study.

3. WORLD OF CHEMISTRY

Characterized as a fantastic-themed Serious Game, the *World of Chemistry* is a virtual reality application that stimulates the feeling of immersion by representing the player as an avatar capable of movement (using the arrow keys) and interaction, in a three-dimensional (3D) virtual environment in a first person view (by using the mouse to control the camera) The first person view can be seen in Figure 1. A set of challenges are proposed to the player test his knowledge while participating in an adventure. The platform development utilized Unity 3D, a set of tools that facilitate and abstract the development of games and is distributed to the Windows operating system.

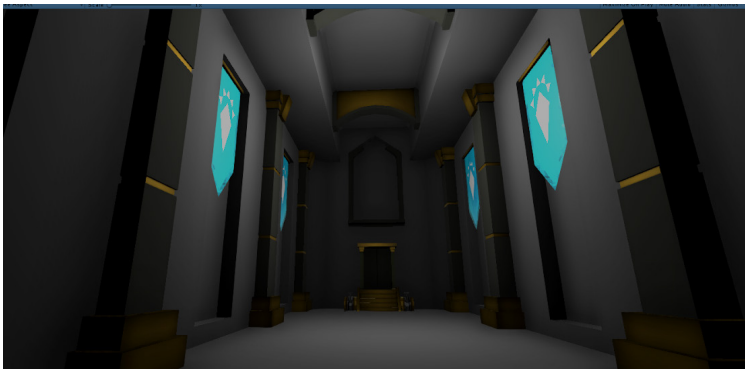


Fig. 1
First person view of the initial level of Lewis Mine phase

The fantastic theme in platform is incorporated by an emotional narrative with the objective of stimulating the sensibilization feeling defined on MDA. The narrative introduces a character which his mother is sick and to heal her, he seeks the help of an alchemist in his village. The alchemist proposes to help him with a healing potion. However, he lacks two ingredients: a carbon and an oxygen atom. Thus, the player must venture into the game to get these two atoms in them respective phases.

Introduced by means of cinematic based in two-dimensional (2D) images, text and song, the narrative is divided in two main parts and two auxiliaries. The first main cinematic is responsible for introducing the narrative and clarifies the main goals of the player: to collect the atoms. The second main cinematic is the closure, which is presented after the player completes his goals. There are also auxiliary cinematic that are presented after the player collects each atom, in order to demonstrate to the player, the conclusion of each goal. Examples of 2D arts used in the cinematic can be seen in Fig. 2 and 3.

The phases were developed in a way that the environment refers the characteristics of their own atom. The first phase is the Mine of Lewis, an excavation mine divided into four levels, each of them is a hall, and the carbon atom, represented by a large diamond, can be collected at the end of the last level. The second phase is Aeris, a flying city divided into three flying platforms, each as a level, connected to the others by teleportation portals, and the oxygen atom is represented by a sphere with wings. The representation of the atoms is just aesthetic, to turn them into notable objects.

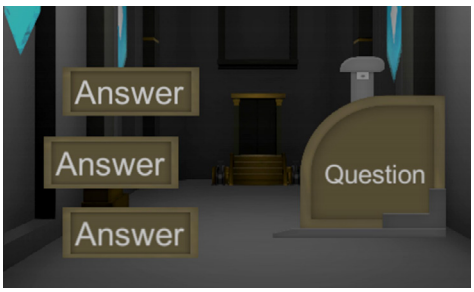
Fig. 2
The alchemist

Fig. 3
The main character and his mother

The challenges proposed in the *World of Chemistry* are based into three structures; the first one is questions and answers. This structure challenges the player, through a custom screen, to answer a question by selecting one of your answers. The custom screen is loaded by interacting with a 3D object which represents the challenge. To solve the challenge in this structure, the player just has to select the correct alternative and confirm.

The challenges of questions and answers have two approaches, one for questions of all the contents of chemistry supported (general approach) and the other just for isomerism (isometric). Each approach presents a different interaction object and screen in order to soften the monotonicity and allow in the isometric approach the use of images, which is an important aspect of the visualization of the chemical components in the questions. The general approach is represented by a Lever, as can be seen in Fig. 4 and 5, and the isometric approach by a display, as in the Fig. 6 and 7.

Fig. 4
Lever approach custom screen.



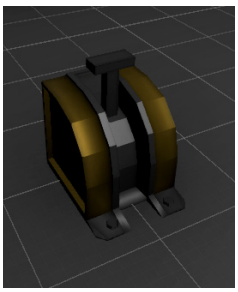


Fig. 5
Lever activator object.

The second challenge structure is fitting, where the idea is the player to catch an object and fit it in a structure denominated totem. The fitting object can be an atom or a 3D structure of chemical compounds. A panel, located above the totem, is responsible for specifying which object must be fitted in the totem, as demonstrated in the Fig. 8. This structure is composed by three approaches:

- Electronegativity: presents a totem and various atoms and the player must select one of the atoms and fit in the totem according to the required electronegativity (low or high);
- Chemical bonds: presents two totems, each one is an atom of a chemical bond and the player must fit the atoms that, based in their electronegativity, generate the required chemistry bond (Ionic or Covalent);
- Molecular Geometry: presenting only one totem, where the player must select the chemical compound in its correct 3D form, based on the Lewis structure presented in the totem's panel. An example of this approach can be seen in the Fig. 8 and 9.

Fig. 6
Isomerism approach custom screen

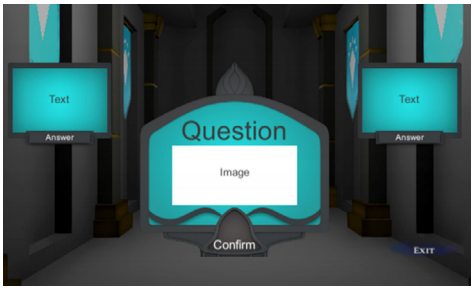


Fig. 7
Isomerism activator object

The last challenge structure is called impact and is based on the idea of target shooting. Using a rune, an object capable of casting a spell, the player must aim the spell on a target and hit it to solve the challenge. Each target is a sphere with a Valence Shell Electron Pair Repulsion (VSEPR) model inside and only one rune is associate to each VSEPR model; thus, only one enchantment will solve each challenge. The runes can be selected by a panel available to the player.

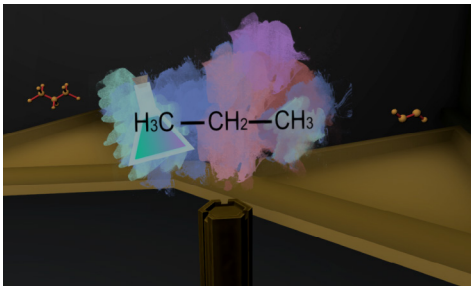
The challenges have their own dynamicity and this it is important in the definition of the sequence of challenges in the phases. The dynamicity is defined by the player's response time from the moment that the challenge is proposed to the moment it is answered; thus, the questions and answers structure is considered not very dynamic, the fitting has medium dynamicity and the impact more

dynamic. The sequence of challenges in *World of Chemistry* was made in order to avoid repetitions of less dynamic challenges and thus, avoiding player to get tired.

To ensure that the challenges are clear to the player, the platform has tutorial screens, which are loaded automatically in the first contact with the challenge. These screens have a brief description of the challenge, the contents of chemistry that the approach supports and how to interact with 3D objects in order to solve the challenge. Also, we have developed tutorials to present the variations of the 3D models of the challenges that can happen from one phase to another, with the intention of notifying that it works in the same way.

All the challenges have a score mechanic applied to stimulate the sense of progress defined on the MDA. The score mechanic works with a base value and a bonus, so regardless of the outcome of the challenge, the player will always receive a score when solving it. The bonus is a value proportional to the number of attempts to solve the challenge: if it is solved on the first attempt, the player will receive the total value, if the number of attempts exceeds a limit, the bonus value is zero. The player's score is displayed throughout his experience by a Heads-Up Display (HUD). By allowing the players test more than one hypothesis in the challenges, besides testing their knowledge, it is possible to earn knowledge by the trial and error (Giasolli et al. 2006).

Fig. 8
Totem de encaixe com a abordagem de Geometria



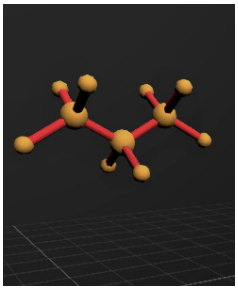


Fig. 9
Objeto de encaixe da Figura 7

The platform proposes fall obstacles and attributes lives to the player to stimulate danger. The fall obstacles are basically precipices as can be seen in the Figure 10, if the player falls; he loses a life and suffers a penalty based on the remaining amount of lives. If the amount is greater than zero, the player will return to the phase in a location where all past challenges have been solved and all ahead

are pending solution. If the amount is equal to zero, the player will be redirected to an end game screen that can restart the phase. The initial number of lives is set to 5 and is presented to the player by a HUD.

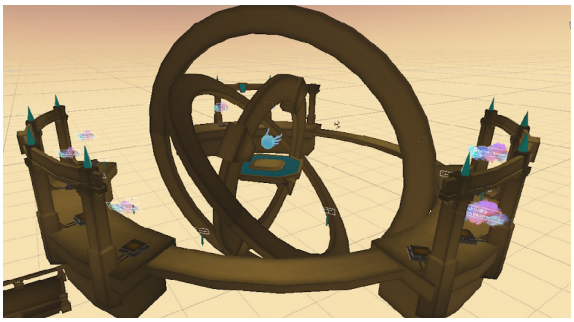


Fig. 10
Fall obstacles of Aeris phase.

The fall obstacles are present in all the game experience in way to define, among other obstacles, the player's route from the beginning to the end of the phase. To overcome the precipices, the player can jump over it if the distance between the platforms of a precipice is short but, if the distance is too long, there is a hidden or broken bridge that turns out or gets fixed by solving the nearest challenges. The other obstacles are closed doors and gates (Fig. 11) that allow the player to proceed on the route by solving challenges.

The conquest feeling is stimulated by the use of badges, which are visual representations of achievements. Each achievement was developed to reward the player for his performance and is defined by the criteria of player's number of lives and failed attempts in challenges. Motivational badges were also developed which are received at the end of each phase regardless of his performance as a motivator to continue playing.

Fig. 11
Gate obstacle blocking player's route.

4. INITIAL STUDY

An initial study to analyze the potential of the platform as a playful test of knowledge was carried out. The study consisted with the participation of 30 volunteers (including 6 teachers) with a mean age of 23 (the oldest participant with 36 years and the youngest with 16). The participants are not exclusively involved in chemistry fields; they include 10 areas of knowledge defined by The Brazilian National Council for Scientific and Technological Development.

The study was mostly performed remotely, and the methods consisted in provide the application on the volunteers' personal computer and let them play the game freely after a general explanation of the study and the basic commands of movement and interaction. After finishing the game, the volunteers were submitted to a form to describe their experience. The form consisted in questions on a scale of 1 (weak) to 5 (strong) about the playful aspects of the experience, the motivational influence of the mechanics and how the platform suits as a knowledge test. The form also allowed the participants comment about their experience.

Throughout the application we have noticed that the volunteers were very interested to participate in the study, of which chemistry students stood out appearing very excited about the idea of a Serious Game as auxiliary tool. Overall, the platform was well approved as a chemistry knowledge test by all of the 30 participants (4 or 5 on the scale), of which only two did not describe the experience as fun (weak influence). These two participants are not from the chemistry field, which may have affected the experience due the difficulty in responding the challenges. However, the other 14 participants that are not from the chemistry field described their experience as fun.

The 3D immersive approach was described as more engaging and divergent from common educational game applications, however, many of the participants reported that the approach did not perform well on their computers and some applications (out of the 30) could not be performed due the computers did not support the applications.

About the motivational effect of the mechanics, the score had a good influence (4 or 5 on the scale) on 80% of the participants, who reported that were motivated to have a better performance in order to get a good score. This motivation can be associated to the familiarity of the volunteer with the test scores in regular education. The badges had influence (more than 3 on the scale) on 70% of the participants, who said felt motivated to obtain exclusive badges. The resource of the narrative presented a positive impact on the game, being approved by 93% of the participants that affirmed

like the resource. Although the narrative motivational effect had a good influence on only 19 participants, that wanted to fulfill the goals in order to help the main character heal his mother. All the players had the goals of the game clarified by the narrative.

The participants reported that the platform allowed them to identify which contents of chemistry they had more difficulties, an important feature for reflect the player's self-knowledge. When questioned if it is interesting to use the game as an evaluation method for the classes, 86% of the volunteers considered the idea interesting, which included all the participating teachers.

5. CONCLUSIONS

Through the results of the initial study, it can be concluded that the platform provided a playful experience to the majority of the participants and the mechanics provided a good motivational influence in a considerable number of participants, which are important aspects of the Serious Game and its transformation. Even based on exclusively contest of chemistry he platform demonstrated a good engagement with participants without much knowledge in chemistry, as they also affirmed had a fun experience.

It has been realized that Serious Games should be developed to guarantee good performance in machines with few resources due the variety of the target audience. If possible, it is preferable to develop an application based on 2D environment to facilitate platform compatibility or a 3D environment optimized as much as possible.

As future improvements, the possibility of integrating external questions to the platform is already being analyzed to allow teachers to customize the game with their own questions; the possibility to generate a report on participant's experience: including questions that are wrong and plots that the player had more difficulty in order to make the platform more precise as an evaluation method of the student's knowledge and at least a menu that allows the player to customize the move and interaction commands as well as a screen to access the challenge tutorials.

REFERENCES

Alflen, R. A., Lima, L. D., Bussador, A., Willemann, L. and Aikes Junior, J. *Desenvolvimento de uma Plataforma para Auxílio na Fisioterapia de Pacientes com Encefalopatia Crônica Não Progressiva da Infância* – ECNPI. Revista Eletrônica Científica Inovação e Tecnologia. 2016.

Aparecida, M. B., Antônio, L. C., Ferreira, L. C., Plucinski, C., Steinbach, G. M., de Sá Júnior, W. F. and Olguin, C. F. A. *Uma Proposta para Trabalhar Reações Orgânicas no Ensino Médio.* Congresso Paranaense de Educação em Química. 2009.

Barbosa, S. D. J., Silva, B. S. *Interação Humano-Computador.* Elsevier Brasil. 2010

Chou, Y. –K. *Actionable Gamification: Beyond Points, Badges and Leaderboards.* Createspace Independent Publishing Platform. 2015

De Quadros, A., da Silva, D. C., Pereira, A. F., Aleme, H. G., Oliveira, R. S. and De Freitas, S. G. *Ensinar e Aprender Química: A Percepção dos Professores de Ensino Médio*. Educar em Revista. 2009.

Giasolli, V., Giasolli, M., Giasolli, R. and Girasoli, A. *Serious Gaming: Teaching Science Using Games*. Microscopy and Microanalysis. 2006.

Hunicke R., Leblanc M., and Zubek R. *MDA: A Formal Approach to Game Design and Game Research*. Workshop on Challenges in Game. 2004.

Laranjeira E. et al. *Dificuldade e Aprendizagem no Ensino de Química*. Congresso Nacional de Educação. 2014.

Leal, S. C., Leal, J. P., Faustino, M. A. F. and Silva, A. M. S.. *A Química Orgânica no Ensino Secundário: A Percepção dos Alunos*. Boletim da Sociedade Portuguesa. 2011.

Lee J., and Hammer J. *Gamification in Education: What, How, Why Bother?.* Academic Exchange Quarterly. 2015.

Lima, E. C., Mariano, D. G., Pavan, F. M., Lima, A. A. and Arçari, D. P *Uso de Jogos Lúdicos como Auxílio para o Ensino de Química*. Revista Científica da UNISEPE. 2011.

Mouaheb, H., Fahli, A., Moussetad, M. and Eljamali, S. T*he Serious Game: What Educational Benefits.* Procedia – Social and Behavioral Sciences. 2012.

Schell J. *The Art of Game Design: A Book of Lenses.* Morgan Kaufmann Publishers. 2013.

Webach, K. and Hunter, D. *For the Win: How Game Thinking Can Revolution Your Business.* Wharton Digital Press. 2012.

Zichermann, G. and Cunningham, C. *Gamification By Design.* John Wiley & Sons Inc. 2011.

Chatting as interface in gaming — case example: *Bury me, my love*

TERHI MARTTILA[1]

ABSTRACT

In the 2010s, several games, interactive fictions and mobile applications have been published which utilise chatting as interface. I briefly present a selection of such games and applications, and finally, analyse *Bury Me, My Love (BMML)* as a specific case example. *BMML* was chosen because the chatting interface creates a procedural representation of the experience of a husband accompanying the path of his beloved wife on a perilous journey out of Syria. My approach is autoethnographic. I claim that *BMML* enriches player experience through the chatting interface, because the act of chatting with a loved one is reproduced within the game quite accurately by resorting to multiple aspects of chatting behaviour. These representations of chatting behaviour are easy to identify with as they echo our own behaviour and experience of chatting with our loved ones. This identification in turn allows us to build deeper empathy with the characters in the story. Empathy with the characters allows for deeper engagement with the story and ultimately, with the games' bitter message about the difficulty of entering fortress Europe. Future work might scrutinise the impact of the chatting interface on player experience in this particular game or others using a more diversified research approach.

KEYWORDS

Chatting Interface;
Games;
Interactive Fiction;
Cybertext.

[1] University of Porto, Porto, Portugal — terhi.marttila@gmail.com

1. INTRODUCTION

Why is chatting interesting as an interface for mobile games? Perhaps because chatting is an integral part of our daily lives in the 2010s. Chatting has been around since the internet emerged, and was present through SMS exchanges, yet mobile messaging apps that send data through the internet, but which identify us through our mobile numbers, have made chatting a pervasive part of our everyday media usage.

In recent years, several games have emerged that utilise chatting as an interface. Some are better categorised as interactive fiction, while others sit more in the domain of the videogame. Some are strictly branching narratives, yet some incorporate variables which affect possible outcomes and system behaviour. The original chatting interface can be attributed to *Eliza* (1966). Some examples of games and apps which use chatting as an interface are *Komrad* (2016), *Event[0]* (2016), *Avery* (2018), *Bury Me, My Love* (2017), and Lifeline (2015). In the past two years, several mobile applications have been created to allow people to read linear stories which unfold as chat messages, for example *Lure* (2017), *Yarn* (2017), *Hooked* (2017), *Tap* (2017) among others. And importantly, *urnd* (2018) which combines text elements with specifically produced multimedia content such as videos, images and audio messages enacted by professional actors. These aforementioned mobile applications are sometimes referred to as *chat* stories.

Historically, the most prominent example of such a conversation exchange with a computer program is Weizenbaum's 1966 Eliza. But what makes chatting interfaces intriguing in the context of digital games and more specifically, in mobile games? How does Aarseths's classic theory of the cybertext and in particular his concepts of user functions shed light on the differences between linear and non-linear, static and dynamic digital narratives? We will briefly survey the domain of digital games and apps which have emerged in recent years which utilise chatting as interface. Finally, we look at the specific case example of Bury Me, My Love, to understand how the chatting interface contributes to immersion into the narrative and consequently, into a deeper connection with the topic of the story and ultimately, with the real-life events on which the story is based.

2. CHATTING AS INTERFACE IN DIGITAL GAMES AND NARRATIVE

Along the history of digital media, Joseph Weizenbaum's *Eliza* continues to be a work of reference in the domain of interactive systems based on chatting. Weizenbaum created *Eliza* in 1966, attempting to proceduralise a rogerian psychotherapist. Weizenbaum was successful enough that some users were momentarily able to

suspend belief, and truly immerse themselves into dialogue with a seemingly human counterpart. This so-called Eliza-effect was mainly achieved due to the fact that although users could communicate with *Eliza* in natural language, Eliza simply picked up on a limited set of keywords. Eliza dealt with user input in a limited manner, mostly placing questions to the user. Thus, *Eliza*'s scope of knowledge was extremely limited. And within this limited scope, *Eliza* was quite fluently able to carry on a conversation (Weizenbaum 1966).

More recently, in 2015, an app called *Lifeline* was published, which allowed for users to follow a branching narrative with a chat interface. The user cannot chat like with *Eliza*, yet the interface looks like a chat. The narratives unfold in real time and the outcome is influenced by user choices. In 2017, several apps were published (*Hooked, Tap, Yarn*, among others), which allow users to tap through narratives which unfold through a chatting interface. The user cannot make any choices and their role is left to passive tapping to allow the next block of text to appear on the screen.

However, the apps are meant to be read on a smartphone and mimic our messaging apps in terms of interface. What is interesting about these apps is the manner in which they appropriate the chatting culture of the 2010s and utilise this context to nest the narratives in. This model has proven to be a success, with teenagers more likely to finish reading a 1,000-word story when presented as a chat story as opposed to a single block of text. *Hooked* creator Prerna Gupta recounts the process of developing their chat story app:

Then we had an off-the-wall idea to test a story written as a text message conversation between the characters. It was 1,000 words, or a five-minute read, the same length as everything else we had tested thus far. The first chat story we tested had staggering results. Almost every teenager who started reading our chat story finished it in one session. (Gupta 2017)

In late 2018 an app called *unrd* was published which sits into the canon of the previous chat story apps yet makes a large jump in terms of the budget of the production. *Unrd* includes original multimedia content such as images, audio messages and even video featuring professional actors. Stories in *Unrd* unfold in real time only and the narratives are linear. Users do not tap to view further messages or content, but rather the content appears on their phone according to the scheduled time. These applications are continuously evolving, with *Hooked* publishing content, which unfolds over days, for Snapchat in late 2018.

In the video game *Komrad*, the player chooses from pre-existing choices or phrases, which in turn influence the outcome of the game. Thus, the game is more like a branching narrative, with eight possible endings. *Komrad* was developed by Brad Becker, a former chief design officer working on IBM's Watson. Watson is a kind of conversational agent which understands natural language (High 2012). In *Komrad*, the player needs to converse with an AI in order to hack it and find out information. According to Becker, the game uses a mix of code and pre-scripted dialogue to simulate real speech (Webster 2016). The narrative thus plays out in dialogue with the AI according to a pre-defined path. Importantly, the player cannot use natural language to interact with the AI, but instead must choose responses from pre-sets. Thus, the interaction unfolds through clicking. As such, *Komrad* follows rather the aesthetics of click-through adventure games. *Komrad* is meant to be used on the mobile phone, hence making reference to chatting and messaging behaviour on mobile phones.

In *Event[0]* according to its creator Sergey Mohov, the player *"will also influence [the AIs] attitude, mood, and emotions and experience the consequences of that throughout the game."* (Webster 2016). Furthermore, *"a core design principle was to be open from the outset of the game that the player was dealing with an AI"* (Cross 2016). This AI is called *Kaizen*. *Kaizen* is responsive to the players input: if the player treats *Kaizen* kindly, *Kaizen* will treat the player kindly. Alternately, if the player is mean and mistrusting with *Kaizen*, *Kaizen* might try to mislead or even kill the player. Thus, *Kaizen* is truly responsive, and the video game takes on cybertextual qualities. These types of qualities for characters I video games were envisioned by videogame theorist Eskelinen in the early 2000s:

competing conversation programs may be allowed to affect both developments and outcomes of narratives, including the behavioural patterns of certain characters and narrators … In that way the attitudes and speech acts of our real world are given their chances to affect the fictive world (Eskelinen 2001, 60).

Avery is an artificial intelligence in love, who has forgotten things about herself. The player must interact with *Avery* and thus help *Avery* uncover the mysterious events of the past. A key starting point in *Avery* is transparency, since we are told that we are speaking with an artificial intelligence agent. Thus, *Avery*'s character is also clearly defined from the outset. Interestingly, and unlike in the other applications and games available at the time of writing this, interaction with *Avery* happens using natural language. This has its benefits, as we feel freer to input whatever we want, sustaining

somewhat the illusion that we might be participating in a relatively unconstrained narrative or domain of play. Naturally, interaction breaks down quite often, as *Avery* is simply unable to process complex input. For example, *Avery* asks for our name, and cannot make sense of the result unless the name is capitalised. Here, the Eliza-effect breaks down to the detriment of player experience and immersion.

Bury Me, My Love (2017) (hereafter referred to as *BMML*) sits between the categories of interactive fiction/branching narrative and video games. *BMML* is a game about a Syrian refugee trying to make their way to Europe. The narrative unfolds through a chat between husband Madj (player character) and wife Nour, who leaves Syria and communicates with Madj on her mobile phone. The game is based on the experiences of Dana, a Syrian refugee, as well as on other true stories. The game is a reality-inspired game or newsgame.

BMML unfolds in real time, although the player can choose a fast playthrough mode as well. *BMML* is above all a branching narrative and it has 19 different endings available. Importantly, the branching of the narrative is not only decided based on actions which the character chooses, but on four distinct variables. The variables are the main character, Nour's, relationship status with her husband (the player character) Majd, Nour's inventory, Nour's money, and Nour's morale. The outcomes are also affected by the advice which the player character Majd gives to Nour. Since the branching of the narrative is influenced by both player choices about which actions the character (Nour) should take, as well as on the four variables which take into account player the behaviour and attitudes towards Nour, on a continuous scale *BMML* would fall somewhat closer to the category of game than branching narrative in comparison to the other examples discussed.

Overall, chatting as interface in gaming and interactive fiction is a relatively recent phenomenon, most likely brought on by the prominence of messaging apps used on mobile phones. The emergence of the interactive fiction apps suggests an evolution in the manner in which we consume narratives inspired by the ongoing Whatsapp and Snapchat era. All in all, the developments of recent year suggest that media which is based on a chatting interface is fertile ground for study.

3. CHATTING INTERFACES AND THE CYBERTEXT

In the domain of digital art, games and narratives, one publication continues to be discussed although it has been published two decades ago: Espen Aarseth's *Cybertext* (1997). What is interesting about the work is that even though the author did not have any

way of knowing what the future of digital technology would bring, he yet managed to envision how interactive technologies could function and more importantly, why the increasing degrees of interactivity would make such technologies a point of fascination for humans. We will take a look at some of the theories discussed, and then examine how these theories are expressed in practice in the works introduced above and in our case example *Bury Me, My Love.*

Espen Aarseth initially wrote his seminal book titled *Cybertext* in 1997, but like most visionary endeavours, one might wait for decades before such visions and musings for the future can even begin to take shape due to technology constraints. Yet in 2018 we see many of Aarseth's musings becoming reality. Importantly, Aarseth's starting point for developing *Cybertext* lies in the observation that:

> a search for traditional literary values in texts that are neither intended nor structured as literature will only obscure the unique aspects of these texts and transform a formal investigation into an apologetic crusade. (Aarseth 1997, 22)

For example, to analyse *BMML* as literature would undoubtedly leave it appearing rather bleak by comparison to other works of equal length, despite the fact that *BMML* contains 110,000 words, the same number of words as J.K. Rowlings's *Prisoner of Azkaban* (Corbinais 2018).

The manner in which Aarseth distinguishes static and dynamic texts from each other according to various levels of user function is still highly applicable today and provides an interesting lens for understanding why some media is experienced as more engaging or immersive than other media. Importantly, we try to understand how the inclusion of various user functions could affect the player experience and immersion.

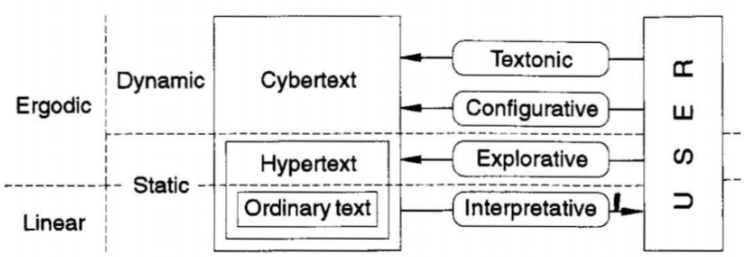


Fig. 1
User Functions and Their Relation to Other Concepts (Aarseth 1997,64)

In Fig. 1 above we observe the defining characteristics of a cybertext: besides the interpretative and explorative user functions, the user is able to influence the textonic and configurative aspects of the

text. The interpretative user function means that the user interprets the contents of the ordinary text. The explorative user function means that the user explores various branches of the branching narrative or hypertext. In the case of the ordinary text, the text content is static and reading of it progresses in a linear manner. In the case of the hypertext, the text content is still static, however, reading of the text is no longer linear. Aarseth calls texts which allow for non-linear reading ergodic. The configurative and textonic user functions are rather more complicated, implying not only an ergodic (non-linear) reading, but also a dynamic text content. Here, two levels of dynamic content are defined: through *"the configurative function, in which scriptons are in part chosen or created by the user"* (Aarseth 1997, 62), where the user chooses or inputs content ("*scriptons*") which becomes integrated into the reading, or even textonic:" *if textons or traversal functions can be (permanently) added to the text, the user function is textonic*"(Aarseth 1997, 62). In clarification, Aarseth recounts what he means by textons and scriptons:

It is useful to distinguish between strings as they appear to readers and strings as they exist in the text, since these may not always be the same. For want of better terms, I call the former scriptons and the latter textons ... In addition to textons and scriptons, a text consists of what I call a traversal function - the mechanism by which scriptons are revealed or generated from textons and presented to the user of the text." (Aarseth 1997, 62)

Scriptons are thus text as it appears to the user, and textons are the text or strings which appear in the code of the digital piece. Moreover, cybertexts are dynamic, and in order to define these dynamics, the cybertext must contain rules for how to process the textons in order to reveal them as scriptons to the users. These rules Aarseth calls traversal functions.

Here Aarseth's terms scripton and texton are rather misleading given the use of similar terms and language from today's computer sciences. In computer sciences, we understand a script as a bit of code which gives instructions for processing data in a particular way. Aarseth calls these types of programmed instructions *"traversal function — the mechanism by which scriptons are revealed or generated from textons and presented to the user of the text"* (Aarseth 1997, 62). In other words, textons are bits of code which traversal functions process to reveal text, or scriptons, to the user. With reference to, for example, javascript as code embedded in html documents, it would make more sense to refer to processes as traversal functions, to code as scriptons, and to vari-

ous items of text which are actually displayed as it is written (prose, sentences etc.) as textons. Nevermind this confusion of terminology, Aarseth's original categorisation is interesting and ever more relevant in today's landscape of digital narratives and games.

In particular Aarseth's categorisation raises the issue of what is a digital, dynamic, ergodic narrative which allows for textonic user function? Do any of the case examples discussed earlier exhibit properties of this sort? Let's remember that the textonic user function would allow users to in fact tweak the textons permanently — the elements of code which guide the configuration of current and future readings of the cybertext. This would imply that a user could program the behaviour of, for example, characters of a narrative or in fact program the sequence of events which the narrative could take. In fact, none of the examples discussed earlier reach this level of user function. The implementation of textonic user function is not straightforward since it is difficult to design dynamic, digital narratives which allow for such randomness, since an excess of textonic user function may result in excess randomness which in turn may render a narrative rather meaningless.

In the examples addressed earlier, the closest we come to the essence of the cybertext is with *Avery*, which allows users to input. The chatstory apps allow for users to create their own stories and to share these with others. *Avery* allows for natural language input, which is then at times displayed back to the user, meaning that *Avery* allows for a configurative user function, allowing for manipulation of scriptons. Other branching narrative games or fictions, such as *BMML*, allow also for this configurative user function, albeit by choosing from a list of predefined possibilities. Nevertheless, the chosen possibility becomes part of the reading of the text.

If we read our real-life chatting behaviour with a loved one as cybertextual, we will see that both configurative and textonic user functions are present. Real-life chatting is configurative in the sense that our loved one might ask us to choose where to have lunch, what to bring home for dinner, etc. In answering, we indeed choose or alter the scriptons, and also the course of events. These scriptons become integrated into future chat messages, as our counterpart might refer to the name of the restaurant, we chose a few messages further on. If we simply say "yes, let's go for lunch" and then proceed for the lunch, our user function might be considered explorative rather than configurative.

Now, if we suggested another course of events entirely, which led to an elaborate plan of food shopping and a picnic in a nearby park, we might be touching upon the textonic user function, in which the

plan (or transversal function), written by our beloved to go out for lunch, was altered to contain subprograms which were not originally conceived by them, altering the structure and contents of the narrative. And of course, real-life chatting shouldn't and can't be read as a cybertext, since it is real-life behaviour and not media.

Madj is able to choose from various things to say to Nour (scriptons). Importantly, these scriptons alter Nour's four variables, which in turn alter the outcome. Thus, the user function is **not only explorative**. User function is *configurative*. (User function would be *explorative* if Nour's four variables had no influence on possible paths to take.). There is no evidence of *textonic* user function in *BMML*, as we are at no point able to input natural language (scriptons), nor input functions (transversal functions) which would reconfigure existing textons into scriptons.

Immersion and engagement with *BMML* might in part be explained by the fact that *BMML* allows for configurative user function: we realise that we can influence the outcome both with our attitudes towards Nour as well as what we tell her to do as opposed to just clicking the story through (explorative user function). More importantly, immersion and engagement in *BMML* might result from the fact that the configurative user function as well as the patterns of chatting behaviour are modelled true to reality when comparing to our real-life chats to our loved a ones. We might also ask whether immersion and engagement in chatting-based media might be enhanced if it also allowed for textonic user function, since textonic user function translates into the agency we experience in our real-life chats and interactions with real people.

3. CHATTING AS INTERFACE IN *BURY ME, MY LOVE*

I will focus my discussion on the analysis of player experience in *Bury Me, My Love (BMML)*. My approach is auto ethnographic and I analyse my own playing experience of chatting in *BMML*, drawing parallels to my real-world experience of chatting to my loved ones to understand how the two experiences combine to produce immersion and engagement in *BMML*. In addition to my personal experience of playing the game I refer to interviews with the game designers to elucidate some of the motives behind game design decisions, as well as to accounts by game critics who describe their experience of playing the game. My research question is:

> **RQ: How does the chatting interface in particular contribute to player experience and immersion?**

I argue that the procedural mechanics of chatting in *BMML* are responsible for a major component of the overall immersion and ensu-

ing engagement and emotional effect which the game produces. *BMML* represents the journey of Nour through her chats with her husband Madj, who stays behind in Syria. Thus, the game serves as a truly procedural representation of the real-world experience which refugees face. Maurin states, "*Bury Me, My Love is designed to mimic the way migrants use messaging apps*" (Maurin 2018c). Importantly, we as the player character Madj experience the hopelessness of not being able to help Nour more than through the messages we send. Nour is far away and all we can do is keep in touch, give advice and maybe google some more information. Thus, we experience first-hand the inability and lack of agency which those who stay behind feel when accompanying from far away the trajectories of their loved ones.

4.1 OBSERVATIONS ABOUT CHATTING IN MY LIFE AND IN *BMML*

Over the course of a few days, and reflecting on past experiences, I first asked myself, what are the particular characteristics of chatting with my loved one and how do I act out these chats in my everyday life? I then observed the characteristics of chatting behaviour in *BMML*, asking, in what types of situations do Nour and Madj interact, what types of information do they exchange and how does Nour involve Madj in her journey through the messaging application. See these characteristics outlined below in Table 1.

Table 1
Observations related to chatting behaviour in my life and BMML

CHATTING IN MY LIFE AS:	CHATTING IN BMML AS:
... implies that we are separated momentarily	... keeping in touch with your loved one
... These chats are private	... social contact when sorrounded by strangers
... Time spent waiting for them to respond...	... waiting for Nour to respond
... Being worried about them (are they ok?)	... asking for help (googling information)
... Humor	... asking for a second opinion on what to do
... Sending icons, smileys, hearts, etc...	... moral support in time of crisis
... Jokes, inside jokes	... sharing news, sharing events that happen
... Little fights, big fights	... ultimately, a lifeline through the perilous journey
... Sending photos	
... moral support	
... updating on events	

4.2 ELEMENTS OF REAL-LIFE CHATTING BEHAVIOUR IN *BMML*

Humour is expressed in nearly aleatoric situations, where the characters allow a small typo to evolve into a humorous exchange. We follow the humorous exchange as it unfolds in real-time. This is much like what might happen and has happened spontaneously in a chat with my loved ones. Sending photos is an integral aspect of the exchanges between Nour and Madj. *BMML* comes with digitally drawn images that mimic mobile phone shots of events on the street or selfies with icons added to them. For example, Nour takes an image of herself while waiting at the bus stop.

Nour and Madj send each other icons, hearts, smileys, etc. throughout the game. Oftentimes, the player character Madj is given the option to choose from various icons instead of a textual message. Indeed, the three emoticons available (eg. shocked, sad or overwhelmed face) might all denote more or less the same thing and have no great influence on the course of the game, yet we leave the exchange with a sensation that we have been allowed to make a minute choice about which colour of emotion we feel at that moment. Furthermore, reacting to a message with only an emoticon is rather a common pattern of behaviour in our real-life chats.

The couple reminisces about the past and shared memories. As Nour passes through a city which has been bombed, she shares a photo of the bombed city with Madj, recalling the time that they visited that place together. Their exchange unfolds in shared disbelief of how much damage the war has done to familiar places. I am reminded of my own trips with my loved ones, imagining what it would be like if the scenery of our holiday photos was all of a sudden translated into a warzone. Also, the chat between Nour and Madj is strictly private. For example, Nour sends Madj a photo of herself tucking cash into her bra, an image which she would surely not share in a group chat.

Madj spends time waiting for Nour to reply. If we play in the pseudo real-time mode, we need to wait minutes, hours and sometimes days until we hear back from Nour again. Game creator Florent Maurin states in interview with Priestman: *“one of the techniques used to do this is ‘pseudo real-time’ texting, borrowed from the 2015 game Lifeline… [if] you tell Nour to wait at a closed border for two hours to see if it opens, you won’t hear from her again for two real-world hours“* (Priestman 2017). Furthermore, in interview with Robertson, Maurin states that this *“waiting isn’t something you can do in a book or movie”* (Robertson 2017).

As Madj, we worry about Nour. Having to wait for replies puts a sense of anticipation in the player. Indeed, Madj is often waiting for Nour to come back online again, knowing that she is in a tricky situation

which might turn out very bad in the end. Sometimes we must wait for a very long time until we hear news from Nour again. At times it is good news, at other times it is not. As we wait, we imagine all the possible things that could be happening to Nour meanwhile. As a game reviewer Chan puts it: *"when Nour stops texting you, tucked safely in your cozy bed with a roof over your head, you'll find yourself wondering if she's alright"* (Chan 2017).

4. CONCLUSIONS

This case study has shown that *Bury Me, My Love* successfully creates a procedural representation of the experience of a person who accompanies the perilous journey of their loved one on a journey out of Syria via a messaging app. According to Aarseths' theory of the cybertext, the levels of user function in *BMML* are the interpretative, the explorative and the configurative user function. The procedural representation of the migrants' journey is created in particular through the reproduction of patterns of chatting which are familiar to us from everyday life. Immersion is built through recreating many of these dynamics of real-life chatting practice relatively accurately, but also through the incorporation of the configurative user function.

5. FUTURE WORK

In this case study, we looked at how the act of chatting and chatting as interface contributes to the player experience of the game *Bury Me, My Love. BMML* could in fact be analysed from a multitude of perspectives, as a news game or persuasive game about an ethically pressing issue. We analysed *BMML* using an auto ethnographic approach. We might diversify our research approach to include other methodologies targeting questions related to chatting as interface within *BMML*. Alternately, we could analyse a different game in order to build a deeper qualitative understanding of chatting as interface in games in general.

ACKNOWLEDGEMENTS

This work was developed under the supervision of Professors Dr. Patrícia Gouveia (FBAUL) and Dr. Diamantino Freitas (FEUP). This work was financially supported by Operation NORTE-08-5369-FSE-000049 co funded by the European Social Fund (FSE) through NORTE 2020 - Programa Operacional Regional do NORTE.

REFERENCES

Aarseth, Espen. *Cybertext - Perspectives on Ergodic Literature*. Baltimore: John Hopkins University Press, 1997.

Corbnais, Pierre. Bury Me, My Love: tips for writing a game that feels real. Blogpost published on *Gamasutra*. Available at: https://www.gamasutra.com/blogs/PierreCorbinais/20180205/314272/Bury_Me_My_Love_tips_for_writing_a_game_that_feels_real.php, 2018.

Cross, Katherine. Making a chatbot that drives a narrative in sci¬fi exploration game Event[0], Article published in *Gamasutra - The Art and Business of Making Games*, Available at: https://www.gamasutra.com/view/news/281842/Making_a_chatbot_that_drives_a_narrative_in_scifi_exploration_game_Event0.php, 2016.

Eskelinen, Markku. Introduction to Cybertext Narratology. In Cybertext Yearbook 2000. Jyväskylä: University of Jyväskylä. 52 - 68. Available at: http://cybertext.hum.jyu.fi/articles/123.pdf, 2001.

Gupta, Prerna. How We Got 10 Million Teens to Read Fiction on Their Phones - The story of Hooked. In *Medium*. Available at: https://medium.com/@prernagupta/how-we-got-10-million-teens-to-read-fiction-on-their-phones-19a2a475084c, 2017.

High, Rob. The Era of Cognitive Systems: An Inside Look at IBM Watson and How it Works. Available at: https://developer.ibm.com/watson/wp-content/uploads/sites/19/2013/11/The-Era-of-Cognitive-Systems-An-Inside-Look-at-IBM-Watson-and-How-it-Works1.pdf, 2012.

Priestman, Chris. A Game About Syrian Refugees and WhatsApp. Article published on *Waypoint*. Available at: https://waypoint.vice.com/en_us/article/kbm4y3/a-game-about-syrian-refugees-and-whatsapp, 2017.

Robertson, Andy. 'Bury Me, My Love' Is A Video Game That Will Change What You Think Of Migrants. In *Forbes*. Available at https://www.forbes.com/sites/andyrobertson/2017/12/07/bury-me-my-love-is-a-video-game-that-will-change-what-you-think-of-migrants/#67d6b9f5bb3a,2017.

Webster, Andrew. In these games starring AI bots, chatting is the new shooting - KOMRAD and Event[0] are games you can talk to. Published in *The Verge*. Available at: https://www.theverge.com/2016/9/14/12905356/komrad-evento-chatbot-games-preview-conversation-ai-personality, 2016.

Weizenbaum, Joseph. ELIZA - a computer program for the study of natural language communication between man and machine. *Communications of the ACM*, 9(1). 36-45, 1966.

OTHER REFERENCES

Campbell, Colin. Bury Me, My Love tracks life for a Syrian refugee - New game focuses on emotional cost and strain on relationships. In *Polygon*. Available at: https://www.polygon.com/2017/3/29/15116188/bury-me-my-love-syrian-refugee-game, 2017.

Chan, Stephanie. Bury Me, My Love review — an intensely personal look at the journeys of Syrian refugees. In *VentureBeat*. Available at: https://venturebeat.com/2017/10/26/bury-me-my-love-review/, 2017.

Gach, Ethan. Bury Me, My Love Tells A Moving Story With Text Messages. In *Kotaku*. Available at: https://kotaku.com/bury-me-my-love-tells-a-mov-

ing-story-with-text-message-1820228225, 2017.

Landsteiner, Norbert. *Talking ELIZA*. Available at: http://www.masswerk.at/eliza/, 2013.

Gabriel, Sonja. The Potential of Serious Digital Games for Human Rights Education. In *Proceedings of Play2Learn 2018* edited by Kathleen Tyner and Conceição Costa. 52 - 66. Available at: http://gamilearning.ulusofona.pt/wp-content/uploads/full_P2L_Proceedings.pdf, 2018.

Maurin, Florent. What reality-inspired games are. Blogpost on the website of *The Pixel Hunt* -company website. Available at: https://www.thepixelhunt.com/blog_en/what-reality-inspired-games-are, 2018a.

Maurin, Florent. The Emotional Rollercoasterride of making a videogame. Blogpost on the website of *The Pixel Hunt* -company website. Available at: https://www.thepixelhunt.com/blog_en/the-emotional-rollercoaster-of-making-a-video-game, 2018b.

Maurin, Florent. Exploring Helplessness in games with Bury Me, My Love. Presentation at *GDC 2018*. Slides available at: https://gdcvault.com/play/mediaProxy.php?sid=1025422, 2018c.

Murray, Janet H. *Hamlet on the Holodeck: The Future of Narrative in Cyberspace*. Cambridge, MA: The MIT Press, 1997. 2017.

Taylor, Haydn. Bury me, my Love: Using video games to push back far-right rhetoric. In *GamesIndustry.biz*. Available at: https://www.gamesindustry.biz/articles/2017-11-14-bury-me-my-love-using-video-games-to-push-back-far-right-rhetoric, 2017.

GAME REFERENCES

Avery by MixedBag. Available at: http://mixedbag.it/portfolio/avery/, 2018.

Bury Me, My Love by Playdius. Available at: http://www.burymemylove.com/, 2017.

E.L.I.Z.A. Talking by Norbert Landsteiner/Joseph Weizenbaum. Available at: https://www.masswerk.at/eliza/, 2013/1966

Event[0] by Ocelot Society. Available at: https://store.steampowered.com/app/470260/Event0/, 2016.

Hooked by Telepathic. Available at: https://play.google.com/store/apps/details?id=tv.telepathic.hooked&hl=en, 2017.

Komrad by Sentient Play. Available at: https://itunes.apple.com/pt/app/komrad/id1020876671?mt=8/, 2016.

Tap by Wattpadd. Available at: https://play.google.com/store/apps/details?id=com.wattpad.tap, 2017.

Unrd by UNRD Ltd. Available at. https://play.google.com/store/apps/details?id=com.foolsandgeniuses.unrd, 2018.

Yarn by Science Mobile LCC. Available at: https://play.google.com/store/apps/details?id=com.science.yarnapp, 2017.

Music, interaction and *cinematicability*: between *Bound* and *Abzû*

JOANA FREITAS[1]

ABSTRACT

Videogames, being an audio-visual media which makes use of presentation and visual techniques mainly linked to cinema, are distinguished due to their focus on interactivity and the relationship between media and user. Interaction is key not only for the image itself but for the music that accompanies it. And the soundtrack of a videogame only *exists* if there's an agent that controls the universe, allowing its audition and perception. However, it's possible to note the convergence between videogames and visual characteristics of films regarding image and what's present on the screen in the last decade of the mainstream overview – videogames aim to be, in a growing rate, more *cinematic*. The absence, or reduction of informative elements in the screen, the increased development of graphic quality and design, alongside the notion of spatiality and open environments, are being frequently integrated and invested in by not only big companies but also independent studios. Through two case studies — *Bound* (Plastic Studios 2016) and *Abzû* (Giant Squid 2016)—, this paper examines the role of cinematicability and its use as a narrative tool where music builds an ergodic process of communication, meaning and interactivity. The soundtrack, game mechanics and the cinematic compose an interactive musical experience where the user is, at the same time, the interactive and performative agent in the narrative universe.

KEYWORDS

Soundtrack;
Cinematic;
Interactivity;
Narrative.

[1] CESEM – NOVA FCSH, Lisboa, Portugal — joanareisfreitas@fcsh.unl.pt

1. INTRODUCTION

God of War 4, an exclusive PS4 videogame launched in April 2018, received excellent reviews, critics and scores. Already being considered not only the best *God of War* game of the franchise but "(...) one of the most beloved (...)"videogames in the last decades (Plante 2018). In an online review in *The Guardian*, the author points out the visual mechanics of the game and its cinematic aspect:

> The game is one continuous shot, with no interruptions; irritating necessities such as loading screens are hidden so effectively that you barely realise they are there. This cinematic commitment to Kratos' point of view enhances the story's efforts to humanise him. (MacDonald 2018)

The interruptions like loading screens (and probably the author also thought about the cutscenes) — considered *irritating* — are totally disguised throughout the visual and narrative arc in *God of War*, thus following the main character, Kratos, in the sense of, as Macdonald puts it, *cinematic commitment*, which aims to humanize him (in an emotional and affectionate way). I find this remark quite curious — the development of technology for videogames has allowed to reduce loading screens' time, avoid interruptions in the gameplay flow and improve cutscenes quality and depth; however, *God of War 4* goes so far to try and give the illusion of a continuous action, crossing direct interactions of the player and more passive moments, such as dialogues. If cutscenes are, in essence, a narrative tool for this medium, and if *God of War 4* presents a more narrative-oriented gameplay, how are these mechanics renegotiated and actually improve the entire experience?

I believe that, in the last 7 years, the growing proximity and usage (and consequent transformation) by videogames of the *cinematic* idea is based not on the appropriation of the term by this medium and its techniques similar to films, but in cinema itself, on a visual and design levels. That is, videogames which employ an interactive audio-visual apparatus which is, in essence, clean: a minimal or no interface, no external information (such as map, objectives, HP, orientation guide, etc.), development of graphics quality and design, and new visual perspectives that, sometimes (and at a flourishing rate), are similar to a camera that limits our own interaction, *forcing* the player to look or focus at a certain aspect (but never fully removing his control of the gameplay). At the same time, videogame music is being a target of more and more attention. Shifting the development focus in this industry for the production and investment in this area, resulting in carefully designed soundtracks with more resources, sound quality and more possibilities of composing and recording (Kamp, Summers, and Sweeney 2016). The

convergence between the cinematic dominance referred to before and this soundtrack paradigm result, in my view, in *cinematicability*, an audio-visual framework which transforms videogames in an interactive musical experience, where music is key in defining and maintaining the continuity that these games aim to achieve. In an ergodic communicational process, music is one of the semiotic forces working in the renegotiation of meaning by the player, reinforcing and deepening his gameplay.

It's important to note, however, that this framework does not apply to all videogame genres; this cinematic shift can be observed in, primarily, narrative-based games, walking simulators, storytelling, exploration and other similar tags, both from mainstream and indie studios. Being an initial and ongoing research, still in an exploratory and reflection stage, my aim in the context of this paper is to examine and discuss two case studies with the mentioned characteristics, *Bound* and *Abzû*, both from two indie studios that I believe are clear examples of how *cinematicability* is applied in them.

1.1 ON CINEMATICS

It's important to consider how the term *cinematic* is applied in videogames and how it's usage and development created its own set of characteristics. In a general sense, cinematic is directly linked to cinema — from the medium itself to the employment and borrowing of certain techniques and tools (McDonald 2016). In videogames, Karen Collins notes that "[G]ames often contain what are called *cinematics, full motion video (FMV)*, or *noninteractive sequences*, which are linear animated clips inside the game in which the player has no control or participation" (Collins 2008). It is possible to verify more than one term for this type of audio-visual sequences in this medium, such as: *in-game cinematic; in-game movie;* or *cutscene*, the most common one. As Hooper claims,

> (...) a commonly encountered definition is that cutscenes—also referred to as 'cinematics' or 'in game movies'—are pre-determined/pre-scripted audio-visual sequences which do not involve direct player intervention - or which, as Sicart puts it, are 'devoid of any procedural agency' (2012, p. 120). (Hooper 2018, 115)

The usage of this resource has as a main objective the narrative development in a videogame through the edit, or cut of that same arc — cutscenes are, essentially, cut scenes (Zagalo 2009). Despite the medium in which this tool is discussed about, the terms mentioned are used for the same purpose. In fact, on the one hand, cinematic either applies to the cinematic aspects that define an audio-visual sequence, or the sequence itself. Cutscene, on the other hand, is always associated to the non-interactive scenes. While some

terms can be used with different perspectives[2] (Collins 2008; Genvo 2008) or Hancock (2002), it's possible to conclude that the most important aspect to notice in the different terminologies in videogames studies is the crucial differences between the active gameplay moments and its *interruptions* — or bridges — through three synonyms: film sequences; cinematics; or cutscenes.

The distinction between active gameplay, that is, the direct participation and control of the player in the narrative action of a videogame, combined with the cutscenes, question the role of interactivity in the context of their use and presentation. As King and Kryzwinska claim, the use of cinematics is one of the most obvious links between cinema and videogames, where in this type of sequences used in many titles the player generally assumes a closer role as an independent observer than in cases of active periods of gameplay (King and Kryzwinska 2002). The opposition between the experiences offered by the two formats is often formulated in a very simplistic way — according to both authors, "[I]t is easy to set up an opposition between game-playing and film-viewing that falls into an overly simplistic distinction between ' interactivity 'or' activity ', on the one hand (games), and' passivity 'on the other (cinema)." (ibid. 2002).

One relevant aspect to briefly mention in relation to cutscenes is precisely its increasing development and integration in videogames. At a growing rate, this medium integrates in its story arc that limit the direct interaction of the player, betting on the development of the narrative, characters and emotional involvement. The significant presence of cutscenes can be observed, for example, in the case of *Metal Gear Solid IV: Guns of Patriots* (Kojima Productions 2014) that broke two records concerning its usage in the *Guiness World Records*: the greater cutscene between two moments of active gameplay lasted 27 minutes; and the largest sequence of cinematics (71 minutes) developed for a videogame (Series Achievements 2017). The recurrence of this audio-visual strategy is perceived by some users as excessive, and even negative, being a factor that eliminates the interactive component that characterizes this format. There are

[2] In the Portuguese academical field, see Gouveia (2010), Filipe (2016), Luz (2009) and Zagalo (2002, 2012).

even discussions and entries in videogame forums about the "hatred" regarding the cinematics and their unimportance: "The main reason I do not like cutscenes personally, is because it ignores the main 'advantage' of video games as a medium has over other art forms. Namely, interactivity. "(JasonpressX 2013). The reference to this type of resource as a "mixed bag of interactivity and cinematics" in the article by Melissa Loomis (2015), which seeks to verify what kind of cinematics is more efficient not to overlap player interactivity with the action of "mere observation" is not the only one, thus revealing a critical position on the part of players and authors regarding this narrative device.

This discussion is not one of the main topics in the context of this paper. It is, however, important and valid for the analysis and discussion of key components in videogames. In my point of view, cinematics is a valuable and important audio-visual strategy for the action of certain videogames. Particularly, if its embedded in narrative-oriented genres. Cinematics are the result of an increased investment of the development studios in this format in order to transmit narratives and expand the roster of interactive tools between the player and action. In fact, there are few video games that do not allow skipping the visualization of cutscenes; most titles that include them introduce the possibility of pressing a certain key to advance with the segments and move on to the following moment of active gameplay.

In addition to the narrative, interactive and emotional aspects that characterize the cutscenes, they also allow the development, or the introduction of new musical material that either characterizes the narrative moment in action, or the general arc. Working alongside with the roles that the soundtrack can play during active gameplay, cutscenes are also an audio-visual enhancement of music itself and how it can define environments, space, time or characters. Thus formulating a relationship of reinforcement and complement between non-diegetic music in non-interactive segments and active gameplay.

In the context of this paper and the two videogames in analysis, it's possible to observe the dilution of the barrier between non-interactive and active moments of the gameplay, creating the sense of full continuity and control, which, besides the visual mechanics employed, music plays an undeniable part in reinforcing this consistency. Thus, as it will be discussed, *Bound* and *Abzû* simultaneously define and employ *cinematicability* as the conceptual base of their gameplay, aiming to remove the gap between what's interactive or not through camera and music.

BOUND: MUSIC AND DANCE BETWEEN THE REAL AND IMAGINED

Bound, developed by Plastic Studios and launched in 2016 exclusively for PlayStation 4, appears to be, according to the trailers[3], a 3D platform videogame in which the protagonist, a woman (the Princess), moves only through dance, blending ballet with contemporary elements.[4] The narrative is based on the order that the Queen — the main character's mother —, gives her when she states that she has to save the kingdom because a monster is threatening to destroy it. The player, controlling the Princess, traverses the various levels of this world through jumping, running and dancing for exploration and defence, while at the same time understanding the main objectives of the story. In fact, the trailers do not give any other information about this videogame without being in this abstract world, geometric and spatially infinite; it is necessary to play, just like in any videogame, to understand the system. The first minutes of *Bound* present the first narrative component and the first musical element: a pregnant woman, only carrying a book, who remains alone on the beach, accompanied non-diegetically by solo piano with a short melodic motif.

Fig. 1
Two examples can be visualized and *played* in *Bound*. The elements present in each illustration are a reference to one of the woman's memories and that integrate each section of the alternate/danced world.

[3] https://www.youtube.com/watch?v=aE37l6RvF-c

[4] It is recommended the visualization of the audiovisual excerpts – accessed through the hyperlinks – while reading this paper in order to ease the understanding of the descriptive and analytical sections of both videogames and any other elements referred to. These excerpts will also be accessible in the final references section.

This sequence[5] will begin the narrative in the alternate world, the geometric space, abstract, luminous and infinite, where the player controls the Princess that moves exclusively through dance steps and movements. It is necessary to spend the first moment of danced play and return to the beach to understand that this woman's book contains the various moments that will be played in the alternative (danced) world. Each page contains illustrations by the woman (as a child) with graphic elements that can be visualized during the gameplay in the alternative world. At the end of each level, the player unlocks a memory of this child — always containing the parents in different situations, usually of discussions, tension, nervousness and anger. The narrative course culminates in the separation of the parents of this woman, still a child, where the father leaves home.

This video game is, essentially, linear. It is possible to choose the order of the diary drawings and to experience the different levels of memory in the danced world; however, in this universe, the only option is to follow the paths that are being built as the player progresses using *Bound's* available mechanics, i.e., running, dancing, and jumping. The soundtrack of *Bound*, produced by the Ukrainian composer Heinali, is about 1h15 in duration. Its main sonorities are based on the exploration of synthesizers, piano, organ and percussion in a minimalist, repetitive register and instrumental tracks, setting on the progressive building through layers and blocks in the entirety of the soundtrack. Music, in this sense, is one of the agents that allows the maintenance of the idea of continuous movement, either by the character itself or by the *obligation* to follow a single route. Simultaneously, the contrast between the digital sonority of the danced universe and the solo (acoustic) piano of the beach reinforces the aesthetic division between the real world, the loneliness of the character and her thoughts; while the virtual world projects strangeness, constantly in mutation and infinite, where it's only possible to dance as a defence and action mechanism. The maintenance of this continuity — except in actual (but short) cutscenes to introduce dialogue, or narrative elements — reflects

[5] https://youtu.be/64FlkreVBMM?t=7s

the lack of actual danger or stress. The player knows that, if he misses a jump or doesn't shield himself by dancing when passing through aerial attacks, he just starts over a few steps behind, with no music changes of other elements that represents failure. This game is a flowing experience and music is key for this objective.

Fig. 2
The two worlds where *Bound's* narrative take place: the reality and the imagined.

Each memory of the danced world has its own sets of tracks with barely any gaps or noticeable changes between them. The referred minimalist register and short but expanding melodies accompany and define the constant movement of the protagonist, reinforcing this main mechanic. In key moments of the narrative, it's possible to observe the introduction of key instruments — such as the piano or organ — primarily associated with the *real* world due to its acoustic nature. Music is always present, connecting not only both worlds but, mainly, the player to the protagonist through her dance and flow.

Like any audio-visual media, it's necessary to examine its music in and out of its original context; in this case, the *paratext* (Genette 1982) of the soundtracks is an important component to understand the narrative as a whole in *Bound*. Amongst the twenty-two tracks (two of which are bonus), it is possible to verify the *Denial, Anger, Bargaining, Depression* and *Acceptance* titles, the 5 stages

of grief (Kübler-Ross and Kessler 2005). In this context, it is the pain of the pregnant woman by the memories that, progressively, are building up information for the player to know how exactly, and why, the father left the family. This process of separation, or divorce is, thus, the central axis of the narrative that shapes the gameplay of *Bound*. These tracks always include the piano — the acoustic element of "real life" — the organ and percussion, creating a moment of realization of the player when finishing a certain level when walking through a red stripe that creates the transition to the *real* world of the woman.

ABZÛ: MUSIC AS NARRATIVE IN AN AQUATIC UNIVERSE

Following the idea of reality, the videogame *Abzû* focuses on a linear narrative based exclusively on the ocean. The possibility of interaction with the most diverse aquatic beings, which are identified in the lower right corner by their common name or the Latin scientific name, appears, at the outset, a videogame whose collection of data on these ecosystems also enables learning and familiarity to the player about this universe. However, this first impression is only one of several levels of meaning that this videogame contains, and it is mainly through music that we can understand all the joint semiotic forces in action that reveal a narrative that, regardless of being linear in terms of results and choices, is complex and based on several metaphors.

Launched in 2016, *Abzû* is a game of ocean exploration, divided into several sequential stages corresponding to ecosystems and areas in which the player has, to a certain extent, influence. One of the main mechanics of *Abzû* is the sensory interaction with fish, accompanying drones and 5 temples to which the player must re-establish the pre-existing life. As the narrative progresses, the player understands that in the depths of the ocean there are robotic mechanisms and entities that control and manipulate the animal life in this environment, and everything is related to the balance of nature. The narrative, being ambiguous, gives room to diverse interpretations and discussions that, through the gameplay, allow for the player to form his own conclusion. However, through the soundtrack, it is possible to reach certain consensuses that, according to my point of view, can contribute to an in-depth understanding of *Abzû*.

The soundtrack, composed by Austin Wintory, is based on a main theme. The first sequence is an introduction to a set of musical materials, however, the base theme in the oboe is the first major musical reference. In fact, the first moment of active gameplay is when the main character controlled by the player — the *Diver* — is

waiting for the *dive* control to be pressed. In surface environment, out of the water, there is no soundtrack - through diving, this action is automatically accompanied by the solo oboe that introduces the *Abzû* theme (Fig. 3)

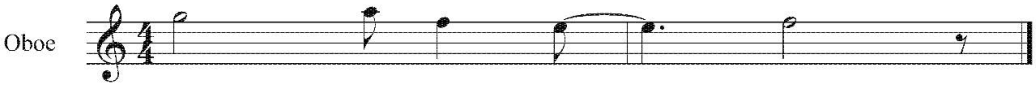


Fig. 3
The main leitmotif of *Abzû*. Transcription by the author.

During the first minutes of gameplay, the soundtrack intensifies and adds more instrumental textures, accentuating the harps and introducing a chorus, emphasizing the female voices with open phonemes. The orchestra, in *Abzû*, represents all the present life in the different "oceans" that the player can (and must) explore, repeating and transforming the main theme, creating small motives that facilitate the empathic relation of the player with the narrative. This main theme is also associated with another character of *Abzû*, the Shark, who appears at specific moments in the protagonist's journey and who, initially seen as a threat, is in fact a guide and potential divine entity in this oceanic universe.

Fig. 4
The different areas and ecosystems that you can explore in *Abzû*.

In addition to several statues, murals and reminiscences of a sunken civilization, it is possible to verify in the final credits the reference to writings of *Enuma Elis,* the Babylonian myth of the creation of the world (Mark 2018), whose first text is sung by the final chorus. The development studio, Giant Squid, drew on the narrative for this videogame through references from Sumerian mythology, thus removing textual information from the first tablet to the two final tracks of the soundtrack, *Their waters were mingled together* and *Then were created the gods in the midst of Heaven*.[6] All this intertextual density is only accessed by the player if there is a research investment during or after the gameplay. Abzû does not contain information throughout the narrative that will help to understand it; however, music plays a pivotal role. It is possible to affirm that the thematic musical transformation throughout the narrative is the clearest link that the player can create in order to decipher it — from the death of the shark (that sacrificed himself for the Diver), whose theme of the oboe is distorted and dissonant — until the final climax of Abzû where the theme is potentiated throughout the orchestra and choir, it is mainly through the soundtrack that we understand the different situations and actions that occur in this videogame.

TOWARDS *CINEMATICABILITY*

The various functions of music in audio-visuals, especially in the field of cinema and theorized, or discussed by multiple authors (Adorno and Eisler 1946; Gorbman 1989; Chion 1994; Citron 2000; Kassabian 2001, 2009; Neumeyer 2014; Elferen 2012, 2013, 2016), are similar to the way in which music in videogames acts, accompanies and also defines action. Kathryn Kalinak points out that film music can: specify the time and space of the narrative; create and form an atmosphere; emphasize both present and non-action

[6] It is important to mention that I could not get access to the text sung by the choir, either by the game studio and the information online about the myth in which is based on. However, through the English translation found in the article by Joshua Mark, it is possible to cross some of the verses of the myth with the paratext of *Abzû's* soundtrack: whether these citations or adaptations, there is a direct intertextual relationship between the musical paratext and the narrative inspiration. For example:

- *They had mingled their waters together* (original text) / *Their waters were mingled together* (track title)
- The game's name, *Abzû*, is the direct link between two Mesopotamian words: *AB*, ocean, and *ZU*, knowing. It can be interpreted as "ocean of wisdom", but this direct junction thus gives name to the introductory music of the videogame, *To Know, Water*. (Takahashi 2016)

elements, enriching the development of the narrative; and also contribute to suggesting emotions, or emotional relationships between characters or situations and the audience (Kalinak 2010, 1-2). The various properties that film music presents, from rhythm and tempo to pitch and timbre, work together effectively through musical conventions whose meanings are conveyed through the idea of association (ibid., 14).

Directly linked and reinforced by the soundtrack, I propose in this paper that *Bound* and *Abzû* employ a set of visual techniques and game mechanics to guide, focus and, sometimes, to force the player's point of view and actions in certain narrative aspects, where the idea of cinematic — previously discussed – is conveyed not only through the design of both games but also through the various tools that determine those actions and images for the player. This *cinematicability*, alongside music, structures an illusory narrative progress of agency and freedom by the player when, in fact, the story and mechanics are linear.

Both games make use of cutscenes in key points of the narrative — either to reveal the outcome of a certain action by the player or to introduce new material for the story — but it's a minor resource. In fact, the transition between non-interactive sequences and the gameplay is noticeable, but no elements of the GUI are renegotiated. In *Bound* and *Abzû*, the visual design and graphics aim towards the idea of an interactive movie. There are practically no external objects to aid the player in her progress, such as a map or HP. One must interact, explore and make use of the settings themselves to understand the objectives in hand.

The only element that is never removed — and, in fact, is reinforced — is the music. The soundtrack is always playing a role, producing and receiving layers of meaning by the player interaction. Even with the non-diegetic techniques of using leitmotifs and thematic material with specific functions, mainly to identify spaces and characters, the timbre of the instruments used is extremely important for these interactive musical experiences. While Monelle (2006), Potter (2003), and Piotrowska (2013) discuss the idea of the musical topic and the representation of water in music — from the waves that represent the tonal flow, or progression in Debussy's *La Mer* or Haendel's *Water Music* woodwinds — Donnelly (2013) and Deleon (2010) explore the use of digital and synthesized sonorities for a futuristic or strange representation of the reality in which we find ourselves, while acoustic instruments, such as the piano, give the listener a sense of familiarity:

> The film's score [Star Wars], composed by John Williams, is full of sweeping orchestration, classical conventions and brass fanfare. The score supports the action and aids in the creation of a strong foundation that allows for easy narrative comprehension, which in turn creates an environment that promotes the viewer to be open to that which is unfamiliar. The use of the band at the bar gives credence to the space, but also comfort and stability. As Williams states, "Music should have a familiar emotional ring so that as you looked at these strange robots and other unearthly creatures, at sights hitherto unseen, the music would be rooted in the familiar traditions" (qtd. in Kalinak, 198). The score adds a few musical elements to cue the viewer to understand that this is a science fiction film, but maintains the familiar structure to allow for easy readability. In essence, the film states that these characters, while placed in new and strange worlds, are relatable and thus the action and narrative understandable (...)
>
> (Deleon in Bartkowiak 2010, 10-21)

In this way, on the one hand, *Bound* bets on the direct gap between the use of synthesizers for the otherness in the virtual world and the piano, the idea of familiar and acoustic, for the reality of the woman. On the other hand, *Abzû* incurs on the use of established musical tropes of woodwinds, harps and chorus's representative of the aquatic movement, of its fauna and flora, as central sonorities in its soundtrack. Both musical languages contribute, therefore, to a direct relation between the audio-visual literacy of the player with musical traditions used and transformed in western classical music already since the 18th century and conveyed particularly in cinema and, later, videogames (Elferen 2016; Freitas 2017). With the soundtrack in this model of production and usage, it functions as many of the visual absent elements usually present in games, functioning as narrative itself, thus constructing *cinematicability*.

This framework is, then, dependent on dynamic elements that constitute a complex process of negotiation and production of meaning not only by the object but mainly by the player — an ergodic interpretation —, namely, audio and music. Following the *cybertextual* theory proposed by Aarseth (1997), this model was a new perspective in the late 90s in literary studies to include new forms of text; videogames are a type of *cybertext* in which each interaction with the player produces new interpretations, creating a new flow of meaning in every new *reading*. If every player has her own perception, social context and identity, then every narrative segment of the same videogame will be read differently. However, music is a crucial part of this dynamic experience, also contributing for the depth of the communication process. On the other hand, Newman (2002) claims that videogames can be looked as a vehicle

of ergodic or interactive elements, discarding the possibility of a single type of experience and involvement. Trough the weaving of the narrative arc with different sequences, videogames can also be an interrupted experience of gameplay due to the cutscenes and the removal of interactivity. While both narratives are linear, as the mechanics themselves, each playthrough is regarded as an experience to deepen the narrative involvement, comprehension and interpretation of the player, aiming to remove potential interruptions of interactivity and, as Aarseth mentions, demanding a non-trivial effort of the player to interpret his own process of playing. The dilution — or its illusion — of a continuous gameplay is possible through the musical accompaniment, contributing to the ergodic flow of the narrative and the interpretation of the player of its progress.

In my point of view, *Bound* and *Abzû*, alongside other videogames like the renown *Journey*, the series *Telltale* or *Dear Esther*, and indie titles such as *That Dragon, Cancer, What Remains of Edith Finch*, are transforming and setting a new paradigm of games with the tags n*arrative-based, storytelling, walking simulator*, or known as *interactive movies*, as I previously mentioned. The discussion among fans and critics of videogames getting closer and closer to cinema has more than a decade — forums and articles dating back to 2008 (skitz8 2008; CPAYNE93 2012; Kain 2012), criticize the introduction of longer cinematics, effects that remove player's control and less gameplay. However, that notion of interactive movies isn't the same as we can observe from the last decade with the rise of narrative games and other formats that challenge the usual mechanics associated with each genre (RPG, action, FPS, etc.). These videogames are constructing a genre in which one of the main mechanics that characterize this medium — failure — isn't present. Removing this component — which sometimes is perceived by players as not challenging enough because there are no legitimate threats — is a way to let the player focus on the story, the characters, their development, and even how music is working towards this objective. In fact, Nicole Clark writes that *walking simulators*, "gaming's most detested genre" (2017) can be considered "true art" (*ibid.*), and how, as I mentioned, becomes also an identifiable tag for this type of videogame:

In true form, the reification of the label "walking simulator" does a better job of describing the kinds of people who create such labels than it does the games it purports to define. The bevy of mainstream backlash coincided not with the creation of walking sims, but rather with the positive critical acclaim of walk-

> ing sim titles like "Dear Esther" and "Gone Home," and later "Firewatch" and "The Vanishing of Ethan Carter." Critics resisted the inclusion of walking sims in the greater gaming oeuvre. Though the label has become nearly neutralized as a descriptor – "walking sim" is a searchable genre on the game distribution platform Steam, along with "adventure" or "narrative" game – people still get stuck on the idea of these games as subtractive, rather than additive. (Clark 2017)

This genre is dependent of what I call, then, *cinematicability*. While mainstream videogames launched by AAA companies are also betting more and more in a cinematic experience, as we can observe particularly in RGPS from the last 3 years and new launches this year such as *Assassin's Creed: Origins, Horizon: Zero Dawn, The Last of Us, Detroit: Become Human,* the new *Spider-Man* and the much expected *Red Dead Redemption 2*, "walking simulators" and narrative-based games propose new ways of exploring the universe through a smaller range of mechanics options. It's also important to note that this genre of videogames propose a reduced time of playability and gameplay, sometimes lasting only one hour. However, independently of the duration of the game itself, music is one of the main components that has the same, or more tracks to fulfil the entire gameplay and out of the original context. This model is dependent of the soundtrack — be it non-diegetic or other — and is key for the entire narrative process of communication. Since there are no other sources of information, music (and audio) only functions because there's an agent to manipulate the environment and explore the narrative. Thus, these games are, at the same time, an interactive musical experience, revealing the increased role and attention this industry is paying to music and how it can be more than accompaniment — a mechanic.

This paper is an attempt to shed some light on what I believe it's the establishment of a new paradigm of an (audio)visual construction of videogames from various studios, teams and, consequently, budgets. While it's possible to affirm that many videogames are getting similar in what concerns visual design, GUI, musical investment — being the orchestra the main resource and sonority for almost every type of universe — and plot, narrative-based games are creating their own niche of production and reception. With such a heterogeneous industry, new narrative formats, stories, characters and identities can be proposed and worked on to reach larger and more diverse communities that, simultaneously, transforms and challenges different audiences and *aca-fans.*

REFERENCES

Aarseth, Espen J. *Cybertext: Perspectives on Ergodic Literature.* Baltimore, Md: Johns Hopkins University Press. 1997.

Adorno, Theodor W., and Hanns Eisler. *Composing for the Films*. London ; Atlantic Highlands, NJ: Athlone Press. 1994.

Chion, Michel. *A Audiovisão*. Lisboa: Texto & Grafia. 2011.

Citron, Marcia J. *Opera on Screen*. New Haven: Yale University Press. 2000.

Clark, Nicole. 'A Brief History of the "Walking Simulator," Gaming's Most Detested Genre'. *Salon*, 11 November. https://www.salon.com/2017/11/11/a-brief-history-of-the-walking-simulator-gamings-most-detested-genre/. 2017.

Collins, Karen. *Game Sound: An Introduction to the History, Theory, and Practice of Video Game Music and Sound Design*. Cambridge, Mass: MIT Press. 2008.

CPAYNE93. 'Are Video Games Becoming Interactive Movies?' N4G. 6 October. http://n4g.com/user/blogpost/cpayne93/520686. 2012.

Deleon, Cara Marisa. 'A Familiar Sound in a New Place: The Use of the Musical Score Within the Science Fiction Film'. In *Sounds of the Future: Essays on Music in Science Fiction Film*, edited by Mathew J. Bartkowiak, 10–21. Jefferson, N.C: McFarland & Co. 2010.

Donnelly, K. J., and Philip Hayward, eds. *Music in Science Fiction Television: Tuned to the Future*. New York: Routledge. 2013.

Elferen, Isabella van. *Gothic Music: The Sounds of the Uncanny.* Cardiff: Univ. of Wales Press. 2012.

———. 'Fantasy Music: Epic Soundtracks, Magical Instruments, Musical Metaphysics'. *Journal of the Fantastic in the Arts* 24 (2): 4–24. 2013.

———. 'Analysing Game Musical Immersion: The ALI Model'. In *Ludomusicology: Approaches to Video Game Music*, edited by Michiel Kamp, Tim Summers, and Mark Sweeney, 32–52. Sheffield, UK: Equinox Publishing. 2016.

Filipe, Eva Patrícia Ribeiro. 'Jogos que nos jogam: o poder do *disempowerment* e da subversão na "engenharia de emoções"'. Mestrado, Lisboa: Faculdade de Ciências Sociais e Humanas, Universidade Nova de Lisboa. https://run.unl.pt/handle/10362/18100. 2016.

Freitas, Joana. '"The music is the only thing you don't have to mod": the musical composition in modification files for videogames'. Mestrado, Lisboa: NOVA FCSH. http://hdl.handle.net/10362/25775. 2017.

Genette, Gérard. *Palimpsestes: La littérature au second degré.* Paris: Seuil. 1982.

Genvo, Sébastien. 'Understanding Digital Playability'. In *The Video Game Theory Reader 2*, edited by Mark J. P. Wolf and Bernard Perron, 133–50. New York: Routledge. 2008.

Gorbman, Claudia. *Unheard Melodies: Narrative Film Music.* London: Indiana University Press. 1987.

Gouveia, Patrícia. 2010. *Artes e jogos digitais: Estética e design da experiência lúdica*. Lisboa: Universitárias Lusófonas.

Hooper, Giles. 'Sounding the Story: Music in Videogame Cutscenes'. In *Emotion in Video Game Soundtracking*, edited by Duncan Williams and Newton Lee, 115–42. New York: Springer. 2018.

Kain, Erik. 'We Should Be Making Games More Like Movies - But Not Less

Like Games'. *Forbes*. 10 March. https://www.forbes.com/sites/erikkain/2012/03/10/we-should-be-making-games-more-like-movies-but-not-less-like-games/. 2012.

Kalinak, Kathryn Marie. *Film Music: A Very Short Introduction*. New York: Oxford University Press. 2010.

Kassabian, Anahid. *Hearing Film: Tracking Identifications in Contemporary Hollywood Film Music.* New York: Routledge. 2001.

King, Geoff, and Tanya Kryzwinska, eds. *Screenplay: Cinema/Videogames/Interfaces.* London: Wallflower. 2002.

Kübler-Ross, Elisabeth, and David Kessler. *On Grief and Grieving: Finding the Meaning of Grief Through the Five Stages of Loss*. London: Simon & Schuster. 2005.

Luz, Filipe. 'Videojogos: Narrativas, Espectáculo e Imersão'. In *VIII Simpósio Brasileiro de Jogos e Entretenimento Digital - Cultura*, 293–99. Rio de Janeiro. 2009.

MacDonald, Keza. 'God of War Review – Violent, Vital and More Brilliant than Ever'. *The Guardian,* 12 April, sec. Games. http://www.theguardian.com/games/2018/apr/12/god-of-war-review-violent-vengeful-and-more-brilliant-than-ever. 2018.

Mark, Joshua J. 'Enuma Elish - The Babylonian Epic of Creation'. *Ancient History Encyclopedia.* https://www.ancient.eu/article/225/enuma-elish---the-babylonian-epic-of-creation---fu/. 2018.

Monelle, Raymond. *The Musical Topic: Hunt, Military and Pastoral.* Musical Meaning and Interpretation. Bloomington: Indiana University Press. 2006.

Neumeyer, David, ed. T*he Oxford Handbook of Film Music Studies.* Oxford ; New York: Oxford University Press. 2014.

Newman, James. 'The Myth of the Ergodic Videogame'. *Game Studies: The Internation Journal of Computer Game Research* 2 (1). http://www.gamestudies.org/0102/newman/. 2002.

Piotrowska, Anna G. 'Water Music, Music on Water or Water in Music? A Short Outline of the Meaning of Water for Musical Culture'. Edited by Pabitra Kumar Mishra. *Bhatter College Journal of Multidisciplinary Studies* IV: 8. 2014.

Potter, Caroline. 'Debussy and Nature'. In *The Cambridge Companion to Debussy*, edited by Simon Trezise, 137–51. Cambridge: Cambridge University Press. 2003.

skitz8. 'Games Becoming Interactive Movies?' *GameSpot* (blog). 2 June. https://www.gamespot.com/forums/games-discussion-1000000/games-becoming-interactive-movies-26395091/. 2008.

Takahashi, Dean. 'Abzû Has Beautiful Underwater Exploration, but It's Too Much like Journey'. *VentureBeat* (blog). 30 August 2016. https://venturebeat.com/2016/08/30/abzu-has-beautiful-underwater-exploration-but-its-too-much-like-journey/. 2016.

Zagalo, Nelson. *Emoções interactivas, do cinema para os videojogos.* Gracio Editor. http://repositorium.sdum.uminho.pt/handle/1822/27674. 2009.

———. 'Cutscenes, "Modo de Usar"'. *Virtual Illusion* (blog). 13 December. https://virtual-illusion.blogspot.com/2012/12/cutscenes-modo-de-usar.html. 2012.

HYPERLINKS

Analog Waves. *Abzu OST - To Know, Water*. https://www.youtube.com/watch?v=2xjBiFF3qkc. 2016.

GameplayOnly. *ABZU - FULL Walkthrough (No Commentary)*. https://www.youtube.com/watch?v=Q-7M10_DQv4&feature=youtu.be&t=1m19s. 2016.

inter230407. *Abzû - Full Original Soundtrack*. https://www.youtube.com/watch?v=TCuhQLgDgIg. 2016.

———. *Bound - Original Soundtrack Full Album*. https://www.youtube.com/watch?v=ubu3o0TVTlw. 2016.

KreativeKill. *BOUND - Journey in Your Mind - Full Game Walkthrough Movie No Commentary [PS4] 1080p HD*. https://www.youtube.com/watch?v=CL_8T-BaGDRU&feature=youtu.be&t=40m30s. 2016.

MKIceAndFire. *BOUND Gameplay Walkthrough Part 1 [1080p HD 60FPS PS4] - No Commentary (First 20 Minutes)*. https://www.youtube.com/watch?v=-64FlkreVBMM&feature=youtu.be&t=7s. 2016.

PlayStation. *Bound - E3 2016 Trailer | PS4*. https://www.youtube.com/watch?v=aE37l6RvF-c. 2016.

A Platform for the Geometry Friends Cooperative Game AI Competition

RICARDO COSTA,[1] RUI PRADA,[2] FRANCISCO S. MELO[3]

ABSTRACT

This paper describes the development of a new online competition platform to support the future of the Geometry Friends Cooperative Game AI competition. Geometry Friends is a cooperative 2D physics-based platformer that presents several challenges for the AI community, in particular, to integrate motion and task planning. This paper presents the work developed to improve the platform used to run the competition. The work was based on best practices of similar platforms. The new platform was developed mostly from scratch, consisting of a new website and a background program in charge of fully handling the received submissions, and more. Virtualization was used to create a secure, fair and reusable evaluation environment. Different features of the new platform were tested by several people across three different test scenarios. The new website was concluded to have an above average usability, while the submission handling program worked as expected throughout the testing phase.

KEYWORDS

Video Game Competitions;
Artificial Intelligence;
Cooperative Games;
Automation.

[1] INESC-ID and Instituto Superior Técnico, Univ. de Lisboa, Portugal — ricardo.gomes.costa@tecnico.ulisboa.pt

[2] INESC-ID and Instituto Superior Técnico, Univ. de Lisboa, Portugal — rui.prada@tecnico.ulisboa.pt

[3] INESC-ID and Instituto Superior Técnico, Univ. de Lisboa, Portugal — fmelo@inesc-id.pt

1. INTRODUCTION

Videogames make one of the best testbeds for artificial intelligence. They provide inexpensive virtual simulations where algorithms can be tested repeatedly. They can also be viewed as good platforms for iterative AI testing models, with the possibility for gradual improvements over time. Geometry Friends (Rocha et al. 2008) is one of such games. Initially designed to be a 2D platform puzzle game oriented towards cooperation, it was adapted to enable the implementation of artificial agents. A Geometry Friends AI competition (Prada et al. 2015) exists and has been receiving submissions annually since 2013. Competitions allow different parties to present and compare their solutions. Several factors make a competition more attractive, such as: the game quality; unique challenges; and good competition platforms. A competition platform is a system composed by several components such as the interfaces which the participants and even competition organizers interact with, participant registry, solution submission and consequent processing, community interaction, etc.

The competition platform of the Geometry Friends Game AI competition (GFGAI) is the main focus of this work. Improving a competition platform not only facilitates participation, but also cuts costs of running and maintaining a competition. As it follows, by improving the Geometry Friends Game AI Competition platform, the number of submissions per competition edition could increase, as well as the amount of editions that could be held in the future. This is relevant because Geometry Friends is a game that poses a rather unique set of challenges, which are not considered to be completely solved. This means that there is still room for improvement, where new algorithms and ideas can be explored throughout the future history of the GFGAI competition.

2. GEOMETRY FRIENDS

Geometry Friends is a 2D puzzle platformer where up to two playing characters — a yellow circle and/or a green rectangle — can move with their unique set of actions to capture purple diamonds. Figure 1 shows a sample level which not only includes the characters and collectibles mentioned above, but also the different platforms available: normal (black) impenetrable platforms; and coloured platforms. A player object will collide with a wall whose colour does not match its own.

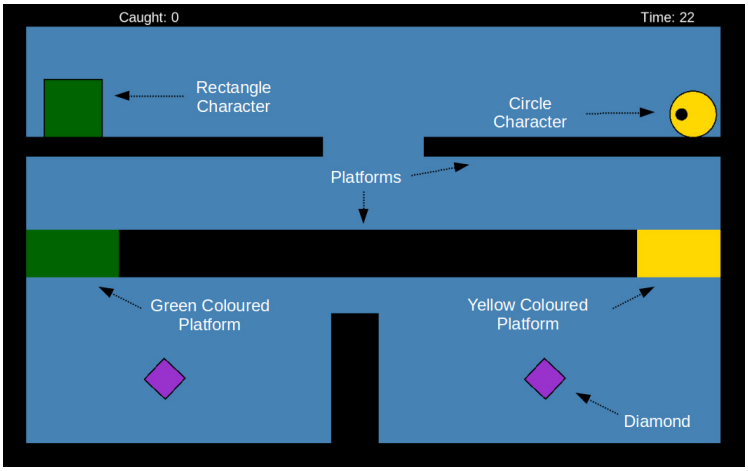


Fig. 1
A Geometry Friends level featuring all elements of the game: the circle and rectangle players, all three types of platforms and the purple diamonds.

One of the most interesting aspects of this game is the cooperation factor in levels, or maps containing both the player characters. It is often required that both the characters combine their efforts and unique abilities to complete the levels.

2.1 GEOMETRY FRIENDS COMPETITION

The Geometry Friends Game AI competition allows participants to implement agents which control one of the characters, and to compete against other participants in the same levels, or maps. Agent development can be done using a C# API, as the original game is also fully implemented in C#. Both the framework and sample agents can be found at the competition website.[4] The competition has been successfully held a few times at IEEE Conference on Computation Intelligence and Games.

Participants are asked to zip their solution containing the source code developed and email it to the competition organizers, along with entry details, such as: a team name; intended category (circle only, rectangle only or cooperative); and a small technical report describing the solution. A command line interface and a Geometry Friends Batch Simulator is available to help participants test their solutions and organizers to evaluate submitted solutions.

[4] http://gaips.inesc-id.pt/geometryfriends

A competition has public and private levels, to discourage overfitting solutions. The score of each entry the sum of the scores it gets in all levels (usually the competition presents 10 different levels). Each agent is run several times in each level. The final score of the level is the average score of the runs. The score of each run depends on the time limit, the time the agent took to solve the level and the number of collectibles it got. This process takes long and, at the time of the beginning of this work, required manual labour. In fact, many of the competition management processes require manual labour, which can scale up with the number of participants. These include the initial setup of the competition, receiving of submissions, handling them (i.e. compiling and evaluating) and updating the results on the competition website.

3. GAME AI COMPETITIONS

Artificial Intelligence competitions are not new. They exist as a way to promote advances in the field by encouraging the development of AI based solutions and sharing with members of the community. Popular examples lie in card games like Poker (Billings et al. 1998), real-time strategy (RTS) games such as StarCraft (Buro et al. 2012) and turn based games, such as Pokemon (Lee et al. 2017). Competitions are also common in real-word applications, such as the Supply Chain Trading Agent Competition (Arunachalam 2005), transportation challenges, such as the DARPA Grand Challenge (Seetharaman 2006) and human conversational intelligence, such as the Loebner Prize (Powers 1998).

3.1 GOOD PRACTICES

Good practices for running AI competitions are explored and suggested by Togelius (2014). The author attempts to explain the reasons why some competitions fails and then suggests guidelines for the success of AI competitions. As for why AI competitions fail, Togelius defends that the lack of continuity, stagnation and irrelevance are the main reasons. That is, competitions fail when they do not evolve and keep their challenges relevant to the field, and when low amount of effort is put into them, preventing continuity to the competition. To run a successful AI competition, Togelius suggests that a competition should:

- be fully transparent in terms of rules and evaluation methods;
- be accessible on a wide variety of platforms and programming languages;
- be repeated to enable improvements over time;
- have a discussion group to encourage community interaction;
- have software that can run locally to test solutions more efficiently;

- have a game that can be sped up, useful to train learning algorithms;
- be easy on beginners, e.g. including sample agents and simple instructions;
- open-source everything, including solutions, to enable sharing and prevent cheating.

3.1 GAME COMPETITIONS PLATFORMS

During this work, several artificial intelligence competition platforms were studied. One of them, the Mario AI championship, is based on the Mario AI Benchmark, which is itself based on the Infinite Mario Bros game developed and made open-source by Markus Persson (Karakovskiy et al. 2012; Togelius et al. 2013). Active between 2009 and 2012, the competition allowed agents to be developed in multiple languages, provided good documentation and community interaction via a Google site and a Google group. Submissions were sent via email. Another platform is OpenAI's Gym, which is not necessarily a competition, but allows the submission, scoring and sharing of solutions based on reinforcement learning (Brockman 2016). A more recent platform called Universe was developed on top of Gym to enable agents to mimic the actions of a computer user, i.e. by simulating keyboard and mouse events. An interesting feature of the OpenAI Gym's framework was the ability to automatically upload a solution to the platform using code.

The General Video Game AI (GVGAI) Competition, which like the OpenAI Gym promotes game agnostic solutions (Perez-Liebana et al. 2016), is a modern competition platform that follows many of the guidelines suggested in Section 3.1. It allows for submissions to be uploaded through the website. Its framework is cross-platform and agents may be developed in multiple languages (Java and Python). In a paper, the authors give an insight into the back-end processes of the platform (Perez et al. 2015) which we summarize and illustrate in Figure 2. An automated process such as this ensures high repeatability and low organizational costs.

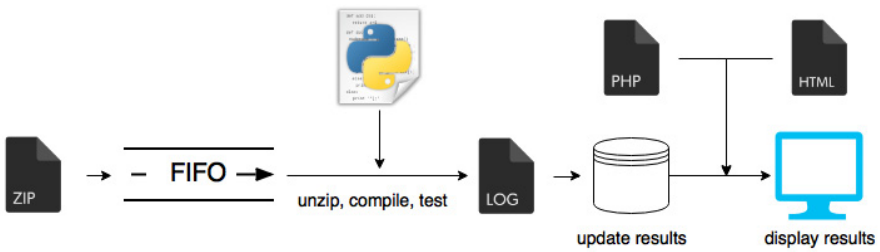


Fig. 2
A simplified diagram which describes the back-end processes of the gvgai competition (1-player tracks only)

As for the GVGAI results tables (see figure 3), they manage to act like a hub for lots of information regarding the submissions, such as score, participant profile and source-code download.

Test Set 2-Player Games CEC 2017

Rank	Username	User ID	Country	Points	Avg. Glicko Score	Games Played	Controller
1	ToVo2	474	Slovenia	161	1183.41	5070	Download
2	ehauckdo	542	Brazil	111	1133.4	6338	Download
3	not2048	671	United Kingdom	111	1071.82	5170	Download
4	essex_acwebb	530	United Kingdom	110	1120.63	5070	Download
5	Number27	441	Germany	84	1124.69	5170	Download
6	sampleRS Sample	636	United Kingdom	78	1108.92	5349	Download

Fig. 3
Part of a table showing the 2-player track overall results of CEC 2017, as indicated by the label above the table. The first row explains what each column represents. Both the usernames and the "Download" are hyperlinks. From http://www.gvgai.net/gvg_rankings_conf_2p.php?rg=2006

Lastly, the Ms. Pac-Man Vs Ghost Team is a competition based on the popular arcade game Ms. Pac-Man (Williams 2016). Its website features a thorough step-by-step image-based guide and also allows for submission uploads through the website. One of the features that stands out, however, is the existence of a controller packaging script, a Bash script that compresses the participant's solution into a single, submission ready file.

4. IMPROVING THE GEOMETRY FRIENDS COMPETITION PLATFORM

The Geometry Friends competition meets some of the good practices, such as, supporting the ability to test the game locally. However, it also had several weaknesses, in particular, the fact that a lot of (human) labour was needed in the organization processes, which was proportional to the amount of submissions per competition edition, or instance. This often led to delays in the availability of competition related information, e.g. past submissions and technical reports, and result tables.

There are three main groups of people that interact with the Geometry Friends competition: the organizers; the participants; and the general public. When considering the main weaknesses previously presented, it is possible to present requirements that the new platform should meet for each of the three groups.

Most of this work focuses on improving the processes related to the organization of the GFGAI competition. With the new platform, an organizer should be able to: create new competitions and configure parameters such as the name, start and end dates, evaluation formula parameters for each level, etc.; easily run predefined submissions to each competition to serve as baselines for the partic-

ipants; have all the submission evaluation processes automated for them, including the reception of submission files, extraction, compilation, execution, obtaining results and making them publicly available, etc.; and be able to update the GF game version in use when evaluating submissions, in case the game itself evolves in the future.

On the other side of things, a participant should be able to: understand if and what competition editions and categories are open for submissions; access competition details and parameters such as levels, time limits and bonuses for each level, etc.; have rapid access to the GFGAI competition framework and quickly create a simple agent; upload a submission for a desired competition instance automatically; understand what happened to his submissions (e.g. possible errors) and what their results were; submit multiple times to a single competition (given that only the latest submission counts); and create and submit more complex submissions which may include C# dependencies and even platform specific dependencies.

Lastly, any person should be able to: have access to all current and past competition details (e.g. levels used, formula parameters) and results/scoreboards; and have access to all submission files and technical reports submitted throughout the lifetime of the new platform (except for Competitions which have not finished yet, to prevent cheating).

4.1 OVERVIEW OF THE NEW PLATFORM

In an attempt to meet the requirements presented above, a new platform was developed. It was highly inspired by the GVGAI competition. Although, with very specific differences resulting from the unique characteristics of the GFGAI competition.

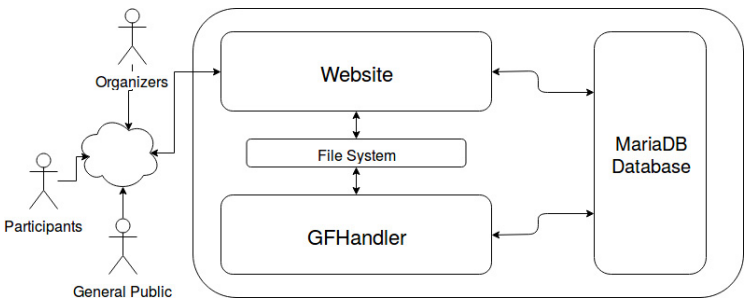


Fig. 4
Conceptualization of the two main components of the new platform.

The new GFGAI competition platform was developed as a web application following a traditional LAMP model. The platform's design was split into two separate and almost independent components,

as shown in Figure 4: the Website the component, which is meant to be interacted with, both by competition participants and administrators; and the GFHandler the background process, which is in charge of the automation of the competition handling processes. They share a MariaDB database, which stores most of the persistent competition related data, such as user information, submission details, existing competitions, etc. The two components also share files in the file system, such as the submission files.

5. THE NEW WEBSITE

The new website is one of the two main components introduced in the previous section. It is the only component which interacts directly with its users: organizers, participants and the general public.

5.1 MANAGEMENT INTERFACES

The management interfaces are meant to be accessed and used by the organizers alone. Because of this, a special type of user account exists, called an administrator account, which enables the use of these interfaces.

Organizers may create competitions and then configure them (Fig. 5) by editing, for instance, the number of simulations executed per level, the maximum submission size and level specific parameters (visibility and formula related parameters).

Organizers are able to run pre-sets, which can be thought of special "participants" controlled by the organizers, which can "submit" a predetermined submission on command. This is useful to have constant baselines across the different competitions.

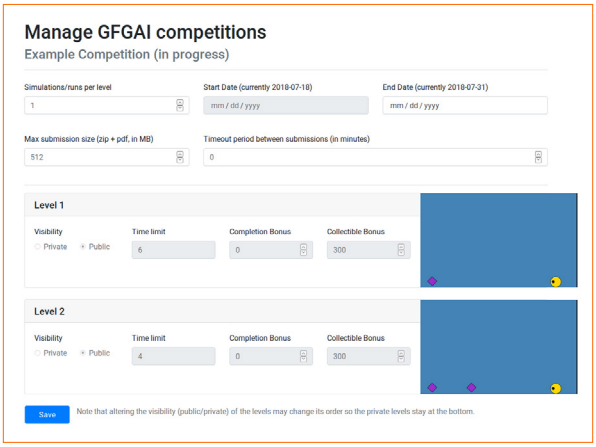


Fig. 5
Management interface to edit competition parameters.

5.2 PARTICIPATING

A participant may pick a competition from a list of competitions and download a competition package containing a copy of the game, a sample agent, the XML world file describing the levels of the competition (only the public levels in case the competition in question is still ongoing) and two packaging scripts to facilitate the creation of the files to be submitted. After submitting an entry to the competition, participants can track their results in real time on their profile page, which shows both the score and state of the user's submissions. This state indicates feedback from the GFHandler component, such as if the submission is still being processed, or if it had errors (the system may even make error logs downloadable), etc.

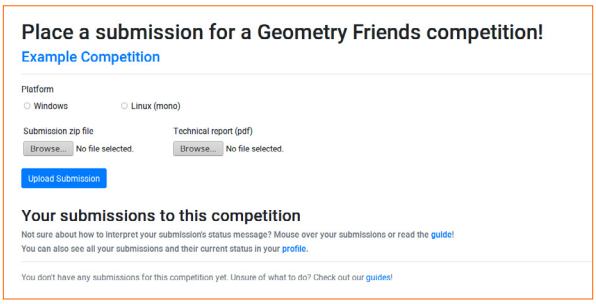


Fig. 6
Submission form to upload a ZIP solution.

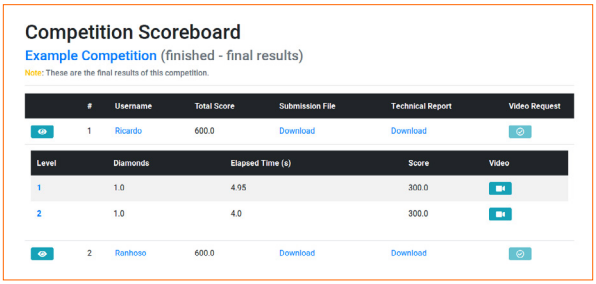


Fig. 7
Scoreboard with two entries. The first entry is expanded to show the results more details.

Finally, users may check the current scoreboard (Figure 7) of the competition they submitted to in order to compare their results against other participants, as well as see their level specific scores and request videos of the execution of their agents.

6. GFHANDLER: THE SUBMISSION HANDLING PROGRAM

The most complex component of the developed platform is a background program, which we called GFHandler, since it is meant to handle Geometry Friends submissions. This ended up being a very custom program tailored for the quirks of the Geometry Friends game and framework.

6.1 THE MAIN LOOP OF THE GFHANDLER PROGRAM

The main loop regularly polls the database for new (unprocessed) submission entries. These submissions are the ones that are uploaded using the new website, using the forms. Each submission entry in the database possesses all information required by the GFHandler, one of the most important being the path where the uploaded submission was stored to. If there is a new submission to handle, the GFHandler will start a submission environment in a virtual machine. This environment is populated with the necessary files, such as the submission (ZIP file), a fresh copy of the game and the levels (XML file) of the competition, which the submission was placed to. Once everything is in place, a series of events occur automatically, including extraction of the ZIP file, compilation of the source code, simulation of the compiled agent on the several levels (usually multiple times per level, a parameter which can be configured by an organizer using the new website) and extraction of the results from a game generated Results.csv file.

6.2 VIRTUAL MACHINES AS VERSATILE, SECURE AND FAIR SIMULATION ENVIRONMENTS

Submissions are handled in environments that encapsulate the submission handling processes in order to: support standardization of the mentioned processes, which may enable all submissions to be handled in the same way and thus simplifying the system; promote fairness, if the environment is guaranteed to be equal for every submission; support modularity, in the sense that the environments may change (e.g. by adapting to future changes of the Geometry Friends framework) without the need to modify the main program or loop of the GFHandler; grant isolation, whose magnitude may vary depending on the environment chosen, but grants a greater security for the host system in case a malicious submission is sent.

Virtualization[5] was chosen as a way to accomplish the desired outcome. Because with virtual machines, we can: run entirely different operating systems on the same machine (e.g. Windows on Linux) and thus avoid the problem of platform specific dependencies; have isolated environments with no access to the host system where even malicious submissions can be executed safely; save a clean state (snapshot) of a virtual machine and then restore

[5] The solution developed uses VirtualBox https://www.virtualbox.org/

a machine to that snapshot every time we handle a submission to ensure a constant and fair environment for each submission.

6.3 HANDLING THE SUBMISSIONS USING VM ENVIRONMENTS

The GFHandler program runs commands remotely (via SSH) in either Bash or PowerShell, depending on the environment required (Linux or Windows). A status attribute of the submissions is stored in the DB to allow the GFHandler to see which submissions have already been processed. After detecting the existence of an unprocessed submission, GFHandler decides what levels the submission needs to be simulated on by looking at whether the respective competition has ended or not. Only when a competition ends will the submissions be evaluated on that competition's private levels.

Another flag in the database indicates whether the submission should be run using Windows or Linux. The respective VM is restored to a clean snapshot and is booted. After a while, the GFHandler connects to the VMs via SSH and begins a series of steps:

1. sends the submission ZIP to the VM via SCP;
2. extracts the ZIP (with "unzip" in Ubuntu or "Expand-Archive" in Windows PowerShell);
3. removes unwanted files from the user's submissions (e.g. the game files, in case the participant also sent them in their submission) to prevent cheating with altered files;
4. sends a fresh copy of the game and an XML file containing only the levels that the submission is supposed to be evaluated on;
5. builds the solution using MSBuild,[6] which should generate a DLL file containing the submitted agent;
6. simulates the agent on the levels, R runs per level, computing the score using equation in Section 2.2 by parsing the results from a game generated CSV file;
7. powers off the VM.

On step 6, the score on each level is computed and updated on the database before the agent is simulated on the next level, making it possible to track the progress in real time.

[6] https://msdn.microsoft.com/en-us/library/dd393574.aspx (accessed July 26, 2018)

ERROR HANDLING

The GFHandler program is expecting errors at any stage of the handling process. In steps, such as, extraction or compilation, submissions may fail. If so, they are assigned a status message accordingly, like “extraction error” or “compilation error”. Contrary to errors in other stages, the GFHandler does not stop the entire progress after encountering runtime errors during game simulation. This is to give a chance to agents who just crash occasionally to still get some score for the levels where they performed well. For both compilation and runtime errors, the GFHandler program stores the output of the executed commands in a single log file which can later be displayed to the participant through the website. This log file may contain, for example, the output of a MSBuild’s compilation, or even runtime error traces for each individual level the submission failed on.

7. EVALUATION

The platform was evaluated in terms of the general usability using a SUS[7] questionnaire. Three test scenarios were designed, one testing the organizational side of things, and the other two the participants side. The competition management (CM) test had testers create and edit a competition. It also had them create and run preset submissions and track their results. A thorough user (TU) test had testers act as participants by creating and logging in with a new account, downloading a competition package (game + sample agent + competition specific levels), creating a simple agent in VisualStudio or MonoDevelop, submitting it to a certain competition and tracking the results. A simple participant (SU) test made available two ready to upload submissions and had the testers create and login with a new account, submit two submissions and track their progress. Testers were also asked to explain what had happened to their first submission after submitting the second.

Each person asked to evaluate the system could do only two of the scenarios, since both TU and SU scenarios had overlapping tasks. As such, each person could test the competition management scenario and one of the competition participant’s scenario. People were invited to perform the tests using their own computers, as a way to also test the platforms across different systems and browsers.

[7] https://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html

7.2 RESULTS

A total of 18 people participated in the tests, from July 20 to September 14. The number of people on each test can be found on Table 1, along with the SUS scores.

SCENARIO	# TESTS	AVERAGE SUS	Ø
CM	18	76.6(6)	17.1499
TU	9	78.3(3)	16.0078
SU	9	84.4(4)	10.8813
Total	36	79.027(7)	15.4605

Table 1
SUS results for all three test scenarios

All but one of the testers were students between 18 and 25 years old, and 2 were female. Over half of the people tested studied IT related fields. One professor of a relevant field of study, AI for games, also participated.

According to results of 500 SUS evaluations, the average SUS score is 68 and achieving over 80.3 is considered a very good score. This means that an above average score was obtained in all our scenarios, and the SU scenario obtained a very good usability score. This is not surprising as it was designed to be the simplest scenario. However, because the main difference between the TU test and the SU test is the fact that the TU test required interaction with the GF framework, the difference in scores may indicate that the website is more usable than the framework.

As for the tasks of each scenario, everyone was able to complete them, and the majority was able to give the expected answers, meaning they were able to create a simple agent successfully (TU) and understand what happened to their submissions or pre-sets (on all scenarios). On the CM scenario, everyone created and configured a competition correctly as expected. However, a couple of people (1 on the SU and 1 on the CM scenarios) did not give expected answers when reporting on the status of their submissions or pre-sets, mostly because they did not realize that the system was evaluating their submissions in real time.

The professor, who had experience using platforms such as Mooshak, complimented the new platform, more specifically the modern design of the website.

8. CONCLUSION

A new and functional platform for the Geometry Friends Game AI competition was developed successfully during this work. The usability of the website was considered above average using a System Usability Scale (SUS). No improvements were required on the platform's second main component, the GFHandler, as it functioned exactly as intended throughout all the tests. All the requirements specified in Section 4.2 were successfully implemented, and most of them tested repeatedly on the aforementioned tests with people. Thus, we can conclude that the main goal was accomplished, since a new platform was indeed designed, implemented and deployed successfully.

Moreover, considerable care was put into helpful documentation not only for the participants and competition organizers (extensive guides on the website), but also to whomever will be in charge of maintaining or continuing the development of the platform itself. The implemented solution takes a different approach from the current state of the art, mostly by using virtualization during submission evaluation processes to guarantee security against malicious foreign code, fairness and more freedom for the participants to develop platform specific code, if they so desire. While this provides a small overhead in submission evaluation times mostly due to booting up the virtual machines, this is still small compared to the rest of the necessary evaluation steps.

ACKNOWLEDGEMENTS

This work was supported by national funds through Fundação para a Ciência e a Tecnologia (FCT-UID/CEC/500 21/2013) and through the project RAGE (Ref. H2020-ICT-2014-1/644187).

REFERENCES

J. B. Rocha, S. Mascarenhas, R. Prada: *Game mechanics for cooperative games*. ZON Digital Games 2008, pp. 72-80, Porto. 2008.

R. Prada, P. Lopes, J. Catarino, J. Quitério, F. S. Melo. *The Geometry Friends Game AI Competition.* Proceedings of CIG'2015 – IEEE Conference on Computational Intelligence and Games, pp. 431-438, Tainan, Taiwan. August 2015. IEEE.

D. Billings, D. Papp, J. Schaeffer, and D. Szafron. *Poker as a testbed for machine intelligence research.* Advances in Artificial Intelligence, pp. 228–238. 1998

M. Buro, D. Churchill. *Real-time strategy game competitions.* AI Magazine, vol. 33, no. 3, pp. 106–108. 2012

S. Lee, J. Togelius. *Showdown AI Competition.* Proceedings of the IEEE Conference on Computational Intelligence in Games, pp. 191-198. 2017

R. Arunachalam, N. M. Sadeh. *The supply chain trading agent competition.* Elec-

tronic Commerce Research and Applications, vol. 4, no. 1, pp. 66–84. 2005

G. Seetharaman, A. Lakhotia, E.P. Blasch. *Unmanned Vehicles Come of Age: The DARPA Grand Challenge.* Computer 39, 26–29. 2006

D. Powers. *The Total Turing Test and the Loebner Prize.* Proceedings of the Joint Conferences on New Methods in Language Processing and Computational Natural Language Learning, NeMLaP3/CoNLL '98, Association for Computational Linguistics, pp. 279-280. 1998

J. Togelius. *How to run a successful game-based AI competition*. IEEE Transactions on Computational Intelligence and AI in Games, vol. 8, pp. 95-100. 2014

S. Karakovskiy, J. Togelius. *The Mario AI Benchmark and Competitions.* IEEE Transactions on Computational Intelligence and AI in Games, 4(1):55–67. 2012.

J. Togelius, N. Shaker, S. Karakovskiy, G. N. Yannakakis. *The Mario AI Championship 2009-2012*. AI Magazine, vol. 34, no. 3, pp. 89–92. 2013.

G. Brockman, V. Cheung, L. Pettersson, J. Schneider, J. Schulman, J. Tang, W. Zaremba. *OpenAI Gym*. arXiv preprint arXiv:1606.01540. 2016

D. Perez-Liebana, S. Samothrakis, J. Togelius, T. Schaul, S. Lucas. *General Video Game AI: Competition, Challenges and Opportunities.* Proceedings of the Thirtieth AAAI Conference on Artificial Intelligence. 2016

D. Perez, S. Samothrakis, J. Togelius, T. Schaul, S. Lucas, A. Couetoux, J. Lee, C. Lim, T. Thompson. *The 2014 General Game Playing Competition*. IEEE Transactions on Computational Intelligence and AI in Games, DOI: 10.1109/TCIAIG.2015.2402393. 2015

P.R. Williams, D. Perez-Liebana, S.M. Lucas. *Ms Pac-Man Versus Ghost Team CIG 2016 Competition*. Proceedings of the IEEE Conference on Computational Intelligence and Games. 2016

Empathy manifestations in interspecies Game Design experiences

FABRÍCIO FAVA[1]

ABSTRACT

In the present work forms of empathy manifestations in interspecies (game) design experiences are observed. In order to do this, general aspects of empathy and its intersections with design and games are discussed. Then, some game design approaches are observed in the context of Animal-Computer Interaction. Finally, four interspecies (game) design experiences are briefly discussed and possible ways of empathy manifestations are pointed out. The research shows that cognitive and emotional empathetic responses such as perspective-taking, relationship-building and reflective thinking are able to be perceived during the game design activity as well as by observing the animal-technology interaction.

KEYWORDS

Game Design;
Empathy;
Animal-Computer Interaction;
Interspecies.

[1] i2ADS / Faculty of Fine Arts, University of Porto, Porto, Portugal — ffava@fba.up.pt

1. INTRODUCTION

Related to the communicative, collaborative and creative processes that unfold in the relations between designers and users, empathy can be observed as the effort to connect with people on a fundamental level: to observe or to comprehend the world in the same way that others do, to understand it from another's experiences and feel it through their emotions (Brown 2009). It is worth to emphasize that the movement towards empathy is not about putting a designer in the role of another, but to be able to connect with others from their experiences and perspectives, supported by a dialogical process.

Empathy is a phenomenon associated with different aspects, such as: competence; ability; intellectual virtue; behavioral response. Batson (2009, 4-8), for example, points out eight distinct conceptions resulting from research on empathy: (i) know a person's internal states, including his or her thoughts and feelings; (ii) adopt the posture or match the neural responses of an observed other; (iii) come to feel as another person feels; (iv) intuit or project oneself into another's situation; (v) imagine how another is thinking and feeling; (vi) imagine how one would think and feel in the other's place; (vii) feel distress at witnessing another person's suffering; and (viii) feel for another person who is suffering.

As Hess and Fila (2016, 4) synthesize, empathy "includes both affective experiences and cognitive processes that may be primed automatically or within the subconscious, and that may operate in isolation or concurrently, but which tend to have a cyclical relationship." In this process, affective experiences comprise empathic distress and empathic concern, while cognitive processes include perspectives that can be oriented to self or to others.

Among the positive characteristics associated with the development of empathy are the interest in another, the apprehension of different perspectives and experiences, the expansion of communication and the tendency to make ethical decisions. Such benefits go beyond improving attitudes and motivating affective behaviors toward humans. Empathetic people demonstrate, for example, stronger feelings of moral obligation to help animals, plants and nature (Berenguer 2007).

Animal-Computer Interaction's (ACI) efforts propose the application of design principles that place the animal at the center of an iterative development process as a legitimate user and contributor of design (Mancini 2013). This involves recognizing that non-human animals have the ability to feel, perceive, experience subjectivity, however without looking at them from an essentially anthropocentric perspective. This implies looking at them without associating

their way of thinking or feeling with ours, or comparing if they are aware of the natural world in the same way that we are.

The use of digital technologies to promote experiences of engagement between people and the natural world (Webber et al. 2017), especially from the perspective of play, have benefited from these qualities. In this sense, the emergence of the ACI discipline (Mancini 2011) seems to put us in a new perspective of expansion of the fields of Interaction Design and Games. But would it be possible to stimulate human empathy through interspecies playful design? If so, how this characteristic is manifested in the relationships between human and non-human animals in a (game) design context?

Seeking to answer those questions, the game design activity is seen here as a way to build new forms of interaction and interspecies communication. And, the playful aspect is an element capable of enhancing empathy in these relationships. Therefore, the present work discusses the manifestation of interspecies empathy in the context of (game) design from an Experience-Centered Design approach.

The discussion presented here is the result of a bibliographical review using the Google academic database in August 2018. A search for the terms “animal computer-interaction”, “game design” and “empathy” returned 10 papers, where: one of these was dedicated specifically to the subject (Webber et al. 2017); two referred to empathy as a cross-cutting theme (Westerlaken and Gualeni 2016; Pons and Jaen 2017); and the others either mentioned the term empathy or cited previous studies. From the analysis of these works and the state of art about empathy, some general considerations about empathy in the context of design and games are traced; after that, the Animal-Computer Interaction discipline and its insertion in game design context is introduced; and finally, some insights related to the manifestation of empathy in the context of interspecies (game) design experience is presented.

2. INTERSECTIONS OF EMPATHY, DESIGN AND GAMES

The empathetic relationship between designers and users has been explored in the context of Human-Computer Interaction and Interaction Design for some time. Suri (2001), for example, has already pointed out empathy as a necessary factor in Ergonomics to deal with future challenges and opportunities. Mattelmäki and Battarbee (2002) explored it in the context of designing personal experiences with interactive technologies. Wright and McCarthy (2008) explored the dialogic characteristic of empathy in user experience design.

These researches are focused essentially on the human perspective

and can be seen as responses to the challenges of a new demand of Design, such as the understanding of significant actions and emotional aspects related to users' experiences since the late 1990s (Mattelmäki et al. 2014). This has revealed a need for finding new ways to deal with the uncertainties arising from the insertion of these immaterial issues. In this context, the notion of Empathic Design (Leonard and Rayport 1997) emerged as an additional approach to ergonomic practices and marketing research. The Empathic Design method was seen as a tool for developing the designer's ability to connect with people and involves: observation; data collection; reflection and analysis; brainstorming for solutions; and prototype development of possible solutions.

This perspective of Empathic Design turned to the User-Centered Design notion, especially with the participatory design movement, from the year 2003, when the change from product design to interaction with systems and services was perceived (Mattelmäki et al. 2014). It is possible to say that this was the moment in which the notion of Design Thinking started gain emergency (Brown and Wyatt 2010). An approach that has among its principles the experimentation, collaboration, co-creation, focus on the human, holistic bias (Brown 2009; Stickdorn and Schneider 2010).

When we talk about codesign or participatory design we are also referring to empathy because its practice reveals the subjects' individuality. The construction of empathy is established by an aesthetic relationship formed by learning the qualities and values of another. This dialogic, immersive process can take time until the designer became able to recognize behaviors and strategies that people use to cope with the complexity of the world. The perception of these behaviors is subsequently translated into design trends in order to generate systems or services that can impact the lives of individuals. In this context, the designer appears as a kind of cultural intermediary.

The state of the art regarding video games and empathy is still recent (Belman and Flanagan 2010; Greiteyeyer 2013; Darvasi 2016). The most recent work seems to be that wrote by Matthew Farber and Karen Schrier (2017). Among the results of this study, it can be highlighted the characteristics of games in promoting immersive experiences are a way of stimulating behaviors and actions related to empathy (Mahood and Hanus 2017). Another striking factor for empathy through videogames is what Janet Murray (2003) calls agency, that is the feeling that the actions and choices made by the player during the gameplay result in significant changes in the game world. Making meaningful choices helps the player to

control his or her gaming experience and usually promtes a sense of free will. Despite this, "it may also lessen empathy because the player is not removed enough from the choices." (Farber and Schrier 2017, 14)

Farber and Schrier also point out perspective-taking and identity characteristics, which refers to the act of taking the point of view of another, making possible to better understand the other, even if we do not have the same view or agree with it. Hofman (2000) considers the perspective-taking the most advanced form of empathy, because it enables us to become affectively empathetic towards another even though they are not present. Perspective-taking in the context of games helps to form a sense of identity and, as argued by Darvasi (2016), the player becomes more easily empathic if he or she is able to see the character on the screen. This can happen in a gameplay experience by enabling a third-person perspective, or by allowing changing between first and third-person perspectives.

In addition to this connection with player-controlled characters, it is also possible to create links to non-playable characters, which are controlled by the game programming. The independent relationship with non-playable characters is developed over time and may result in empathic emotions similar to those established with actors or characters from a book. The last-mentioned aspects are connection, communication and reflection resulted from real people interactions. These can help to support several aspects that are relevant to the practice of empathy, such as perspective-taking, role-playing, reflection, agency, identify formation and relationship building (Belman and Flanagan 2010; Schrier 2015; Hess and Fila 2016).

As discussed previously, an empathetic connection suggests a predisposition for it to occur. At the same time, it demands presence, there is also absence, since there is a need to connect with the other to empathize. This implies a possible detachment of individuality and can take place in both affective and cognitive way. This connection with another can occur through both observation and dialogic relationship. This last one, in fact, seems to be more intense since it is consolidated from the experience of interaction with the other.

In this context, design and game activities can be seen as possible ways for the development of empathic forms. Both are activities that presuppose or stimulate the engagement of their actors and provide an immersive dive into new experiences and contexts. These qualities, which are usually seen from a human point of

view, are presented here as potential indexes for a perceptual and cognitive expansion into a broader field of relationships, which is assumed in this work as interspecies empathy phenomenon.

3. PLAYFUL DESIGN IN THE CONTEXT OF ANIMAL-COMPUTER INTERACTION

Research involving interaction between animals and technology is not recent (Mancini 2017). However, the perception that their design approaches were not focused on animal-centered design gained evidence in 2011, when Clara Mancini published the Manifesto on Animal-Computer Interaction (Mancini 2011). In this paper the author describes scientific objectives, methodological approaches, ethical principles and outlines a scientific agenda for the systematic development of ACI as a discipline. Its purpose is to understand the interaction between animals, technologies and contextual elements of the environment in which they live.

Despite the increasingly number of studies, the design experiments in the context of ACI are still at an early stage and its approaches are mostly based on the knowledge of Human-Computer Interaction discipline and traditional practices of User-Centered Design. Research in this context has tested different technologies (Hirskyj-Douglas et al. 2018), adopted different methodologies (French et al. 2017) and involved different species. An idea of these experiments can be seen in the research by Hirskyj-Douglas and his colleagues (2018). After an extensive literature review of the field, the authors identified and classified the technologies adopted in ACI from their forms of use: tangible and physical; haptic and wearable; olfactory; screen-based; and tracking. These technologies used sound interfaces, biotelemetry collars, GPS, thermal cameras, touch screens, among others, and aimed at the control, communication, well-being, monitoring and playful of animals such as pigs, dogs, elephants and horses.

It is known that play is an activity shared by animals (Fava 2018). Because play is intrinsically motivated and performed for the pleasure of the activity in itself (Huizinga 2007), it represents a characteristic of animal welfare (Oliveira et al. 2010), since it only occurs at times when they are not subject to stress situations. In the context of social play, animals develop play signals to know whether they are in a play activity or not (Burghardt 2005). These signals may perform different functions during play and can be of several types, such as postures, odors, facial expressions, vocalizations. Recognizing those signs may be paramount for defining if an activity is play and to engage with playing experiences in an interspecies' context. In this sense, a design perspective, through prototyping, experimenting and co-creating in playful interaction

contexts, may lead us to a better understanding of play itself and of what is involved in the complex interspecies playful interactions.

The exploration of playful interactions is one of the main objectives of ACI studies. These studies explore, for example, playful interactions mediated by technology as a potential way to improve the quality of life of animals (Alfrink et al. 2013; Geurtsen et al. 2015; French et al. 2018) as well as interspecies interaction design as a form of sensitization for the relationship between humans and non-humans animals (Cheok et al. 2011; Westerlaken and Gualeni 2014; Baskin and Zamansky 2015).

In the following section will be discussed four ACI (game) design experiences: a study with visitors of a zoo conducted by Sarah Webber and her colleagues (2017); an experimental game design activity with children by Patricia Pons and Javier Jaen (2017); an exploratory game design research with two orangutans conducted by Hannah Wirman (2014); and an exploratory (game) design exercise involving an ant colony led by Michelle Westerlaken and Stefano Gualeni (2016). It will be seen, from the point of view of designers and users, how empathy forms and characteristics can possible manifests during the interspecies game design activity.

4. EMPATHY-RELATED CHARACTERISTICS IN INTERSPECIES GAME DESIGN

In a study conducted at the Melbourne Zoo, Australia, Sarah Webber and her colleagues (2017) designed and analyzed an interactive installation for six orangutans to understand the forms of empathy experienced by humans by observing animals interacting with technology (Fig. 1). The team developed four interactive applications for the animals and identified three specific strategies to evoke empathic responses from visitors: (1) enable visitors to observe animals' natural behaviors in close proximity; (2) make visible to visitors the orangutans' cognitive capabilities; and (3) allow visitors to observe differences between individual animals' behaviors and preferences. For four weeks the researchers conducted semi-structured interviews with 25 visitors to discuss aspects of the interaction, such as what they had learned from the experience, how their perception of animals was affected, and what were their impressions about the facility. The authors perceived that distinct forms of empathy are manifested.

In the cognitive aspect, empathy was revealed in the reflection on the animals' intention to interact: "they're not being rewarded for interacting with the technology. So, in that way it's a good thing because it's more free exploration, not sort of training to use it". Interviewees observed different forms of interaction and pointed

out reflections on desire of the animals in the interaction: “what’s really interesting is that they’re using the back of their hands to play with the patterns and she’s obviously intrigued”; “they seem to enjoy it”. Learning aspects and forms of intelligence were also observed, which changed the visitors’ perspective towards the animals: “They can do a lot more than I thought, especially I didn’t think they could do things with technology”. The perception of rapid learning in the interaction with the system also indicated a reflexive engagement with the animals and a particular interest in their intrinsic state: “the challenge of the program is trying to work out a variety of things, they’ll always have to be reviewing this, because I would say, with most animals, if they can solve certain problems they will be able to get to a level and once they get there they’ll get bored”. Perceptions of similarities between orangutans and humans were also considered. This, in fact, is an element that plays an important role for empathy since people are more inclined to empathize to animals by recognizing in them human characteristics (Butterfield et al. 2012).

Fig. 1
Interactive projections powered by a Microsoft Kinect in use by an orangutan.

Responses related to the experimentation of emotional empathy have also been striking: “I’m a bit in love with them anyway. So, anything that is provided that can help them and improve them and make their lives interesting, I think is fascinating”. This is a positive indicator to reinforce perceptions about the benefits of using technology in contributing to positive attitudes towards animals and their potential for improving their quality of life. The results of this project demonstrate that interspecies empathy can be evoked through interaction design from an observatory point of view. The act of observing animals while they interact with technology can be a way of triggering perspective-taking and identity that may establish reflective thinking and different forms of connection with animals.

Patricia Pons and Javier Jaen (2017), on the other hand, carried out a research that allows us to observe these manifestations in the context of the design activity. The authors conducted an experiment where children aged from 5 to 13 years old, patients from a hospital in Spain, assumed the role of game designers to create interspecies games between humans and animals. The children worked individually with the researchers in order to create scenarios for two games, each one for a different animal. The research method involved a pre-questionnaire (to understand the child's knowledge and feelings about the animal before designing the game), a semi-structured interview conducted during the procedure (so that the researcher could understand the game and guide the design process) and a post-questionnaire (to, among other objectives, encourage the child to reflect on his or her design, and thinking about how the animal would enjoy or perceive the game).

Despite the fact that the animals were the focus of the project, their absence in the design activity limited and conditioned the results to the children's previous knowledge of both species and the use of technology. The results showed that many of the solutions centered on the human aspect without considering the implications of the game for the animal. On the other hand, the experience was significant to generate interest and positively impact their opinions about the animals. At the end of the process, they showed interest in knowing more about animals, especially the wild ones. They also considered the game as a tool to increase the animals' skills such as speed, dexterity, and development of smell. These perceptions highlight several aspects of design and games: the importance of involving animals as part of the design process (as argued by Mancini 2011); the potential that games have for learning; the potential quality to empathy sensitization, such as perspective-taking, reflection and relationship-building to name a few.

In another project, Hannah Wirman (2014) conducted an exploratory game design activity with two orangutans at a rescue and rehabilitation center in Indonesia. The researcher introduced computer technologies – particularly touch screen interfaces – and experimented with different games in which the orangutans could perform a set of simple interactions such as moving objects, making items disappear by touching, drawing, selecting and watching videos. Among the objectives of the study were the improvement of the quality of life of orangutans in captivity and the discussion about how games can be used as a way of facilitating interspecies interaction.

Although physical similarities between orangutans and humans suggested a human-like interaction experience – fact that could be observed, for example, in the participants responses of the study conducted by Sarah Webber and her colleagues (2017) –, Wirman's experience revealed limitations of such a pre-conception in at least four aspects: input mechanisms – games were not designed to respond to the interaction used by animals, such as the palm of the hands, wrist, licks, legs, feet and applied force; viewing angle – the orangutans may interact too close (Fig. 2) or too far from the screen, upside down, and the interaction was generally dispersed; software/hardware – the screens were licked, touched and often destroyed; and continuum of play practices – the animals interaction with technology was always competing with other forms of play, and in general, could not be determined when one game started and another ended.

Fig. 2
Orangutan Bento observing orangutan-proof touch screen 'too close' with his keeper.

These are perceptions that are mostly seen in the context of participatory design. This activity demands the adoption of a posture based on dialogism, iteration and open mind to deal with different types of experience. The design and game activities are commonly frustrated, and the researcher or the game designer needs to be prepared to deal with this quality of the process as Wirman says: "Sometimes, I assume, I have been trying to teach them to be what they cannot be. This has occasionally led to feelings of great incompetency, which I am little by little learning to let go and allow control from my side to theirs". The researcher adds: "If I had taken the route to really teach (read: condition) the apes to 'correctly' use and play the games I made, this would have been a step away from my very understanding of play itself" (Wirman 2014, 113). The immersive experience of the researcher was able to promote an empathic experience, which resulted respecting the singularities of the animal hence the observation of new facts about its forms of behavior, interaction and fun.

Unexpected events are a characteristic of the fundamentally exploratory design process (Brown 2009) and the designer needs to be sensitive to perceive possible trends from these episodes. This can be observed in a project developed by Michelle Westerlaken and Stefano Gualeni (2016). Westerlaken acquired a colony of ants and kept it in her work environment for a period of three months. During this time, she made daily observations, studies and small interventions in the colony's arrangement to see how the ants would react. One day the ants found a small gap between the plates of their enclosure and traced an escape route. From this event, the project took a course that was made possible by the empathic relationship that Westerlaken established with the ants.

Inspired by the ants' behavior the researchers sought to expand moral consent to animals and critically rethink our relationships with them. Seeking this they promoted a provocative and speculative activity where students of interaction design and games from a Swedish University should design scape room game prototypes so that the ants could potentially play (Fig. 3). The activity was relevant to promote empathic-related skills as reflective thinking, perspective-taking, identity, agency and communication.

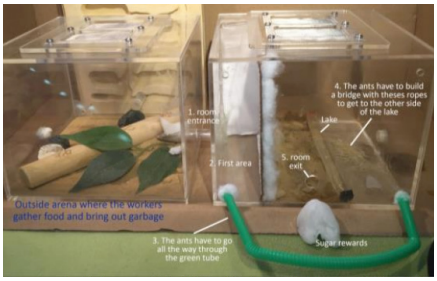


Fig. 3
One of the designed prototypes that propose an escape room in which the ants enter into a small room on the left of the box. The ants then have to crawl through the green tube to enter a bigger area.
The ants can escape the room after crossing a small lake by building a bridge using small ropes.

After the activity the students answered a questionnaire commenting on the implications of designing interaction scenarios for ants: "it should not be dangerous. We should respect these small animals."; "we created a design [in which] the ants can be trapped forever without food. We almost went ahead and presumed they're smart enough to figure [this] out. I feel guilty about this". It also could be noticed that, like the experience of observation with the orangutans (Webber et al. 2017), the workshop changed the way they observe the ants: "it was very interesting to design for something that you have absolutely no clue about. I feel more close to the ants (feels like that). And I can identify more since I know more about them.";

"I think we view them as much smarter animals now."; "We almost humanize them by saying things are 'fun' and all. I don't know how much of this is true, but it does make me wonder". These critical reports show that, through involvement with another promoted by a game design activity, it is possible to raise issues related to the human condition, such as communication links, relationship-building, cognitive expansion and systemic vision.

Finally, the researchers conducted a playtest experience with the prototypes. For five weeks, they watched the ants interact with each of them – they managed to escape from three of them. The experience was transmitted online with the aim of generating conversations and reflections on the ideas prompted by the project. This situation stimulated several online discussions and elicited varying degrees of sensitivity about how people perceived the experience and how the ants interacted with the prototypes. While some were engaged in the project, others discussed ethical aspects of the experiment.

In general, the research revealed that the practice of design with an interspecies way of thinking allowed "through unexpected situations, to stimulate new thoughts, alternative points of view and forms of involvement not previously experienced." And the ants "acting, escaping, responding, and appropriating artifacts unexpectedly" actively influenced the way in which these transformations took place and the way the project evolved.

5. FINAL CONSIDERATIONS

In this work it was investigated how empathy could possibly emerge from interspecies game design activities. It was possible to observe four distinct experiences where empathy-related characteristics were manifested from the observation of animal-technology interactions as well as from a designer perspective during interspecies interactions. Discussions have shown that design and games have specific qualities and general characteristics capable of enhancing the development of empathy that go beyond the human perspective. The empathic relationship with the animal can occur both indirectly, through observation and directly, through an immersive experience in a dialogical and collaborative interaction with animals.

The development of empathetic abilities, such as immersive experiences, perspective-taking, reflective thinking and relationship-building may turn us more open to the perception of new forms of consciousness in the animal world and to access new phenomenological worlds. This means perceiving animals from their biological individuality. Perspective that will possibly bring

positive influences also to the expansion of human consciousness as it makes it possible for new forms of relationships to emerge.

In an ecological perspective for ACI it is necessary to keep in mind that the animal is connected to its own space and the human insertion in this context will show some limitations of traditional User-Centered Design approach. It is not possible, for example, to present the game's instructions to the animal or to question the animal about its impressions regarding the interaction design as we can do when conducting participatory design sections and interviews with humans.

This complex and uncertain scenario, which presents a diversity of unexpected phenomena, is, in fact, the space of design. It is in this environment that the designer acts to restructure theories, strategies of action, and forms of knowledge. Context that is relevant for the exploration of playful design possibilities as well as the expansion of the Game Design field. In this sense, the conception of Design, which was already migrating from product design to the design of immaterial solutions, may also involves the challenges of experimenting with an ecological vision aimed to understand non-human qualities.

REFERENCES

Alfrink, Kars, Irene van Peer, Marinka Copier, Clemens Driessen, and Marc Bracke. *Pig chase.* Playing with Pigs Project, 2013.

Baskin, Sofia, and Anna Zamansky. *The Player Is Chewing the Tablet!* In Proceedings of the CHI PLAY '15, London, UK, 5–7 October 2015: 463–468, 2015.

Batson, C. Daniel. *These things called empathy: Eight related but distinct phenomena.* In The social neuroscience of empathy, Jean Decety and William Ickes (eds.). MIT Press, Cambridge, 3–15, 2009.

Belman, Jonathan, and Mary Flanagan. *Designing games to foster empathy.* Cognitive Technology, 14 (2), 5-15, 2010.

Berenguer, Jaime. *The effect of empathy in proenvironmental attitudes and behaviors.* Environment and Behavior, 39(2), 269-283, 2007.

Brown, Tim. *Change by design: how design thinking transforms organizations and inspires innovation.* New York: Harper Collings, 2009.

Brown, Tim, and Jocelyn Wyatt. *Design thinking and social innovation.* Stanford Social Review, 2010.

Burghardt, Gordon M. *The Genesis of Animal Play: Testing the Limits.* Cambridge: MIT Press, 2005.

Butterfield, Max E., Sarah E. Hill, and Charles G. Lord. *Mangy mutt or furry friend? Anthropomorphism promotes animal welfare.* Journal of Experimental Social Psychology 48 (4): 957–960, 2012.

Cheok, Adrian, Roger Tan, Roshan Peiris, Fernando Owen, James Soon, Imiyage Wijesena, and Janyn Sen. *Metazoa ludens: mixed-reality interaction*

and play for small pets and humans. Systems, Man and Cybernetics, Part A: Systems and Humans, IEEE Transactions on 41.5: 876-891, 2011.

Darvasi, Paul. *Empathy, perspective and complicity: How digital games can support peace education and conflict resolution.* UNESCO MGIEP Working Paper, 2016.

Faber, Matthew, and Karen Schrier. *The limits and strengths of using digital games as "empathy machines".* UNESCO MGIEP, 2017.

Fava, Fabrício. *Fluke: repensando a gamificação para a aprendizagem criativa.* Doctoral Dissertation. Catholic University of São Paulo, 2018.

Fava, Fabrício. *A emergência da gamificação na cultura do jogo.* In: Santaella, Lucia, Nesteriuk, Sergio and Fava, Fabricio. (Orgs.) Gamificação em Debate. Blucher: São Paulo, 2018.

French, Fiona, Clara Mancini, and Helen Sharp. *Exploring Research through Design in Animal-Computer Interaction.* In: Proc. Fourth International Conference on Animal-Computer Interaction, ACI2017, 21-23 Nov 2017, Milton Keynes, United Kingdom, ACM Digital Library, 2017.

French, Fiona, Clara Mancini, and Helen Sharp. *High tech cognitive and acoustic enrichment for captive elephants.* J. Neurosci. Methods, 300, 173–183, 2018.

Geurtsen, Annika, Marteen H.Lamers, and Marcel J.M Marcel J.M Schaaf. *Interactive digital gameplay can lower stress hormone levels in home alone dogs: a case for animal welfare informatics.* In 14th International Conference on Entertainment Computing (ICEC 2015) Switzerland, 9353, pp. 238–251, 2015.

Greitemeyer, Tobias. *Playing video games cooperatively increases empathic concern.* Social Psychology, 44 (6), 408-413, 2013.

Hess, Justin L., and Nicola Fila. *The development and growth of empathy among engineering students.* ASEE's 123rd Annual Conference & Exposition, New Orleans, LA, June 26-29, 2016.

Hirskyj-Douglas, Ilyena, Patricia Pons, Janet C. Read, and Javier Jaen. *Seven Years after the Manifesto: Literature Review and Research Directions for Technologies in Animal Computer Interaction.* Multimodal Technologies and Interact, 2 30, 2018.

Hoffman, Martin L. *Empathy and moral development: Implications for caring and justice.* Cambridge, UK: Cambridge University Press, 2000.

Huizinga, Johan. *Homo ludens: o jogo como elemento da cultura.* São Paulo: Perspectiva, 2007.

Leonard, Dorothy, and Jeffrey F. Rayport. *Spark innovation through empathic design.* Harvard Business Review, nov-dec, 1997.

Mahood, Chad, and Michael Hanus. *Role-playing video games and emotion: how transportation into the narrative mediates the relationship between immoral actions and feelings of guilt.* Psychology of Popular Media Culture, 6(1), 61-73, 2017.

Mancini, Clara. *Animal-computer interaction (ACI): a manifesto.* Interactions, 18 (4): 69–73, 2011.

Mancini, Clara. *Animal-computer interaction (ACI): changing perspective on*

HCI, participation and sustainability. CHI 2013 Extended Abstracts, 2013.

Mancini, Clara. *Como o design de software pode suportar o surgimento de interação entre animais e computadores.* Revista iMasters, 23: 60-64, 2017.

Mattelmäki, Tuuli, and Katja Battarbee. *Empathy probes.* In Proc. Participatory Design Conference 2002, CPSR Palo Alto 266-271, 2002.

Mattelmäki, Tuuli, Kirsikka Vaajakallio, and Ilpo Koskinen. *What happened to empathic design?* Design Issues, 30 (1): p.67-77, 2014.

Murray, Janet H. *Hamlet no holodeck: o futuro da narrativa no ciberespaço.* São Paulo: UNESP, 2003.

Oliveira, Ana F.S., Andre O. Rossi, Luana F. R. Silva, Michele C. Lau, and Rodrigo E. Barreto. *Play behaviour in nonhuman animals and the animal welfare issue.* J Ethol 28:1–5, 2010.

Pons, Patricia, and Javier Jaen. *Designing interspecies playful interactions: studying children perceptions of games with animals.* Proceedings of The Fourth International Congress on Animal Computer Interaction, 2017.

Schrier, Karen. *EPIC: A framework for using video games in ethics education.* Journal of Moral Education, 44 (4), 393-424, 2015.

Stickdorn, Marc, and Jakob Schneider. *This is service design thinking: basics, tools, cases.* Amsterdam: BIS Publishers, 2010.

Suri, Jane F. *The next 50 years: Future challenges and opportunities for empathy in our science.* Ergonomics 44, 14, 1278-1289, 2001.

Webber, Sarh, Marcus Carter, Sally Sherwen, Wally Smith, Zaher Joukhadar, and Frank Vetere. *Kinecting with orangutans: zoo visitors' empathetic responses to animals' use of interactive technology.* In Proceedings of the CHI 2017, Brisbane, Australia, 28 November–1 December 2017: 6075–6088, 2017.

Westerlaken, Michelle, and Stefano Gualeni. *Felino: the philosophical practice of making an interspecies videogame.* Proceedings of the Philosophy of Computer Games. Istanbul, November 13-15, 2014.

Westerlaken, Michelle, and Stefano Gualeni. *Situated knowledges through game design: a transformative exercise with ants.* The Philosophy of Computer Games Conference, Malta, 2016.

Wirman, Hanna. *Games for/with strangers — captive orangutan (pongo pygmaeus) touch screen play.* Antennae, 30: 105–115, 2014.

Wright, Peter, and John Mccarthy. *Empathy and experience in HCI*. CHI 2008 Proceedings. Florence, Italy, Abril 5-10, 2008.

Building creative literacy skills through cooperative and competitive gameplay: the case of *See, Hear, Touch no Evil*

JOSÉ RAIMUNDO,[1] **PEDRO CARDOSO,**[2]
MIGUEL CARVALHAIS,[3] **ANTÓNIO COELHO,**[4]
JOÃO JACOB[5]

ABSTRACT

This paper presents our research on a collaborative play-oriented framework for creative literacy, a much-needed skill to improvise solutions in today's competitive setting. Although digital media has democratised tools and resources, it also contributes to the risk of alienating one's personal creative potential, and/or replacing it with technical expertise, leading one to arrive to solutions that are not creative but simply express the affordances of the medium/ system being used.

We believe that games are able to address this issue effectively, because they are able to generate experiences focused on the exchange and articulation of knowledge between people, while being focused on problem-solving strategies.

To explore how games can be used for such purposes we present a case study – *See, Hear, Touch no Evil* –, a multiplayer, role and turn-based game where players are free to compete, cooperate or collaborate with the intent of stimulating emergent gameplay. We chose this because creative choices often call for the ability to accommodate opposing perspectives in order to trigger unexpected solutions.

[1] INESC TEC/ Faculty of Engineering, University of Porto, Porto, Portugal — joseraimundo3d@gmail.com

[2] INESC TEC/ Faculty of Fine Arts, University of Porto, Porto, Portugal — pcardoso@fba.up.pt

[3] INESC TEC/ Faculty of Fine Arts, University of Porto, Porto, Portugal — mcarvalhais@fba.up.pt

[4] INESC TEC/ Faculty of Engineering, University of Porto, Porto, Portugal — acoelho@fe.up.pt

[5] INESC TEC/ Faculty of Engineering, University of Porto, Porto, Portugal — joao.jacob@fe.up.pt

We conclude with the fact that the complex game mechanics of this game generated too much cognitive effort on players, and that empirical evidence showed that creativity can extend beyond play itself, given that criticism is accepted, something that may draw players and the audience into certain designer roles, able to build new hypotheses.

KEYWORDS

Creative Literacy;
Games, Design;
Ideation;
Collaboration;
Emergence.

1. INTRODUCTION

According to Cariani, understanding the processes that underlie the concept of emergence can help in reaching out for creative results (2008, 4). This led us to believe that if games can sustain such processes then they are also good means for cultivating creative literacy. Yet, emergent gameplay, as Bycer points out, is hard to design because it involves predicting unexpected behaviours from projected constraints, rules and mechanics (2015).

According to Bogost *et al.*, a creative approach to something also calls for accepting risks that some may be not so eager to take (2005). With this in mind, we believe that cultivating creative literacy through games can help empowering individuals to deal with the unexpected.

We chose games because, as Sicart claims (2014, 5), their playfulness can be highly engaging and useful for "expressing our being in the world". The potential that games have for teaching has already been profiled by Gee (2004). Games that provide space for questioning can help pave the way towards literacy as players can contribute with new aesthetical, ethical and socially meaningful hypotheses (Magro & Pierce 2016).

With this in mind, we are working on a framework for cultivating creative literacy, based on a set of procedures and guidelines for building games capable of building creative skills.

We have opted for a Design-Based Research methodology, since developing games for building creative literacy calls for theory and practice, sustained and refined by one another (Wang & Hannafin 2005, 6). With this in mind, we have developed a prototype of a board game in which players choose to either compete, cooperate

or collaborate[6] in a contrived environment. This prototype is our first case study (detailed in section 3), and aims to explore the following questions: *Can scarce information and challenging game settings trigger emergent gameplay? Is it possible to support cooperation and competition and still have collaborative emergent gameplay?*

1.1 WHAT IS CREATIVE LITERACY AND WHY IT IS RELEVANT FOR TODAY'S CITIZENRY

According to a Cambridge Assessment Report (2018), literacy is the mastery of abilities or processes to better understand our surroundings (e.g. language, aesthetics, etc.). In turn, creativity is a process still wrapped in mystery and in paradox, between developing something out of nothing or through constraints (Boden 2004, 11). Ribeiro bears witness for today's abundance of technical experts and for the scarcity of creators, since transferring know-how and acting according to established work practices seems to be easier than promoting an innovative *posture*.[7] Furthermore, if no one is born with expertise and know-how, should we attempt to learn or to teach for being creative? He informs us that this discussion has not yet reached consensus (2018, 194), and that current teaching practices are prone to establish rigid personalities (*ibid.,* 197). Cultivating creativity, however, can only be done by increasing the number of creative acts, make them intrinsically desirable and possibly turning those into a habit (*ibid.,* 211).

Nowadays, individuals are expected to be creative, to learn to face adverse conditions, or to improve what became ineffective, tasks once thought of to be better addressed by so called geniuses. Vygotsky counters this last statement arguing that acts of geniuses are just small drops of the creative human potential, which in turn can only be harnessed through diverse socio-cultural interaction (2004, 11). As such, we believe that cultivating a creative posture can stimulate lifelong learning, by allowing one to become open-minded, curious, risk-taker, able to understand difference and diversity, and to be attentive to their surroundings (Mohamed 1986).

[6] In a competitive game, players have opposing goals whereas in collaborative games players share these. Cooperative games alternate between competition and collaboration (e.g. the classic cooperative game is an iterative version of the prisoner's dilemma).

[7] Posture (definition): is seen here as the ways or habits through which individuals position and interact with their environment and each other. The scope of assumed postures by creators and how and why they are taken is thoroughly documented by Ribeiro (2018, 121-125).

1.2 COMPETENCES NEEDED FOR CREATIVE LITERACY

All endeavours need *motivation* to endure challenges and adversity, and learning helps raising confidence on the task at hand. As Anthropy claims, learning can be encouraged by open access to creative knowledge resources, which in turn allows for skill building and empowerment (2012, 3,7,45). Scott and Ghinea argue that motivation can be fostered by nurturing one's self-worth, by relating fantasy game activities to real world roles (2013, 1,4). Koster further asserts that motivation for learning can be found within experimental, playful and meaningful game spaces (2005, 40).

Play is explained by Nachmanovitch as a natural process for developing capabilities in a fun and rewarding way (1991, 42), while fun can be triggered by simulated experiences and by exploring this relative freedom under controlled game settings (Frasca 2007,78). Conversely, Söderberg (2002) states that effort can be a source of motivation and involvement, namely when goals transcend a single individual and aim at a greater good. With this in mind, a *playful attitude* seems to be a requirement here.

Emotional involvement seems to play a relevant role here as well, since emotions are a significant part of cognition and primordial processes for reacting to our surroundings in a more intense, motivated, and involving way. They are also key to reacting quickly when compared to cognitive assessment (Norman 2004, 13). Also, in our view, emotional reactions to a game can hint at unexpected design hypotheses. E.g. Juul (2013, 27) states that evoking positive emotions for winning can be useless sometimes when player interest resides on exploring the game's sandbox through failure. According to Bogost *et al.*, arcade game operators strive for addiction to make players feel compelled to continue, yet the author's concerns lay beyond this: it is what videogames have to say through their procedural rhetoric that counts, i.e. the meaningful ideas for discussing how and why systems work in the real world and that are able to stimulate behaviour change (2007, 46-47).

We also think that being *attentive to serendipity* can be of great value, since, according to Melo, that has the potential for gathering unpredictable information by observing into unconsidered discipline fields or seemingly unrelated subject matters (2018, 45). As such, malleable procedures and collaborative practices can be adequate for building creative literacy, as we regard them to be similar

to Melo's *six serendipity heuristics*.[8] Toop's account on 20th century music challenges seemed already aligned with some of Melo's heuristics, e.g. the ability to bypass the composer's intentions through complex and flexible algorithms that embrace chance and accident (2004, 240-241).

We envision that games can provide learning contexts for individuals with diverse socio-cultural backgrounds, something resonating with McGonigal assertion that games provide fun and inclusive contexts for individual contribution and for joint exploration to occur (2011, 97), and that by following such player, game designer, or theorist perspectives one may solve real-world problems more easily (2011, 7). This is also backed by Galloway, in the sense that he argues that the interaction-driven nature of game systems supports simultaneous individual experiences (2006, 2). For instance, serious games can stimulate critical thinking, cooperative attitudes and awareness for one's working surroundings and exploring the combination of resources as a team (Agogué, *et al.* 2015, 4, 6).

1.3 EMERGENT GAMEPLAY

The term *emergence* can occur across several disciplines and accordingly assume diverse meanings. Cariani found it to be closely related to creativity, as it implies something novel that springs from a given process (2008, 4,11). Waggoner argues that emergent gameplay raises from re-discovering and repurposing game resources beyond their designed intentions (2013, 104), and for this to occur Bycer suggests open-world and open-ended game systems to be the fitting contexts for that to happen. However, he also asserts that when everything is grounded on openness, player experiences become hard to predict and to develop (2015). Therefore, and because developing emergent gameplay is risky, we need to thoroughly test the game and assume an inquisitive posture to explore new interactive options (Sweetser, 2008, 417).

[8] Melo's serendipity heuristics are: *Unexpected Interaction, Encouraging Exploration, Guiding the Interaction, Interactor Cedes Control, Linking Information*, and *Timely Interactions* (2018, 220).

Sensors and actuators, the elements of an *actor's input/ output structure*,[9] and their diverse states are crucial for player and game system interaction, as they shape gameplay response and behaviour (Cardoso 2016, 161-166). As such, we find that having access and being able to choose amongst several combinations of such states can lead to the emergence of cooperative and competitive player behaviours, which can be correlated to Bartle's MUD[10] player types, and that according to him, although some players display propensity to act in a given way, they also attempt to explore gameplay differently (1996).

So, *collaboration* can also play a role in our study, as it can be regarded as team effort between players that share the same goals and that are therefore rewarded and penalized as a group, as opposing to competition, that consists on expressing dominance over other players. In their study, Zagal *et al.* found evidence on how distributing abilities and skills, allowing communication and sharing of resources amongst players in an open manner could stimulate collaboration in games (2006, 31). Knizia's *Lord of the Rings* (2000) is a good example of such approach because it was designed with mechanics that hit players badly from every direction should any of them decide to tackle a challenge alone, making it impossible to endure the game singlehandedly. This example can throw down the generic idea that competition is inevitable in games as it relies in active communication and timely sacrifices.

2. THE CASE STUDY OF *SEE, HEAR, TOUCH NO EVIL*

See, Hear, Touch no Evil is a three-player turn-based game, where players can collaborate or compete to accomplish their main goal: exiting the game field. They are able to do it by collecting energy that allows them to open the exit, and to collect oxygen points in order to remain operational, while defending from or attacking their enemies.

[9] Actors are every game element that is able to act in a game, including both the player and game-system. The actors' actions are what changes the game state and what makes it dynamic. An actor's input/ output structure, as described by Cardoso (2016), is comprised of *sensors, processing cores* and *actuators*. Sensors allow the detection of signals, processing cores operate and transform sensor readings to be sent to the actuators, and actuators transmit those results to the environment in specific ways.

[10] MUD or Multi-User Dungeon (definition): are role-playing, text-based, networked games supporting a wide number of players, while sustaining a virtual world for play to unfold.

The following question jumpstarted our design: *Is it possible to balance cooperative and competitive dimensions and still have collaborative emergent gameplay?* Citing Bartle (2004, 128) and Koster (2005), Rayan argues that, although player motivation is something that needs further research efforts, what appears to drive it is individual gratification and pleasure (2006, 348). As such, we have considered self-interest as a common reason to compete and to collaborate, and devised a game where exiting a level can be accomplished by assuming both postures, yet with consequences. Knowing how these postures affect players' chances to attain the goal, while having freedom to choose between them, is something we expect to do in the future.

We chose analogue prototyping as this approach lends itself to quickly test game potential, due to readily accessible materials that offer multiple possibilities, (Manker & Arvola, 2011, 280). Also, it is easier to understand the governing mechanisms behind analogue games when compared to a digital game complexity (Zagal *et al.* 2006, p.25). Plus, player attitudes were autonomous, with no supervision on our behalf (in opposition to what happens in games with a DM),[11] which heightened the consequences for the players' actions.

2.1 BASIC RULES

This game's gameplay is sustained by the elements represented in Fig. 1, taking place on a board depicting the game world which is divided into a grid of hexagon cells, with one entry point and one exit point (Fig. 2). A complementary matrix, printed in a sheet of paper, serves to record players statuses regarding their energy and oxygen,[12] ranging from zero to five slots, arranged in columns according to player (Fig. 3). An adapted six-sided dice provides random input for announcing events, set players' movement range, and appoint penalties (Fig. 4).

[11] Dungeon Master (DM) is a human agent or an automated subsystem that supervises players' actions and constrains them to a given narrative; and is required for RPG game genres.

[12] The time attribute was abandoned during development because it became irrelevant: continuous depletion of oxygen was enough to provide a sense of urgency and, ultimately, limiting the duration of each play session.

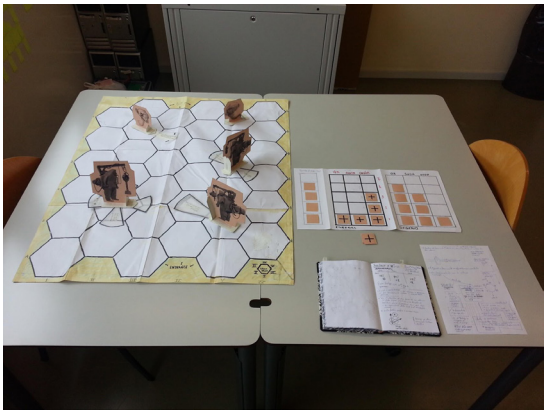


Fig. 1
Game board, complementary status sheet, avatars, enemies and development diary.

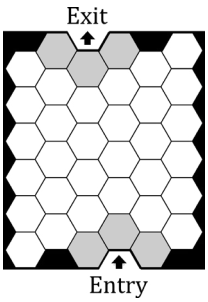


Fig. 2
Game board with entry and exit points.

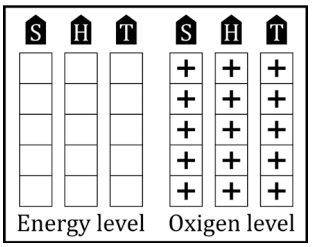


Fig. 3
Record sheet with starting levels for oxygen and energy.

Fig. 4
Dice for random input, the upper face shows V (5 in roman numerals) and E, standing for coordinates in the gameboard.

Player movement is carried along the X and Y axis depending on coordinates resulting from dice rolls (Fig. 5). There are three types of players and one enemy represented in billboard pieces (Fig. 1). Each player can perceive their surroundings according to only one sensorial modality, which is constrained in direction and range. *Sight* senses ahead, *Hearing* sideways and *Touch* in both directions (Fig. 6).[13] Enemies can sense around in all directions within a three-cell radius and they always attack when sensing someone with that area (Fig. 7).

[13] We tried to balance player characteristics (e.g. walking and aiming range) to stimulate collective strategy-finding.

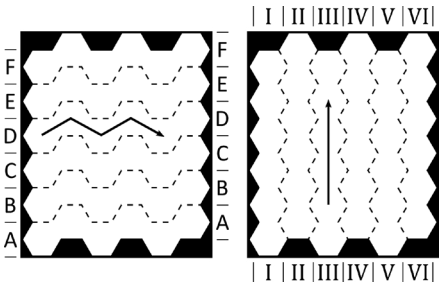


Fig. 5
Game board with entry and exit points.

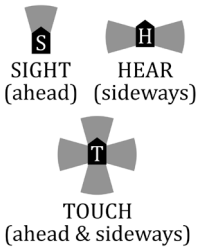


Fig. 6
Player type sensing directions.

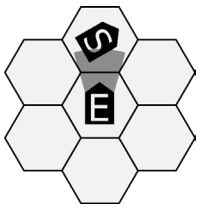


Fig. 7
Enemy sensing directions and range

Players start with no energy and a full supply of oxygen (Fig. 3). They need a full energy supply in order to exit the play area, while managing their oxygen supply that depletes one slot per four turns. If out of oxygen, their actions are disabled. Resuming play depends on donations from the other players which avatars need to be nearby – one player can transfer one of his oxygen slots to another player (Fig. 8).

Events occur when enemies, oxygen tanks or batteries are spawned and positioned randomly in the gameboard (Fig. 9). In each turn, players can walk, attack, dodge, ask for help, or alert unaware players of incoming attacks.

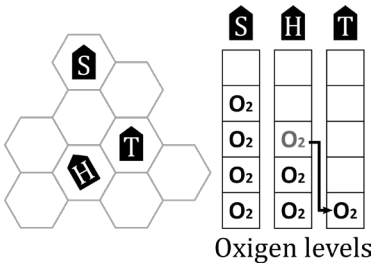


Fig. 8
Donating oxygen is only accomplished in proximity.

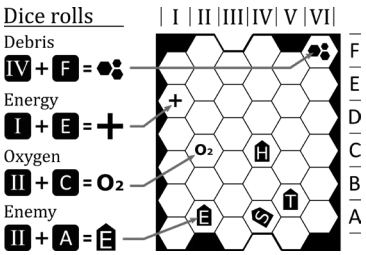


Fig. 9
Positioning events through dice rolls.

Exiting the play area exhausts players' energy supply in one shot, and activating the door depends on the value of a dice roll (Fig. 10). Exiting alone allows a player to carry three slots of energy to the next level. Conversely, holding the door open allows one to take the other players to the next level. A Player's attempt to exit alone can also be disrupted by other nearby players that toss the dice for a chance to prevent that from happening (Fig. 11).

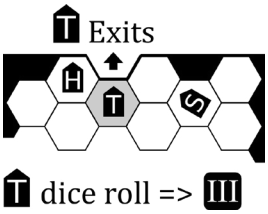


Fig. 10
Touch is able to exit.

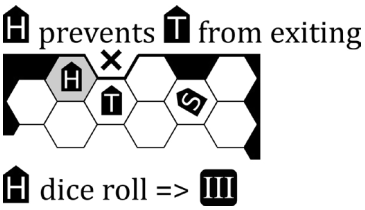


Fig. 11
Hear prevents *Touch*'s exit.

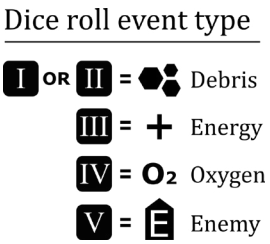


Fig. 12
Events according to dice roll.

Rounds start by determining the *event* type (Fig. 12) and determining its location (Fig. 9). If an event is *perceived* by or endangers a player, he/she takes precedence, otherwise a normal turn sequence applies: *Sight, Hear* and *Touch*. Players *move* in patterns according to their sensorial modality, and position and orient for the next round aligning themselves perpendicularly to one of the cell sides (Fig. 13). Movement range functions according to such constraints but the player can move to any position within said range.

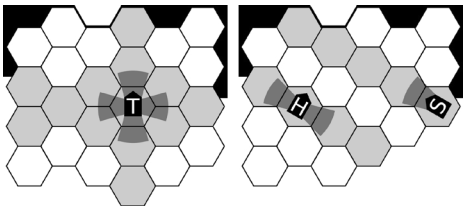


Fig. 13
Perceivable patterns according to player type.

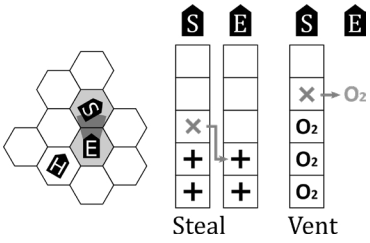


Fig. 14
Enemy attack is successful. Enemy steals one energy slot, unless players don't carry energy, in which case the enemy vents one oxygen slot from the player.

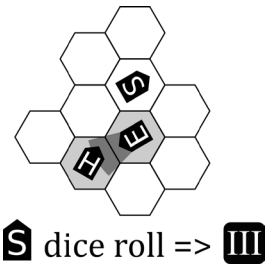


Fig. 15
Player gets to dodge thanks to a dice roll value. The enemy can try to attack other players.

Successful enemy attacks disable players and may steal the player one energy slot – at close range this is always successful. If players possess no energy, enemies puncture their suit, venting oxygen slots (Fig. 14). Stolen energy can only be reclaimed by attacking in the same round. Players that are under attack can try to call for help, to alert others or to dodge (Fig. 15). However, this disables said players for the rest of the turn. A call for help does not prevent damage. Dodging allows enemies to attack other players. Successful player attacks make enemies drop one energy slot and disappear.

2.2 DIGITAL TRANSCODING: GAINS, LOSSES AND EMERGING NEEDS

Developing a digital version granted us the opportunity to learn the implications that stem from transcoding an analogue universe onto a digital one. And to check if it promoted a better chance for emergent gameplay to occur. By distancing ourselves and accepting critique from those willingly involved in the development (players, programmers, observers, among other stakeholders), we were able to discover weaknesses that had not yet been found in the analogue prototype.

The digital game format gave rise to some challenges due to a phenomenon of acceleration of the pace of play, since the game system took over key-procedures originally handled by players themselves. This new pace allowed players to reach the world boundaries in a single move. Therefore and since we wanted to promote the exploration, we have limited the view of the play area and enlarged the initial space of play. Widening the playfield called for additional events to meet higher oxygen and energy demands, but also increased player disorientation as the world extended with no landmarks beyond the visible play area. We have tried to solve this by using a mini-map, which also proved insufficient to resolve this issue.

This transcoding process also obliged to design new digital means to convey information for the players through a Heads-Up-Display (HUD) and a User Interface (UI). We wanted to prevent cluttering the game view, so we opted for a HUD like *Dead Space* (2008). Energy status was shown by light appendages and oxygen through a window in a tank, both in the back of the suit. But, considering that the avatar had such a small screen size, statuses became hard to read (Fig. 16) so we have opted for hovering over that information near the playable characters themselves. For the UI, available actions are presented similarly through text and can be triggered by a box-shaped pointer placed and clicked within the player's movement range (Fig. 17).

Fig. 16
Original HUD comprised of oxygen tank with window to check level, and lighting appendages for knowing energy status. The original models scaled to game screen dimensions became too small and therefore made inspecting statuses hard.

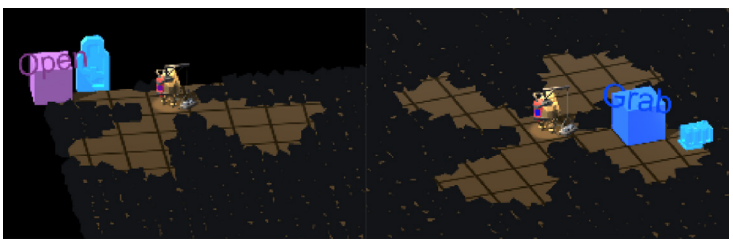


Fig. 17
In-game screenshots of the digital version with current UI.

2.3 TESTING

We understood that the game's complex gameplay was a major upgrade from the analogue prototype due to the constant need to compute manually where, how and if actions were possible, something that slowed down the game's pace and discouraged play itself. Conversely, the digital version accelerated the game's actions, since a machine was able to compute those actions much faster, and this acceleration created other problems:

1. The accelerated pace greatly affected perception of the travelled distance. Players easily reached the game world limits, hindering their willingness to explore the game world.
2. Swapping between player's turns was represented by fast camera movement with pan, tilting and awning, which, although engaging, revealed to be confusing. Therefore we believe that players require a small pause between turns to allow them to "digest" a little better their actions and surroundings.
3. Disorientation was initially thought to be useful. To enforce this, we have only allowed each player a limited perception. We now think differently. The better players grasp their surroundings and share this with others, the better they can build strategies or choose their postures (e.g. competing vs collaborating).
4. The game world doesn't have any visible landmarks, this increases disorienting regarding positioning and distances. This could be solved by placing large recognizable landmarks.

We were also open to critique from those willing to play,[14] and we were able to gather the following relevant suggestions:

1. Adding an inventory for picking additional useful items, e.g. stimpacks, items that enhance player reflexes and range at the expense of health status, like the ones used by the Terran Marines in *StarCraft* (1998) or even a shovel to divert debris.
2. Allowing players to sabotage each other may offer alternative means of sustainment, as they could steal health/ energy resources from each other.
3. Calling for help was deemed as interesting but hardly justifiable, since anyone confined into a makeshift suit would have trouble being heard by others. This further ensued the suggestion of tethering players to enable communication, but then it would also limit movement.

[14] We took some opportunities to demonstrate both the analogue and digital prototypes in various informal gatherings of game developers.

3. DISCUSSION & FUTURE WORK

With this work, we strived to develop a game for individuals to collaborate and avoid competition, a balance that turned out to be hard to achieve. For such, it was necessary to distribute sensing and movement capabilities amongst different player types, but still prevent any competitive edges over one another. Such approach was envisioned as capable to enforce thinking before committing to any action and to reflect on the potential individual role in the ensuing collective effort.

One of the features to be explored was the potential for empathy. Empathy can be established between reader and digital artworks, when the reader (the player in this case) develops mental simulations for understanding how such artworks operate (Carvalhais and Cardoso 2018, 223). So, we aimed at building a game prototype for players to *empathise*[15] with one another in order for them to gain a better understanding of each other's abilities and different field of possibilities, their different horizons of possible actions. Players' traits could then be used in particular combinations in order to devise specific strategies. With that into consideration, these emergent behaviours can then be seen as an exercise in creativity for solving particular problems.

Playtesting allowed us to draw further questions beyond those mentioned in the introduction section, which we list next, taking the opportunity to reflect a bit upon them:

1. *Can scarce information and challenging game settings trigger emergent gameplay?* We are not sure if the gameplay itself was challenging enough. In the analogue prototype, acting is difficult because movement is calculated manually, being hard to keep all rules in mind. In the digital version, however, there is insufficient time to decide how to act and players get easily lost.
2. *Is it possible to support cooperation and competition and still have collaborative emergent gameplay?* As mentioned, when players compete they either have opposing goals or they are trying to accomplish their goal first. Competition differs from collaboration as it gives no certainty of wining for all parties, so

[15] Empathy (definition): Is the ability to place oneself in other's shoes, i.e. a willingness to understand the other's perspective.

players are free to alternate between joint effort, *free riding*[16] and *backstabbing*,[17] all of which can become major strategy advantages in due conditions. The analogue prototype supports to some extent all of these strategies, yet and as stated, playing was so difficult that players could not go beyond a single play session.

During the development of these prototypes, we were able to project other hypotheses beyond the original's intended goals, something we expect to explore in future studies:

1. *Does empathy play a significant role in stimulating collaborative emergent gameplay?* How can games induce empathy? The analogue prototype demonstrated that distributing different abilities amongst players does not necessarily lead to empathy (in the case at hand, those traits are just too hard for players to mentally compute or to simulate). Conversely, in the digital version, speed does not allow for time to reflect on how traits can be turned into an advantage if used together.
2. *What does it mean and what is the influence of collective success over individual success in this game? And are players able to recognize the need for collective success?* Collective or individual success can only be meaningful or influential if it is perfectly clear for players that individual actions have particular consequences (which is not the case in this prototype).
3. *What is the role of the players' educational and socio-cultural background in this game? Can we design for collaboration by turning to players lived experiences?* Insufficient testing did not allow us to infer on how and if player background influences gameplay. Again, this is a valuable question for when designing future prototypes. If they are aimed at different audiences, then they will need to take life experience into account.

[16] Free Riding (definition): happens when players are being evaluated and rewarded as a group and individual group members do not contribute as they should or as much as others do, which can harm the team or group's performance. Free Riding can be very effective in a cooperative game when the rewarding process is blind to individual contribution, possibly favouring those who do not work.

[17] Backstabbing (definition): is the act of betraying someone. It can be an advantageous competitive manoeuvre, e.g. the key to *Diplomacy* (1959) is establishing the right alliances and knowing when to backstab your allies.

In conclusion, the initial analogue prototype was led by an ambition to include too many features, and that resulted in an overly complex experience. This made us realize that future prototypes should be designed with:

1. Less features in mind, keeping context, narrative and graphics as simple as possible to facilitate development and analysis. Distributing different features across different prototypes may allow for easier testing.
2. Means or features that should ease the exchange of information and communication amongst players, as this may be key to attaining successful, in-game collaboration.
3. Rewards for smaller achievements attained collectively, something that seems to share similarities with Gee's principles (2003). Building mastery of the game in smaller steps will ease taking on larger objectives, i.e. the *Incremental Principle* (*ibid*., 201). By doing this with groups bonded by shared interests, i.e. the *Affinity Group Principle*, it will be easier to tackle goals collectively (*ibid*., 201).
4. Balanced rules capable of stimulating cooperation. For this we suggest that future research should focus on players' preferences and on what is important for them, in order to better understand the foundations of collaborative gameplay, thus being able to apply them accordingly.

Regarding the digital prototype, we already listed in section 2.3 some problems we have encountered, and added some possible solutions as well. We should point out that this digital version was a proof-of concept to inspect potential for digital transcoding, and by doing so, if that was able to further stimulate emergent gameplay. Despite the available time and our resource constraints, we believe that procedure to have been successful as we achieved a functional solution. However, in order to achieve our other goals, the game's features and rules will need to be thoroughly fine-tuned.

As-is the digital version is sustained by a single computational device, enforcing the original turn-based game, but we would also like to try to develop a real-time version where all players can act simultaneously. Given all these reasons, we believe that the digital prototype has the potential we seek and we expect to refine it in the future.

ACKNOWLEDGMENTS

The research leading to these results has received funding from the FCT, scholarship reference SFRH/BD/137169/2018.

REFERENCES

Agogué, Marine, Kevin Levillain, and Sophie Hooge. "Gamification of Creativity: Exploring the Usefulness of Serious Games for Ideation". *Creativity and Innovation Management* 24, no. 3 (2015): 415–29. https://doi.org/10.1111/caim.12138.

Anthropy, Anna. *Rise of the Videogame Zinesters: How Freaks, Normals, Amateurs, Artists, Dreamers, Dropouts, Queers, Housewives, and People like You Are Taking Back an Art Form.* New York: Seven Stories Press, 2012.

Bartle, Richard A. "Hearts, Clubs, Diamonds, Spades: Players Who Suit MUDs". *Journal of MUD Research* 1, no. 1 (1996): 19. Last modified, August 1996 at: https://mud.co.uk/richard/hcds.htm

Bartle, Richard A. *Designing Virtual Worlds*. Indianapolis, Indiana: New Riders, 2004.

Boden, Margaret A. *The Creative Mind: Myths and Mechanisms.* New York: Routledge, 2004.

Bogost, Ian. *Persuasive Games: The Expressive Power of Videogames.* Cambridge, MA: MIT Press, 2007.

Bogost, Ian, Michael Mateas, Janet Murray, Michael Nitsche, and The Georgia Institute of Technology. "Asking What Is Possible: The Georgia Tech Approach to Game Research and Education". *The International Digital Media Arts Association Journal* 2, no. 1 (2005): 59–67.

Bycer, Josh. "Examining Emergent Gameplay". 2015. Accessed December 17, 2018 at https://www.gamasutra.com/blogs/JoshBycer/20150916/253682/Examining_Emergent_Gameplay.php.

Cambridge Assessment. "What Is Literacy? An Investigation into Definitions of English as a Subject and the Relationship between English, Literacy and "Being Literate"". *Cambridge Assessment*, 2013. Accessed March 21, 2018 at http://www.cambridgeassessment.org.uk/images/130433-what-is-literacy-an-investigation-into-definitions-of-english-as-a-subject-and-the-relationship-between-english-literacy-and-being-literate-.pdf

Cardoso, Pedro. "Playing in 7D: An Action-Oriented Framework for Video Games" PhD diss., Universidade do Porto, 2016. Accessed September 27, 2018, from: http://hdl.handle.net/10216/82685.

Carvalhais, Miguel, and Pedro Cardoso. "Empathy in the Ergodic Experience of Computational Aesthetics". *ISEA 2018: International Symposium on Electronic Art*, 220–26, 2010. https://doi.org/10.5281/zenodo.1303347

Cariani, Peter. "Emergence and Creativity". *Emergência! - Simpósio Emoção Artificial 4.0*. São Paulo, Brazil, 2009.

Frasca, Gonzalo. "Play the Message: Play, Game and Videogame Rhetoric" PhD diss., IT University of Copenhagen, 2007. Accessed March 26, 2017, from: http://www.powerfulrobot.com/Frasca_Play_the_Message_PhD.pdf

Galloway, Alexander. *Gaming: Essays on Algorithmic Culture.* Chicago, USA: University of Minnesota Press, 2006.

Gee, James. *Learning by design: Games as learning machines.* New York: Palgrave Macmillan, 2004.

Juul, Jesper. *The Art of Failure: An Essay on the Pain of Playing Video Games.* London, UK: MIT Press, 2013.

Koster, Ralph. *A Theory of fun for Game Design.* Arizona, USA: Paraglyph Press, Inc., 2005.

Manker, Jon, and Mattias Arvola. "Prototyping in Game Design: Externalization and Internalization of Game Ideas". In *BCS-HCI* (2011).

Magro, Karen, and Kathleen M. Pierce. "Creative Approaches to Literacy Learning: Grappling with Enormous Problems and Huge Opportunities". *Creative Intelligence in the 21st Century*. Rotterdam: SensePublishers, 2016.

McGonigal, Jane. *Reality Is Broken: Why Games Make Us Better and How They Can Change the World.* New York: Penguin Publishing Group, 2011.

Melo, Ricardo. "On Serendipity in the Digital Medium: Towards a Framework for Valuable Unpredictability in Interaction Design" PhD diss., Universidade do Porto, 2018. Accessed September 27, 2018, at http://hdl.handle.net/10216/113140

Mohamed, Naz O. "An investigation of the relationship between early childhood education teachers' attitude on creativity and the instructional behaviour in the classroom" PhD. diss., University of Massachusetts Amherst, 1986. Accessed February 5, 2018, at https://scholarworks.umass.edu/dissertations_1/4175

Nachmanovitch, Stephen. *Free Play: Improvisation in Life and Art.* New York: Penguin Publishing, 1991.

Norman, Donald. *Emotional Design: Why We Love (or Hate) Everyday Things*. New York, USA: Basic Books, 2004.

Ribeiro, António. *O mistério da criatividade: teorias e práticas criativas nas ciências, na vida quotidiana e na educação.* Porto: Edições Afrontamento, 2018.

Ryan, Richard M., C. Scott Rigby, and Przybylski Andrew. "The Motivational Pull of Video Games: A Self-Determination Theory Approach". Motivation and Emotion 30, no. 4 (December 2006): 344–60. https://doi.org/10.1007/s11031-006-9051-8.

Scott, Michael 'Adrir', and George Ghinea. "Integrating fantasy role-play into the programming lab: exploring the "projective identity" hypothesis." *SIGCSE* (2013).

Sicart, Miguel. *Play Matters*. UK: MIT Press, 2014.

Söderberg, Johan. "Copyleft vs. Copyright: A Marxist Critique". In *First Monday* 7, no. 3 (March 2002). Accessed December 26, 2017, at http://firstmonday.org/ojs/index.php/fm/article/view/938/860

Sweetser, Penny. *Emergence in Games: Course Technology*. Boston, MA: Cengage Learning, 2008.

Toop, David. "The Generation Game: Experimental Music and Digital Culture". In *Audio Culture: Readings in Modern Music*, edited by Christoph Cox and Daniel Warner, 454. Redmond, Washington: A&C Black, 2004.

Waggoner, Zach. *Terms of Play: Essays on Words That Matter in Videogame*

Theory. Jefferson, North Carolina, USA: McFarland, Inc. Publishers, 2013.

Wang, Feng, and Michael J. Hannafin. "Design-Based Research and Technology-Enhanced Learning Environments". *Educational Technology Research and Development* 53, no. 4 (2005): 5-23. https://doi.org/10.1007/BF02504682

Vygotsky, Lev., Semyonovich. "Imagination and Creativity in Childhood". Moscow: Prosveshchenie, 1967. In *Journal of Russian and East European Psychology* 42, no. 1 (Translation, 2004): 7-97.

Zagal, José P., Jochen Rick, and Idris Hsi. "Collaborative games: Lessons learned from board games". *Simulation & Gaming* 37, no. 1 (2006): 24-40. https://doi.org/10.1177/1046878105282279

LUDOGRAPHY

Lord of the Rings. Reiner Knizia. 2000, Fantasy Flight Games.

Dead Space. EA Redwood Shores. 2008, Electronic Arts.

StarCraft. Chris Metzen & James Phinney. 1998, Blizzard Entertainment.

Diplomacy. Allan B. Calhamer. 1959.

Gaming as Performance: Sound as Conductor and Sound as Agent in Videogames: two case studies

ANA MARGARIDA PESSOA,[1] PEDRO CARDOSO,[2] MIGUEL CARVALHAIS[3]

ABSTRACT

The inclusion of game elements in non-game systems provides great potential and challenges for artistic works. In this paper we study conceptual aspects of action to understand the relationship between player and game system. We study videogames as musical instruments for a performance approach admitting that the relationship between musician and instrument is close to the relationship between player and game system, from an operational point of view. This research aims at an understanding and to explore the potential and artistic challenges that emerge from this. Two case studies were created that explore two ways of playing, or performing with games as musical instruments. These were submitted to experimentation tests with musicians and non-musicians in order to provide us with feedback on the experience of playing them and on how players related with the game system, considering these aspects for future work.

ABSTRACT

Videogames;
Action;
Music;
Performance;
Instrument.

[1] Faculty of Engineering, University of Porto, Porto, Portugal — margaridapessoa2@gmail.com

[2] INESC TEC/ Faculty of Fine Arts, University of Porto, Porto, Portugal — pcardoso@fba.up.pt

[3] INESC TEC/ Faculty of Fine Arts, University of Porto, Porto, Portugal — mcarvalhais@fba.up.pt

1. INTRODUCTION

Games have been pervasive in several other areas with different objectives, music being one of those. Music is present in all levels of society and accompanies our daily life in a very close and constant way. There is a common feature to games and music: a similar relationship between actor and system, i.e. the relationship between musician and instrument is consistent with the relationship between player and game system. With this in mind, this paper is centred on the affinities between playing a video game and playing a musical instrument. We intend to reuse very particular components of videogames to create an audio-visual instrument that enables artistic expression. On the first part of this paper, we focus on the concept of game and non-game; on a second moment, on the relationship between action, player and game system; and then on videogames as musical instruments in a performance context. At the end, we describe two case studies of prototypes of game-instruments we created: *Instrumental Space Invaders* and *Pac-Music*, the former using sound as a controller and the latter exploring game elements to generate music in real time.

2. GAME AND NON-GAME

David Parlett (1999) states that the word *game* is used for so many different activities that it may be pointless to insist on any particular definition. Although it is a term that refers to a wide variety of perspectives. He distinguishes between *game* and *play*, designating a game and a child's play as *formal* and *informal* games respectively. An informal game refers to an activity that is not directed by rules, that lacks a fixed structure, whereas a formal game takes on a double structure with rules and goals, where the rules define a way to attain goals. Thus, for a game to be formal the player needs to comply with a set of rules and procedures previously determined to produce a winning situation. Katie Salen and Eric Zimmerman (2003) also report that a formalized set of rules and a competition to win take the form of a game. Clark C. Abt (1987) proposes a definition of game that adds new components: an activity where players take an active and decisive role, an achievement of goals and rules that govern the game. Salen and Zimmerman (2003) also refer to interaction as a way by which rules are manipulated to achieve objectives. Johann Huizinga (1955) indicates that a game is a free activity that absorbs the player intensely and no profit can be obtained by it. A game progresses resorting to fixed rules within its own limits of time and space. With a similar perspective, Roger Caillois (1961) states that playing a game is a free activity, isolated, defined, uncertain, unproductive and unreal. Many authors refer to the rules of the game as essential to define the game it-

self, with Jesper Juul (2003) stating that the rules of a game add meaning and allow actions to happen. Elliott M. Avedon and Brian Sutton-Smith (1971) consider a game to be an exercise of voluntary control systems, where there is a power struggle confined by rules to produce an unbalanced outcome. With this in mind, Salen and Zimmerman offer a game definition that combines most of the elements already mentioned: "A game is a system in which players engage in artificial conflict, defined by rules, that results in a quantifiable outcome" (2003, 80). And Juul brings together six game features in a clear and concise definition: "A game is a rule-based formal system with a variable and quantifiable outcome, where different outcomes are assigned different values, the player exerts effort in order to influence the outcome, the player feels attached to the outcome, and the consequences of the activity are optional and negotiable." (2003)

But are these the only ways to define a game? If Parlett (1999) indicates that the game is a word that assumes diverse typologies, is it possible for a game without rules to be denominated as such? Can a game not be confined to rules and goals and still be considered a game? We are not calling into question the grounds of these authors, but if a game that does not worry about rules nor objectives, can it still be considered to be a game? It is in this way that the term *non-game* arises, contradicting some considerations previously defended.

Non-games don't necessarily have a goal or rule-based structure. Dave Szulborski (2008) states that most games we know possess elements that can be divided into four basic categories: 1) a set of defined rules; 2) a set of elements through which the game is conducted; 3) a set of winning or loss scenarios that define the end of the game; and 4) a set of goals for the players. Non-games, which the author prefers to designate as *alternative reality games*, do not feature some of these elements and therefore do not look like games. But, Szulborski also states that this does not mean that non-games cannot be successful and enjoyable experiences. In fact, in our perspective, non-games can be a way of expression in performance and in other arts, as considered by Michaël Samyn (2010) who tells us that non-games are an artistic and a design challenge. He describes them as an activity that provides a virtual experience that allows us to travel to other worlds when our bodies merge with the system, without a competitive factor hindering that experience.

In *Surround* (1977) each player controls a constantly moving wall, and the goal is to trap and force the opponent to crash into a wall. In addition, there is a video graffiti mode which allows players to draw on the screen, being an example of a non-game.

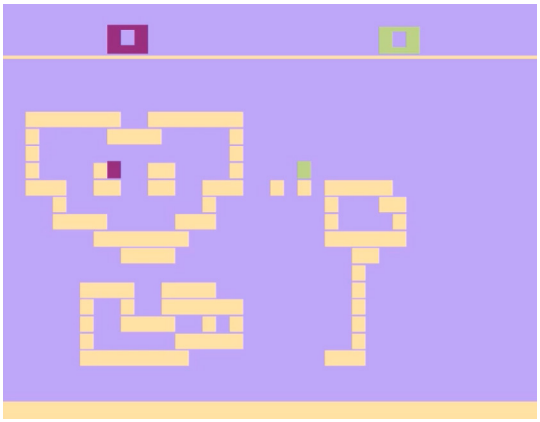


Fig. 1
Surround's video graffiti mode (1977)

In *Alien Garden* (1982), the game world is covered by 24 different types of crystalline flowers that alter their behaviour as the player controls an embryonic life-form while it grows, survives and reproduces through 20 generations. It is considered to be a non-game because it is a videogame based on experimentation without a structured challenge, a set of rules, nor goals.

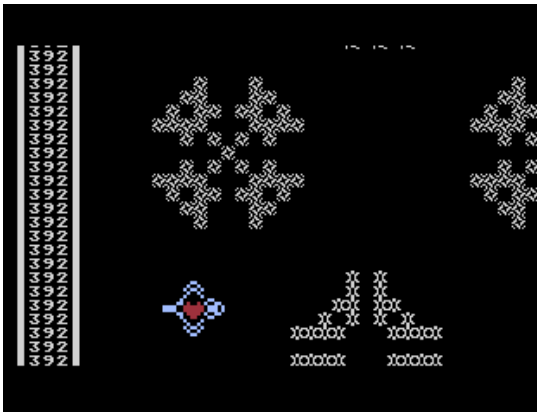


Fig. 2
Alien Garden (1982)

Moondust (1983) is an experimental game that fuses a complex control mechanic with a musical score generated by the player's movement, the goal is to cover the bullseye at the centre of the

screen with *moonjuice*. It can also be considered a non-game because it is an experimental videogame where the player can play freely without rules and goals, worrying only about the visual and sound results.

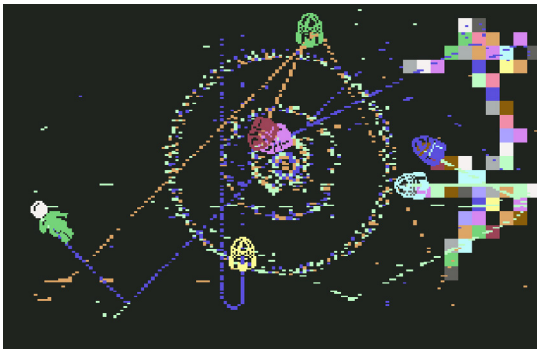


Fig. 3
Moondust (1983)

Biophilia (2011) is a musical project and album of the singer Björk. It includes an application with generative music videogames. These focus on the generated sound and can be considered non-games because each is centred on exploration of the game space, on which the player is able to explore the game world by interacting with game elements that promote the creation of musical patterns, roaming without worrying about game goals.

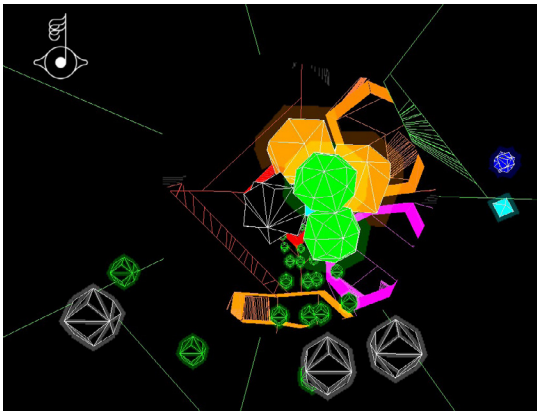


Fig. 4
Crystalline (2011) from the album *Biophilia* (Björk 2011)

Initially, *Minecraft* (2009) was an exploration non-game, that could be used as a creative tool, allowing the player to create constructions by stacking blocks. Currently this videogame has become a more conventional game with game objectives.

Fig. 5
Minecraft (2009)

Games and *non-games* are different, but they have elements in common. Jesse Schell (2008) proposes a way of organizing the basic elements of games into four categories – The Elemental Tetrad –, as a way to balance all parts of a game in order to create a satisfying experience: mechanics, story, aesthetics and technology. *Mechanics* consist of the procedures and rules that structure the game. *Story* is the sequence of events that unfold throughout the game. *Aesthetics* relates with the players' experience. And *technology* refers to the materials and interactions that make the game possible. Some elements are more visible than others, while others are not present at all times, such as *story* – as evidenced in *Pong* (1972), *Asteroids* (1979), *Pac-Man* (1980), *Tetris* (1985), *Flappy Bird* (2013), *2048* (2014), etc.. However, all of these elements contribute to the overall experience of games and non-games alike.

3. ACTION, PLAYER AND GAME SYSTEM

In early videogames, graphical capabilities consisted mainly of two-dimensional figures without visual effects due to the technical limitations of computers. Priority was focused on gameplay (Rollings and Adams 2003, 292).

"Even in contemporary videogames, image is constantly sacrificed in favour of action – despite the increasingly mesmerizing graphical capabilities displayed by contemporary game-dedicated hardware, with all visual resources having to be strictly, optimized to favour its performance" (Cardoso 2016, 56).

The player can imagine the visual details, but it is imperative for action to be conveyed (Wolf 2001, 30). Without action, a videogame becomes passive entertainment, since the main prerogative of a game is to be playable. With this in mind, players are required to act in order to influence the game world in several ways. Thus, they participate actively in the game's events instead of being mere spectators (Cardoso 2016, 56). "Action is then the means by

which the player is able to alter game states" (Bjork and Holopainen 2005, 20). Players thus assume an active role in the game system, but they are not the only ones able to change the state of the game. Alexander Galloway (2006) states that when players move their hands and their eyes, the machine also acts in response to those actions, distinguishing *machine actions* (those performed by the software and the hardware) from *operator actions* (those performed by the player). Therefore, the experience of the game arises when both the machine and the operator work together, changing and/or maintaining game states (Cardoso 2016).

With this in mind, it was possible for us to explore various behaviours in the relationship between the player and the game system, something that was fundamental for the creation of the two prototypes we present next, which are focused on exploring notions of musical performance.

4. GAMES AS INSTRUMENTS AND PLAYING THEM AS PERFORMANCE

Playing in 7D: Considerations for a study of a musical instrumentality in the gameplay of videogames (Cardoso and Carvalhais 2014) proposed that the relation between player and system is similar to that of a musician and his instrument, without stating that games are equivalent to musical instruments, but that their relationship is similar from an operational point of view, a perspective in which "an instrument is seen as an artefact that it is used to produce or to perform something". With that into consideration, we suggested a notion of "instrumentality" applied to videogames and characterized by *dialectical ability, freedom of expression* and *actors*.

Dialectical ability refers to the fact that the player and the game system act in opposition to each other, e.g. when the player is constantly challenged by the presence of enemies who populate the game world. Crawford (1984) calls it "a *conflict* that arises naturally from interaction with the game where the player pursues some goal", stating that conflict can only be avoided by eliminating the active response to the player's actions and that there is no interaction without this active response. Therefore, to eliminate the conflict of a game is to destroy it, because conflict is an intrinsic element to games, despite the many forms it may take. However, some contemporary videogames do not have win or lose conditions, because the focus is on the experience itself, on the narrative, etc. Notwithstanding, the dialectical ability is still present as a force opposite to that of the players' as they struggle to change the course of events and consequently their experience. "This is a type of conflict that the game system constantly presents to the player, through various means and nuances." (Cardoso and Carvalhais 2014)

Freedom of expression is a term that refers to games that allow players to manipulate diverse the elements in the game and to reconfiguring its structure, instead of just following a predetermined path or set of predetermined paths.

Finally, with *actors* we refer to the entities that have the capability to act in the game world. They can influence the course of events and change the game states. Anything that is capable of acting in a game is considered to be an actor, be it a character, an enemy, a power-up, etc. From this perspective, the player and the game system are also actors, albeit with some differences. The game system is an actor because its components operate in a network that contributes to the game's execution. The player, if human, can also be seen as a set of simpler actors who act together, allowing the player to receive and process information, e.g. with the eyes, ears, and all elements of the body that allow the player to process information and express himself physically.

Having this established, we need now to understand the relationship between performance and videogames. According to Richard Schechner (2003) there are five basic qualities of performance that are featured in videogames as well: 1) a special ordering in time; 2) a special value attached to objects; 3) a lack of productivity in terms of goods; and 4) a set of rules and spaces of action.

Let's compare these basic qualities between performance and videogames and understand how they relate with each other – the following table is based on this definition.

Table 1
Basic qualities of performance and videogames, adapted from Schechner (2003)

BASIC QUALITIES	PERFORMANCE	VIDEOGAMES
Time	Time can be determined according to a series of steps to be completed. It can also be designated specifically when there is something predetermined, or symbolic when the activity is represented by another period of time.	Time in a game can be reflected in two ways: *play time* when we refer to the time the player takes to play, and the *event time* when we refer to the time of the game world itself (Juul 2004).
Objects	In performance, objects don't acquire the same value as they do in real life.	In videogames, the value of an object is also only related to the value it has in the game (Fernández-Vara 2009).
Non-Productivity	Performance does not produce goods or monetary value, unless someone pays to witness the someone's performance.	Several authors define games as non-productive like Huizinga (1955) and Caillois (1961), however, in the same way, some games can challenge this, e.g. serious games.
Rules	A performance is a rule-oriented activity, in which said rules specify its course.	A videogame is also guided by rules that define the final result and regulate the functioning of the game, despite of how strange and even apparently absent as they may be, such as those found in in non-games.
Performance Spaces	A performance is a shared, regulated activity and experience that happens within a particular space.	In videogames, the separation between game space (where the game occurs) and player space (where the player is actually located and acts/ performs) is also not clear, as these spaces often overlap (Cardoso 2016).

Through this comparison, we can say that videogames can also be analysed as performance, as they seem to be somehow closely related. It was having this in consideration that we have developed two prototypes presented in the following sections.

5. INSTRUMENTAL SPACE INVADERS: SOUND AS CONDUCTOR

This prototype, called *Instrumental Space Invaders*, is an adaptation of *Space Invaders* (1987), in which the player controls the avatar by means of sound, i.e. by playing a musical instrument as a game controller. It functions as a musical structure to improvise or to explore an instrument that arises from the actions of the video game.

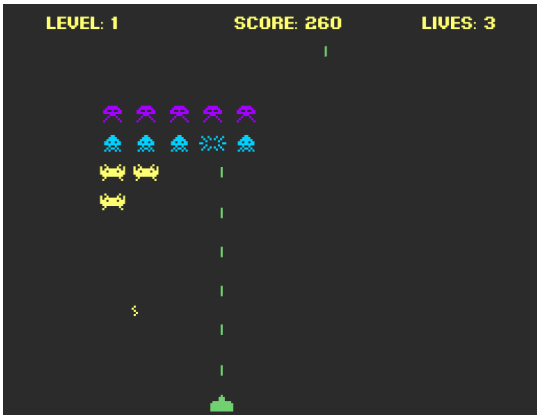


Fig.6
Instrumental Space Invaders

The algorithm employed in this prototype is able to analyse a particular sound and relate it with certain mechanics in the game. I.e. it determines what should be performed on the musical instrument so that the system can respond: each action on the instrument triggers an action in the game. Ascending musical notes move the avatar to the right and descending musical notes move the avatar to the left. Perfect octave intervals[4] allow it to move upwards and the absence of sound allows it to descend. The player can fire when playing a variation of notes within a range of values that represent the height of the sounds.

[4] The interval between one musical pitch and another with double its frequency.

The system supports a range of sound emitters, even the human voice. The simple mechanics that we have implemented allow the player to have a certain *freedom of expression* in accordance with the rules of the game, i.e. the user can improvise without rules and can combine musical dynamics to fulfil some goals of the game.

Here, sound acts as a conductor, as that is the only way to control the player's avatar, i.e. the way to change game states is by emitting sound to conduct the actors in the game. Although the player is free to combine different sounds and even different timbres (giving voice use, for example), the game only changes when it recognizes the musical patterns executed by the instrument, responding accordingly. In this way, in a performance setting, the audience can perceive and relate what happens in the game system with what they see from the musician and hear from the instrument. The audience is even able to predict particular actions the player will have to enact to achieve certain goals.

6. PAC-MUSIC: SOUND AS AGENT

Pac-Music is an adaptation of *Pac-Man* (1980), capable of generating music in real time. The player explores the space and the game elements to manipulate an already determined sequence of notes. The space of the video game consists of a maze divided into four equal parts with white and pink dots for the playable character to eat. There is a two-note sequence at the beginning of the game (a perfect fifth),[5] and when the avatar eats a pink dot, the system generates a random note on the natural minor scale.[6] Each quadrant corresponds to a harmonic transposition.[7] In addition, we have implemented the intensity of the attack of each random note, which allows the player to obtain a melodic interpretation, because the intensity of the notes tends to lower gradually as the player is inactive – that is, without eating a pink dot.

[5] A perfect fifth is a musical interval that corresponds to the distance between two musical notes with a frequency ratio of 3:2, or very nearly so.

[6] A natural minor scale consists of a sequence of determined musical intervals.

[7] A harmonic transposition means a change of pitch; in music, the pitch of a note corresponds to how high or how low the note is.

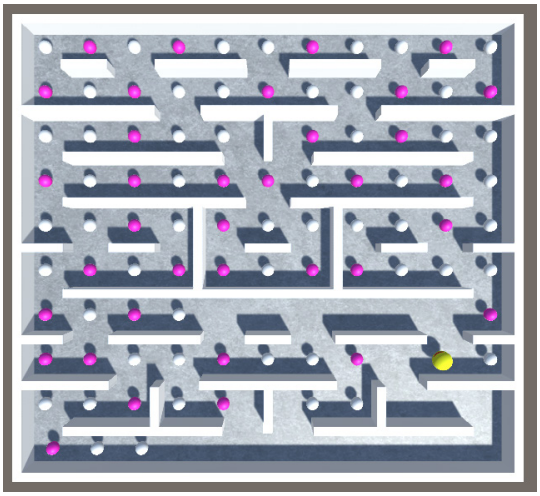


Fig.7
Pac-Music

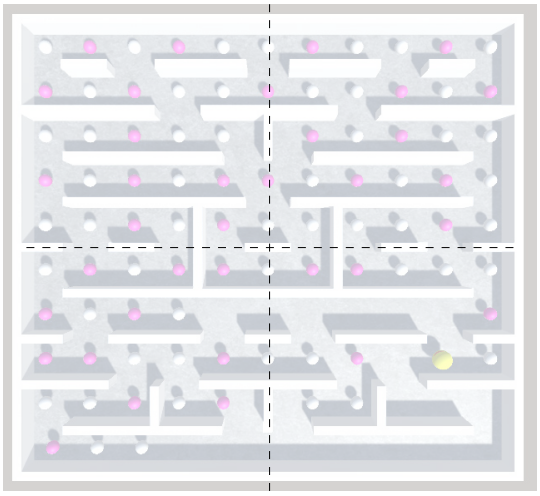


Fig.8
The Quadrants in *Pac-Music.*

Sound agents are represented by the visual elements of the videogame that exist to change the initial sequence of notes that the player and the audience hear. For example, pink dots exist to produce a sound in a specific quadrant. Normally, in videogames the visual elements are the centre of attention, but here the auditory environment becomes the main focus due to the sonorous events that change several times according to the actions of the player.

During experimental tests, we have observed that the players were surprised by the different sound events that were appearing during the course of the game. After they understood the game's basic dynamics, their intentions were already premeditated to influence the sound.

In a performance setting, the concept of this videogame can be used to generate music, compose and mix in real time with other harmonies that can complement one another. Experimental music can be an interesting branch of music to apply this concept to, since it defies conventional conceptions of musical composition. Another very interesting aspect of this concept is the possibility that non-musicians can create music without previous knowledge or musical education, since the system generates random music within defined parameters, so that all actions can generate sounds that, in tune, form a harmony.

7. CONCLUSIONS AND FUTURE WORK

The main premise of this project was the research of conceptual elements that can give rise to a structured and organized system centred in the action and the development of an artistic performance. This work demonstrated the possibility of creating and applying two projects that act in the convergence of playing a videogame and of playing a musical instrument. Both projects revealed to be successful experiences and demonstrated potential for further research.

After some tests, we have conclude that videogames can function as music-producing artefacts; they can be both an instrument and a game. We can say that playing a videogame and playing a musical instrument are activities that share a particular set of traits from an operational point of view (artefact-operator) despite their differences.

We have observed the behaviour of the players in the two prototypes and we had an open discussion about their lived experience that revealed some considerations about future work, such as applying these concepts in the area of pedagogy and musical composition as a game system that works like sheet music for various instruments and a game to study musical education.

Many variations can be considered for these prototypes, e.g. in *Instrumental Space Invaders* it may be interesting to add recognition of diverse levels of sound intensity so that the player is able to manipulate the system also with musical dynamics; or creating a multiplayer game so players are able to articulate two musical instruments and play together, or even a videogame for a string quartet.

In *Pac-Music* the addition of new game elements that alter or allow the creation of new musical transformations may also be interesting, as well as the inclusion of other elements that increase conflict in gameplay, e.g. enemies, obstacles, etc.

Variations on any of these two prototypes are able to include new and different game goals, rules, gameplay from where very interesting

musical actions and behaviours are reflected or emerge.

Having accomplished this short study, we are able to recognise four major different areas where these games may focus: entertainment, music composition, pedagogy, and artistic performance. By considering these, the breadth of possibilities is extensive, where videogames promote new means of musical expression.

BIBLIOGRAPHY

Abt, C. Clark. *Serious Games.* University Press of America. 1987.

Bjork, Staffan, and Jussi Holopainen. *Patterns in Game Design.* Charles River Media. 2005.

Caillois, Roger. *Man, Play, and Games.* University of Virginia. 1961.

Cardoso, Pedro. *Playing in 7D: An Action-Oriented Framework for Videogames.* Ph.D. Thesis. Faculty of Fine Arts, University of Porto. 2016. Accessed on 2018/10/09. http://hdl.handle.net/10216/82685

Cardoso, Pedro, and Miguel Carvalhais. *Playing in 7D: Considerations for a Study of a Musical Instrumentality in the Gameplay of Video Games.* ICLI 2014: International Conference on Live Interfaces, Lisbon. Accessed on 2018/10/09. http://users.fba.up.pt/~mc/ICLI/cardoso.pdf

Crawford, Chris. *The Art of Computer Game Design by Chris Crawford*. 1984.

Elliott Avedon and Brian Sutton-Smith. *The Study of Games.* New York: John Wiley & Sons. 1971.

Fernández-Vara, Clara. *Play's the thing: A framework to study videogames as performance.* Digital Games Research Association. 2009.

Galloway, Alexander R. *Gaming: Essays On Algorithmic Culture.* Minneapolis: University of Minnesota Press. 2006.

Huizinga, Johann. *Homo Ludens: A Study of the Play Element in Culture.* Boston: Beacon Press. 1955.

Juul, Jesper. *The Game, the Player, the World: Looking for a Heart of Gameness. In Level Up: Digital Games Research Conference Proceedings.* Utrecht: Utrecht University. 2003. Accessed on 2018/09/24. https://www.jesperjuul.net/text/gameplayerworld/

Schell, Jesse. *The Art of Game Design: A Book of Lenses.* Morgan Kaufmann. 2008.

Szulborski, Dave. *This Is Not A Game: A Guide To Alternate Reality Gaming.* New Fiction Publising. 2008.

Parlett, David. *The Oxford History of Board Games.* Oxford: Oxford University Press. 1999.

LUDOGRAPHY

2048. 2014. Solebon LLC.

Alien Garden. 1982. Epyx.

Crystalline. 2011. Björk.

Moondust. 1983. Creative Software.

Asteroids. 1979. Atari.

Flappy Bird. 2013. dotGears.

Minecraft. 2009. Mojang.

Pac-Man. 1980. Namco.
Tetris. 1985. Alexey Pajitnov.
PONG. 1972. Atari.
Space Invaders. 1987. Taito Corporation.
Surround. 1977. Atari.

Virtual Reality Game to teach Organic Chemistry

IRIS RODRIGUES,[1] **RUI PRADA**[2]

ABSTRACT

This paper describes the work conducted to develop a game in Virtual Reality to help teach Organic Chemistry. Other educational games were analysed to identify their strengths and weaknesses and the importance of games and Virtual Reality technologies in education were studied to obtain guidelines on how to approach the implementation of this game. The manipulation of objects was also studied because it is extremely important in Virtual Reality and it takes a central focus in this game as the player will be manipulating atoms and molecules. To help with this component, the Leap Motion sensor was used alongside the HTC Vive headset. The game development, which included mechanics and gameplay, was done in three iterations. There was an evaluation performed per iteration, and a final evaluation was performed at the last iteration with high school students. The results showed that the approach of using VR is viable for teaching Organic Chemistry.

KEYWORDS

Virtual Reality;
Organic Chemistry;
Serious Games;
Gestural Interfaces.

[1] INESC-ID and Instituto Superior Técnico, Universidade de Lisboa, Portugal — iris.rodrigues@tecnico.ulisboa.pt

[2] INESC-ID and Instituto Superior Técnico, Universidade de Lisboa, Portugal — rui.prada@tecnico.ulisboa.pt

1. INTRODUCTION

This paper describes the development of a game to improve and complement the traditional methods of teaching Organic Chemistry to high school students. The idea is not to substitute the classroom learning process, but used the game as an extension to the existing learning methods. This means that players should have some previous knowledge about the domain, because it doesn't teach everything from the beginning. The game allows students to play with the concepts learnt in class. The game explores immersive Virtual Reality (VR) to add interactivity and immersion to the traditional methods, thus enabling the students to better understand the more difficult subjects and the more abstract concepts. The use of VR comes with the challenges to define proper interaction mechanisms with objects, which is extremely important in this project since the player will be directly manipulating atoms and molecules throughout the game. To help with this aspect, this project makes use of the Leap Motion sensor responsible for tracking the user's hands, enabling the use of the them to perform the manipulations in the virtual world. This allows the implementation of interaction techniques that simulate the way we interact with objects in the real world.

2. BACKGROUND

2.1 DOMAIN

The domain present in the educational game that was developed focuses on the basic knowledge that a high school student should acquire about Organic Chemistry. This knowledge consists on information about the organic molecules, their nomenclature, structural drawings, 3D structure, class and formula.

2.1 DISCIPLINE

.1 TOPICS

Since the target audience of this project are high school students, it was necessary to know and to understand what is taught in high school about Organic Chemistry.[3] From this initial research the discipline topics focus on the bonding, structure and nomenclature of organic molecules, the fundamental groups, isomerism, organic bases and acids and reaction mechanism. These are the overall goals in Organic Chemistry courses. However, they were not all learning objectives in the game that was developed. This will be further explained in the Implementation section.

[3] http://www.stc.edu.hk/home/life/curriculum/chem.pdf

2.2 VIRTUAL REALITY AND GAMES IN EDUCATION

To understand how Virtual Reality can be used in education, it is necessary to understand how humans learn and improve their skills and capabilities. According to the constructivist theory by Piaget, a person learns in real life by doing. And improves his skills through practice on realistic tasks, meaning that active learning must be present to have improvement. Since humans learn by having experiences and by interacting with their environment, Virtual Reality becomes a clear choice to create educational games. When creating a VR game or tool, there are three aspects to consider: immersion, interactivity and multi-sensory feedback (Christou, 2010). Immersion means being enveloped or surrounded by the environment. The key benefit of this component is that it ensures the feeling that one is really in the virtual world. Interactivity is the ability to control events in the virtual world using one's body movements and having the world generate responses to them. And multi-sensory feedback allows the simulation to be more believable and engaging because the information is derived from several senses making it more redundant which reduces potential ambiguity and confusion. These features make VR a great option to use in educational games, because it means that a student can be put in a depicted world, interact with it, generate solutions to problems presented and have responses from the world to those actions, all within a safe environment. There are studies that show that games have a positive impact in changes in perception, attention and spatial cognition. From the results of those studies, we can assume that games can have an impact in teaching but creating a useful and fun educational game is not an easy task. There must be a balance between the educational purpose and the entertainment aspect for the game to improve learning and to be engaging at the same time. Kiili (2005) proposes a model that links gameplay with experiential learning to facilitate flow experience. The basis of this model are the challenges based on educational objectives provided in the game, which through a cycle of attempts of the player and feedback from the game, active experimentation is induced. From this, it is possible to see a parallel between this model and the constructivist theory.

2.3 CHEMISTRY GAMES AND APPLICATIONS

Most chemistry games, that exist to date, are more commonly card or board games. There aren't many video games that focus on Chemistry. There are more applications and tools. The main applications and games analysed, and the conclusions taken from them are:

- Groupica (game) – shows how to correlate elements to their group families;
- Elemental Periodica (game) – uses the information about an element for the players to find out what element it is and what is its name;
- MolyPoly – depicts how gestures can be used to interact with molecules with the help of a manipulation panel.

MANIPULATION TECHNIQUES

The interaction with objects within the virtual world is an important issue to tackle, it has a direct effect in the immersive feeling of the virtual environment, thus impacting the whole experience. In the game developed, the interaction with objects (atoms and molecules) is extremely important, and for that reason it was necessary to understand how to manipulate objects in a virtual world. There are a couple of aspects that need to be explored for this component to be implemented: the technique or techniques used and the device.

There are several techniques that can be used for manipulating objects, but one aspect that they all must have is that they should provide the means to accomplish at least one of the three basic manipulation tasks: object selection; object positioning; and object orientation. Poupyrev and Ichikawa (1999) created a taxonomy which categorizes the different methods of virtual objects manipulation available at the time by analysing their characteristics. They defined two major metaphors for the techniques: exocentric and egocentric. In this project the focus will be on the techniques from the egocentric metaphor. Although there are many techniques used for manipulation of objects, there are two major categories: Virtual hands – provides direct manipulation capabilities by resembling the user's real hand in a virtual space. This method is intuitive and natural due to the direct control of objects based on analogies from the real world, but the user is restricted to the physical reachable area around him; Virtual pointers – can expand the reachable area by allowing the user to cast a ray at a distant object that enables the user to pick it, grab it and interact with it. Because of the ray cast, this technique requires relatively less effort to perform any manipulation to the object. Although this is an easier technique to use and more efficient, it can be subjected to

inaccuracy due to hand jitter and the Heisenberg effect.[4] For this project, the classical hand was mostly used for the manipulation of objects, since they are all close to the players, and he doesn't have a large space to move around on.

FEEDBACK

One important aspect regarding the manipulation of objects in Virtual Reality is the feedback that is given to the player when he performs different actions in the virtual world. The best type of feedback that can be used in a VR game or application is haptic feedback, which allows the user to have the sensation of touching a virtual object by simulating some features of the object such as: hardness, weight, inertia, surface contact geometry, smoothness and slippage. However, the hardware that was available to use in this project didn't have haptic feedback, making it necessary to find an alternative, whose results should be as close as possible to the results of using haptic feedback. Most games and applications rely on visual and auditory feedback which, comparing to haptic feedback, are a low-cost type of feedback. The visual and auditory sensorial channels have a one-way, information-only flow, which means that they only collect and analyse information coming from the environment but have no interaction with it. Also, these two senses are allocated to relatively large areas in the sensory cortex, suggesting that visual and auditory displays have the potential of presenting haptic feedback with good results (Richard, 1996). For this reason, the chosen replacement for haptic feedback was the combination of auditory and visual feedback

3. IMPLEMENTATION

3.1 CONCEPT

After researching and talking to a high school Chemistry teacher, the defined domain of the game includes the nomenclature, structural drawings and functional groups of organic molecules. The several parts of the domain are integrated in the different game modes available on the game. There were two main game modes defined which were the Normal and the Speed Run modes. Both use the domain in its full scope, meaning that they have different types of challenges related to each part of the domain. These game

[4] http://www.businessdictionary.com/definition/Heisenberg-effect.html

modes will be detailed in section Gameplay. There were also four sub game modes that focus on the different types of challenges that the game has, which means that each mode only presents one type of challenge. Therefore, these sub game modes are Build, Complete, Transform and Multiple Choice. These types of challenges will be described in the section 3.1.2.

The game mechanics used in all the game modes are the same, making it easy for the player to switch between modes without having to adapt to different mechanics. The player can create molecules by connecting the atoms and manipulate the created molecules.

3.1.1 LEARNING GOALS

One of the most relevant components to define are the learning goals which must clearly define what the users should learn about the domain through the game. This means that the game must provide the means to reach the learning objectives. The final learning goals are:

- Recognize and name the major functional groups (hydrocarbons, carboxylic acids, haloalkanes, alcohols, aldehydes and amines);
- Recognize the functional group a molecule belongs to;
- Know the nomenclature of the molecules;
- Correlate molecular structure with the nomenclature;
- Correlate conventional drawings of molecular structures with their 3D structure.

3.1.2 CHALLENGES

There are four different types of challenges that the player is faced with, which are: **Build molecule from scratch knowing some information about it** (Build) – the player must connect the atoms to build the molecule with only a piece of information about. This information can be anything about the molecule, it can be the structure, the name, the functional group it belongs to or the formula; **Complete a given molecule knowing some information about it** (Complete) – this challenge is very similar to the Build challenge. The difference is that instead of building the molecule from scratch, the player has a partially built molecule that he must complete, considering the information that is given; **Multiple choice question** (Multiple choice) – in this challenge the player has to answer a question about the molecule that is placed in front of him. The question has 3 possible answers and the player must look at the molecule and figure out what the correct answer is. **Transform a molecule into another** (Transform) – for this challenge, the player is faced with a complete molecule and information about the molecule that he must achieve. The objective is to transform the given molecule into a molecule that corresponds to the information that

is given. This information can be the name, the functional group, the formula or the structure of the intended molecule.

One of the things that was discussed with the teacher was how the exercises applied in this subject solidify the concepts that the students learn. It was clear that the same type of exercise can be used for different concepts. This means that the same challenge can be used for different learning objectives, making them versatile.

3.1.3 GAMEPLAY

Two main game modes were considered: Normal and Speed Run. The Normal mode is a slow-paced game mode that focuses on the player having time to learn and to absorb the knowledge. In this mode, we plan to have 50 levels. One level can have multiple challenges of the same type, or it can have challenges of different types. The difficulty for this mode will increase as the number of learning objectives tackled in the levels increases. The first 20 levels tackle a distinct learning objective at a time, meaning that there are 4 levels per learning goal. The order of the learning objectives is correlated to the order in which the students learn the different concepts in class. The next 15 levels mix two learning objectives and the last 15 levels mix three learning objectives. Besides this evolution, the challenges within each level also get increasingly difficult. The Speed Run mode is a fast-paced game mode that emulates a quiz, where the player has a time limit to complete all the challenges he is faced with. In this mode, we plan to have 10 levels, each level with 5 challenges that players must solve as fast as they can. All the levels tackle a distinct learning objective at a time, meaning that there are two levels per learning goal.

3.1.4 SCORING SYSTEM

The scoring system of the game is based on two measures: number of attempts and number of moves. In the Normal mode, the skill of the player is measured in number of moves for the challenges Build, Complete and Transform because these challenges force the player to manipulate the atoms and interact with the molecule to solve them. For this reason, it makes sense to count the number of moves that the player performs until he reaches the desired molecule. For a Multiple Choice challenge the player is rated by the number of attempts he makes until he selects the correct answer. In the Speed Run mode, the skill of the player is measured only in time, since the only thing that matters is how fast the player can finish all the levels.

3.2 TECHNICAL IMPLEMENTATION

The game was developed in three iterations: the first was focused on implementing the core mechanics; the second was needed to improve some of those initial mechanics; and finally, the third had the main objective of implementing the gameplay components (levels and challenges) and some extra elements. One of the most important aspects implemented in this stage was the relationship between an atom and a molecule as objects in the game (figure 1). When two atoms are connected, a bond is created between them and a molecule is formed. Every molecule has a pivot, which is a gear that is used in the manipulations techniques to help the player interact with the molecules. The position of the pivot is the mean of all the atoms position with an offset on the x axis, which means the pivot appears always to the right of the molecule.

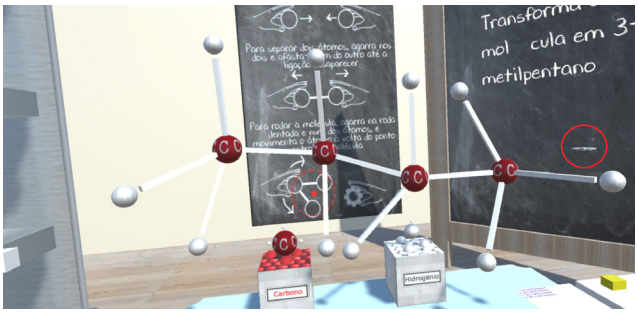


Fig. 1
Example of a molecule
(the gear is within the red circle).

3.2.1 CORE MECHANICS

The core mechanics were implemented at this stage, which are connecting atoms, translating and rotating molecules. For connecting atoms, there were two methods implemented, one that was based on distance and another that was based on touches. The method based on touches consisted on grabbing two atoms, one in each hand, and touch the atoms together. Each time the atoms touch each other, while the player is grabbing them, the type of bond increases, from single to triple bond. When it reaches the triple bond and the atoms touch each other again, it circles and goes back to a single bond. The technique based on distance starts the same way as the first method described, but after the atoms touch each other once, the player must define the bond he wants to create by moving the atoms away or closer to each other. The closest the atoms are, the stronger the bond type is, and the farthest, the weaker.

To move the molecule into a different position, the player could use two different ways. One method was to grab one of the atoms of the molecule and move it to the desired location and the rest of the atoms would be dragged along. The other meth-

od was to grab the pivot with his left hand and move it, which would make the whole molecule move without losing its shape.

Initially there were three different rotation methods implemented. For two of these methods the user needed to define the axis around which the molecule should rotate. The player could set the axis through two distinct hand gestures with his left hand, which vary according to the method being used, while the right hand grabs the gear of the molecule. One of those methods rotated the molecule automatically after the axis is defined and the gear is held. The other method had the same process as the previous method with the addition of having to rotate the right hand's wrist to rotate the molecule. For the third method it wasn't necessary to define an axis. The player needed to grab the gear with his right hand and grab one atom of the molecule with his left hand. He then should move the atom around the centre of the molecule, which was represented by a small red sphere to provide a visual reference of where it is, making it easier to understand how he had to move the atom to rotate the molecule around the central point. As the atom is moved around the pivot, the whole molecule follows its movement, making it rotate around the pivot.

From the results of the testing phase of the first iteration, the conclusion was that the preferred technique to connect atoms was the method that used touches and that for translating a molecule, both techniques were adequate for different scenarios. Two of the rotation techniques implemented, Rotation with Wrist Control and Rotation with Atoms, needed to be improved but they were the most preferred methods, and the focus of the second iteration was to improve these two techniques and test them again. After this second evaluation phase, the Rotation with Wrist Control was discarded, and the Rotation with Atoms was defined as the rotation method.

3.2 GAMEPLAY .2

The gameplay was built around the core mechanics by structuring the game in levels, which include the different challenges, and the scoring system.[5] We have created the levels in a flexible way, allowing for easy changes without tampering with the code. This

[5] A video with the gameplay and core mechanics can be watched at: https://www.youtube.com/watch?v=4wdTYYRPyVc

was made through text files that are parsed by the system and that can be easily changed. They have a specific structure that must respected to be loaded correctly. The challenges have their own specific name that must be used. Each challenge has its own structure because each has different components that must be provided. These structures must be respected for the level to be loaded with no problems. For some of the challenges it is necessary to present a molecule to the player, and for this reason, the game needs to have a database with the molecules that should be loaded in those challenges. The database is a collection of text files corresponding to a molecule each, with the information about that molecule, such as the position it should face, the different atoms it has, and the bonds that exist between the atoms.

3.2.3 SCORING SYSTEM

The scoring is based on the number of attempts and number of moves. The number of attempts is used with the Multiple Choice challenges and grants maximum points for a correct answer in the first attempt and minimum points after the third attempt. The actions that are considered for the number of moves are: bonding two atoms; breaking a bond; picking a new atom; throwing a molecule or an atom into the trash; and remove all molecules or all atoms from the scene. Each challenge defines a level of required moves, which is compared to the actual moves the player does to compute the score.

3.2.4 AUDIO AND VISUAL FEEDBACK

Audio and visual feedback were extremely important in this project. The first visual feedback added was a yellow outline to the atoms that it is displayed when the player grabs them. An extra outline in red was used to indicate when the player could not connect two atoms together. This red outline appears when a player touches two atoms together, where at least one of them doesn't have any more available bonds to make. The number of bonds that an atom can have are represented by small spheres around the atom, and each time the player makes a bond with that atom, the correspondent number of spheres disappear.

For audio feedback there were different sounds played for different actions. The actions that had audio feedback were: when an atom is grabbed, when the atoms touch each other while the player is grabbing them, when a bond is formed, when a bond is broken, when something is thrown in the trash, and when a button is pressed.

4. RESULTS

In the final test, the users were asked to perform a tutorial to understand how the mechanics work and to get an initial feel for the game. After a tutorial, they were asked to solve a mini-version of the Normal game mode and, afterwards, to fill a questionnaire. This game mode was reduced to 4 levels, which are detailed in figure 4, that shows the challenges they had and the learning goals they tackled. The challenges used in the test were shown to the Chemistry teacher to make sure the content of the challenges was correct.

LEVEL 1 *(Know the nomenclature of molecules)*

CHALLENGE 1 - Build a CH4 molecule.
CHALLENGE 2 - What is the name of the molecule? (2,2-dimethylbuthane)

LEVEL 2 *(Correlate conventional drawings of molecular structures with their 3D structure)*

Challenge 1 - Complete the molecule knowing its structure. (2,2-dimethylbutahne)
Challenge 2 - Build the molecule from the structure. (CH3COOH)

LEVEL 3 *(Recognize the functional group a molecule belongs to and know the names of functional groups)*

Challenge 1 - Transform the molecule into a haloalkane.
Challenge 2 - Complete the molecule knowing it is an alcohol.

LEVEL 4 *(Correlate molecular structure with the nomenclature)*

Challenge 1 - Transform the molecule into a 3-methylpentane.
Challenge 2 - What molecule is this? (Ethylene)

Fig. 3
Levels the users were asked to perform with their challenges and the learning goals that they tackled.

4.1 USERS SAMPLE

This test was performed by 25 users, 8 were high school students ranging from 16 to 18 years old, and the remaining 17 were college students ranging from 18 to 26 years old. The high school students were from the 11th grade and they had Organic Chemistry lessons in the previous school year, which means that they had knowledge about the domain they had learned recently. The college students hadn't been in contact with any aspect about Organic Chemistry for several years, so they didn't remember most of the subjects that were approached in the game. For this reason, while they were performing the test, they had a printed sheet available to them with the general concepts they needed to know to solve the challenges.

4.2 EVALUATION GOALS

To understand if the created game fulfilled its main objective, the results of the tests needed to show three different points. First was that the students could easily manipulate the atoms and perform the challenges with ease. Second was that they had fun while they

are enhancing their knowledge on Organic Chemistry. And finally, the third was that the content was accurate according to what it is taught in schools. Another relevant aspect is that the tests should show that the levels could be easily changed by the teachers according to what they want the students to practice.

4.3 EXPERIMENTAL METHOD

In this test, the logging technique was used to record information concerning each challenge and level posed to the user. The number of moves, the number of attempts and the points that the user made in each challenge since they were the methods used to attribute a score to the user. The questionnaire used was based on the Game Experience Questionnaire (GEQ) and the VR Sickness Questionnaire, but it also had 3 more specific questions about the challenges and 2 questions about the scoring methods. The questions about the challenges were made regarding each type of challenge that the user had to tackle: Build, Transform, Complete and Multiple Choice. They asked the user to rank in a linear scale how much did he like to use them, how much fun they were and how interesting. The questions about the scoring methods asked the users how fair the methods were and how pressured did they feel using them.

4.4 LOGS

The number of moves and attempts the users made to solve each challenge were compared to the respective optimal number of moves and attempts. The optimal number of moves corresponds to the minimum number of moves to solve a challenge, and the optimal number of attempts is always one.

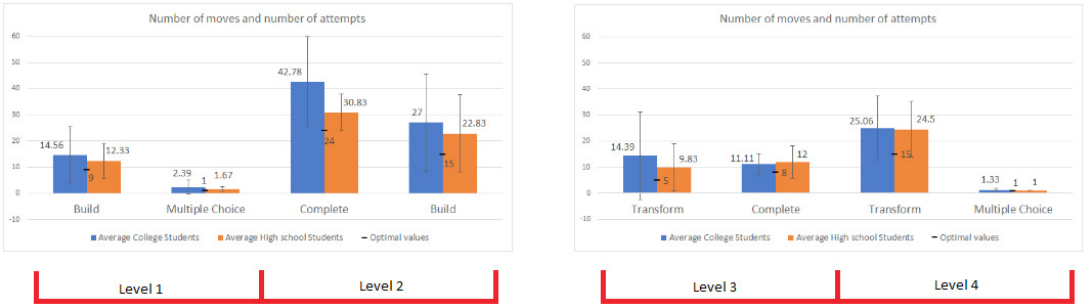


Fig. 4
Results from the logs of number of moves and number of attempts made by the users on each challenge

From the results of the analyses of the number of moves and number of attempts (figure 5), it is possible to say that the high school students had an overall better performance than the college students. This was expected because the high school students had learned Organic Chemistry very recently while the college students had not, meaning that they were more prone to make mistakes while trying to solve the challenges and needing to start over. The expected difficulty in each challenge was close to the actual difficulty displayed by the users. However, there were issues with the implementation that caused big values that could have been much lower had those problems not existed (they are further explained in the Conclusions). For this reason, the users were forced to restart the molecule, being careful not to join two molecules, and thus making a lot more moves than expected.

4.5 QUESTIONNAIRE

From the analyses of the section of the questionnaire about Game Experience (figure 5), the conclusions are that the users had a positive experience with the game. They felt immersed in it and they felt skilful while playing it. This may indicate that the implemented mechanics helped in making the users feel competent. Another important aspect is the game flow, which had high values, meaning that the users felt that the game had a smooth progression. The Challenge aspect of the game had the lowest scores which isn't necessarily a bad sign. These values aren't surprising because the challenges are based on Organic Chemistry and they aren't very complex, which means that anyone with a basic to moderate level of knowledge on this subject can easily solve the challenges. Given that the high school students had had revisions on the domain prior to the test, and that the college students had information about the subject available to them, it is reasonable to assume that the game wasn't considered extremely challenging.

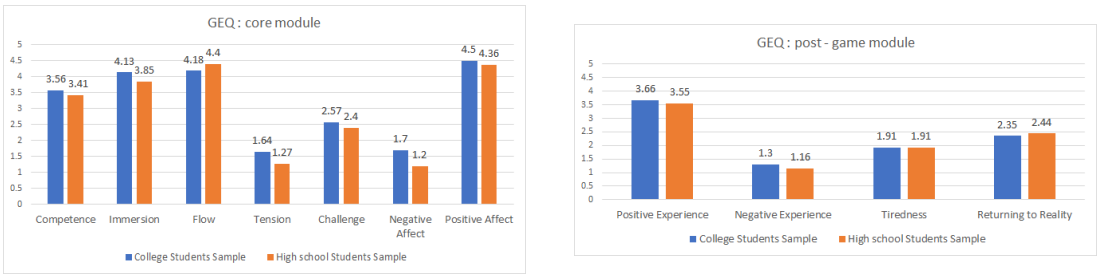


Fig. 5
Results from the core and post-game module from the GEQ.

The Post-Game module results also indicate that the overall experience was positive, with little negative aspects and tiredness reported from the users. Regarding the VR Sickness section, it assesses two components which are nausea and oculo-motor. The results of both components show that the users felt almost no discomfort after they finished the test.

4.6 OBSERVATIONS

All the high school students had fun while playing the game. Some of them even said that at the end of the test. They also seemed focused on solving the challenges and were concentrating on finding out the answer without any help. Most of the college students had fun and enjoyed playing the game. Some of them were really focusing and tried to find out the correct answer by themselves without any help, except from the information that they had available to them. Half of the users mentioned, at the end of the test, that the game made it more fun to learn about this subject compared to the traditional method.

4.7 INTERVIEW TO A CHEMISTRY TEACHER

To have the point of view of a chemistry teacher, an interview was made to a high school Chemistry teacher.

Q: What advantages and disadvantages the game has comparing to the traditional teaching methods on Organic Chemistry?

A: It's more appealing to solve the exercises through the game than through paper and pencil, however it requires more time to solve them.

Q: How would you use the game in a class about Organic Chemistry?

A: In a classroom, it is possible to have 30 students simultaneously. If the game is used in a laboratory class, there can be 15 students at maximum. We would have to have the necessary equipment to have all those students playing the game at the same time. If the school has a room with all the required equipment, it makes the process easier.

Q: Does the game help to approach Organic Chemistry in a more entertaining way?

A: Yes. Without a doubt, it is a good method to cement the knowledge in a fun way.

By analysing the answers given by the teacher, the game might be a good tool to be used in the classroom to help teach Organic Chemistry, since it might be able to bring fun and entertainment in learning the subject.

5. CONCLUSIONS

The result of this project is a functional, fun and interesting game that has potential to be a good educational game to be used in a classroom to teach Organic Chemistry. All the proposed mechanics were implemented, as well as the challenges, levels, overall environment and auditory and visual feedback. The results obtained were very good overall. All the users enjoyed playing the game and the need to solve the challenges correctly, to gain the maximum number of points, made them invested in learning the required concepts by themselves and in understanding more about the domain. It was possible to see that the users that knew more about the domain were applying the knowledge that they already had, and when they made a mistake, they analysed why it was wrong and were able to understand how to correct it and solve it.

5.1 FUTURE WORK

There are several aspects that would enhance the game if they were to be implemented, but there are two that would be the most beneficial. The first one is the possibility to join two molecules together, because not being able to do this is a major flaw in the game, and it takes away a bit of freedom on how the players can interact with molecules. The second is a tool that would enable the teachers to design and to create the levels for the game with a user-friendly interface, and it would automatically create all the necessary text files for the game to load the levels correctly. This would be very beneficial because they could customize the game at their own will, according to what they want or need their students to learn at a specific class. The game would become more flexible and dynamic to be used in classrooms.

ACKNOWLEDGEMENTS

This work was supported by national funds through Fundação para a Ciência e a Tecnologia (FCT-UID/CEC/500 21/2013).

REFERENCES

Chris Christou. Virtual reality in education. Affective, Interactive and Cognitive Methods for E-Learning Design: Creating an Optimal Education Experience, pages 228-243, June 2010.

Eylem Bayor. Developing and playing chemistry games to learn about elements, compounds and the periodic table: Elemental periodica, Compoudica and Groupica. J. Chemical Education, February 2014.

Hsiu-Mei Huang, Ulrich Rauch and Shu-sheng Liaw. Investigating learners' attitudes toward virtual reality learning environments: Based on a constructivist approach. Computers & Education, November 2010.

Ivan Poupryves, Tadao Ichikawa. Manipulating objects in virtual worlds: Categorization and empirical evaluation of interaction techniques. Journal of Visual Languages and Computing, April 1999.

Jing Feng and Ian Spence. How video games benefit your brain. Proceedings, 2008.

Kristian Kiili. Digital game-based learning: Towards an experiential gaming model. The Internet and Higher Education, 2005.

Paul Richard, Georges Birebent, Phillippe Coiffet, Grigore Burdea, Daniel Gomez, Noshir Langrana. Effect of Frame Rate and Force Feedback on Virtual Object Manipulation. Presence: Teleoperators and Virtual Environments, vol. 5, pp. 95-108, January 1996

Winyu Chinthammit, Crystal Yoo, Callum Parker, Susan A. Turland, Scott J. Pederson and Wai-Tat Fu. MolyPoly a 3d immersive gesture controlled approach to visuo-spatial learning of organic chemistry. Australian Computer-Human Interaction Conference, April 2015.

A review of Management Tools for OpenSimulator

BRUNO VICENTE,[1] FERNANDO PAIS DE SOUSA,[2] LEONEL MORGADO,[3] PEDRO FURTADO,[4] JOÃO PASCOAL FARIA[5]

ABSTRACT

To host OpenSimulator virtual world servers at educational institutions, system administrators find at their disposal a diversity of web-based management systems with different sets of features. To support the selection among current management tools and provide a baseline from which to identify subsequent development needs, we installed and evaluated 4 of these systems (*WiFi pages, OSMW, MWI* and *jOpenSim*), analyzing and comparing their features. WiFi pages only provides account-management features. MWI has mostly the same features, but also provides systems administrators with the option of creating their own management website. OSMW has account-management and maintenance features, such as log management and editing of configuration files. jOpenSim provides features for account and event management and feature for generating some actions within virtual world, such as broadcasting a message to all regions. From matching the identified features with the literature-reported requirements for virtual world deployment at educational organizations, we conclude that there is no management tool that fulfils all the functional requirements reported in the literature and, therefore, that the adoption of current tools by system administrators will always require to manually perform some of the administrative tasks. We therefore call for development of novel, more encompassing administrative tools for OpenSimulator virtual worlds.

KEYWORDS

OpenSimulator;
OpenSim;
Virtual worlds;
System management;
System administration.

[1] Dept. of Informatics Engineering, University of Coimbra, Coimbra, Portugal — brpv@student.dei.uc.pt

[2] Univ. Aberta, Lisbon, Portugal & CMMRC / Rovisco Pais, Tocha, Portugal — fpsousa@roviscopais.min-saude.pt

[3] Universidade Aberta, Coimbra, Portugal & INESC TEC, CIAC, & LE@D — leonel.morgado@uab.pt

[4] Dept. of Informatics Engineering, University of Coimbra, Coimbra, Portugal — pnf@dei.uc.pt

[5] INESC TEC & Faculty of Engineering, University of Porto, Porto, Portugal — jpf@fe.up.pt

1. INTRODUCTION

There are now many examples of virtual world use in support of learning and training. Their prototyping capabilities enable the rapid, inexpensive, creation and testing of three-dimensional objects, choreographies, and interaction scenarios for virtual actors. These enable concrete (i.e., non-abstract) renderings of theories, concepts, and ideas among students and teachers (Morgado et al., 2010). Also, the use of virtual reality can give the student the opportunity to experiment, through simulation, situations that if lived in the real world could be dangerous, expensive, or otherwise inaccessible. This can also be done in cooperation between simultaneous participants in the virtual world, geographically separated in the physical world (*ibid.*).

Various alternative technologies exist for using virtual worlds in education. Besides third-party hosting such as the well-known Second Life, or its purported successor Sansar, there are also several alternatives for hosting at the institutions themselves, which enable institutions to use only local resources, avoid virtual hosting fees, and control network access to the virtual world (Vilela *et al.,* 2010). Examples include somewhat recent platforms such as High Fidelity and Minecraft, and older solutions such as OpenCobalt and Project Wonderland. However, OpenSimulator (v.g. OpenSim) remains the most common virtual world hosting platform in education. Or, at least, the most commonly reported in practitioner and research presentations in conferences focusing on this field (e.g. VWBPE – Virtual Worlds Best Practices in Education, which announced its 12th edition for 2019 – https://vwbpe.org/).

However, being the most referenced does not mean that OpenSim (or any other virtual world) is in widespread use. This has been hindered by a variety of issues (Morgado, 2013), such as lack of integration with existing learning management systems and other organizational information systems, lack of support and knowledge for network profiling, content management at the organizational level (Morgado *et al.,* 2016, December), or user authentication federation (Cruz *et al.,* 2015). The overburdened list of administrative and technical tasks that the systems administrators must deal with, can hamper the OpenSim installations, making it very time consuming to set up and manage activities in these environments (Morgado *et al.,* 2016).

For systems administrators of typical educational organizations, an OpenSim server will be only one among a diversity of computing services that must be managed and serviced. The application structure of organizations, whether educational or otherwise, involves a huge diversity of services, which must be managed and

maintained by the systems administrators (Barret *et al.,* 2004). Having to control and manage an OpenSim installation may be seen as yet another unknown server software to be mastered by the people responsible for it. And if usage is not widespread within the institution, it may be a service whose management falls outside daily routines, making it time consuming for the system administrator to review procedures and refresh knowledge about the databases schemas and client-server communication protocols and prone to errors. Hence the importance of a system that systematizes and ensures the quality of its management, impacting on the degree of reliability perceived by users (in the case of an educational organization, teachers and students).

In this paper, we present the outcome of studying the features of four OpenSim management systems, to evaluate their applicability. Section 2 provides some background on OpenSim. Section 3 describes the management tools we installed as well as an overview of their features. Section 4 compares the different tools regarding their functionalities. Section 5 is where we draw conclusions regarding the obtained results.

2. OpenSimulator

The OpenSimulator project (also known as OpenSim) is an extensible virtual worlds platform, built to simulate virtual multi-user three-dimensional spaces, where users can create objects (and modify or delete them) and, through scripts, program interactions and behaviors, considering variables representing physical characteristics of materials, as well as light sources defined in these virtual spaces (Fishwick, 2009). The configuration is managed through the text file “opensim.ini”, which contains the environment parameters: users starting location coordinates; address for access and authentication; etc. (*ibid.*). The system is composed by virtual regions simulators and data services, which include user management, inventory storage, and others. A virtual region is a part of the virtual space where users and virtual objects can be located. The starting location is where users are placed by default upon logging in. An inventory is a personal virtual storage of each user where virtual items can be stored. For systems administrators, there is a diversity of such aspects that must be considered. For instance, OpenSim virtual worlds can be configured in Standalone mode, or in Grid mode. If the system is running in *standalone* mode, it executes the simulation of region and data services in a single computational process (opensim.exe) (Fig. 1). Thus, system administrators must consider the modes and their available physical and virtual machines when pondering OpenSim installations and configuration.

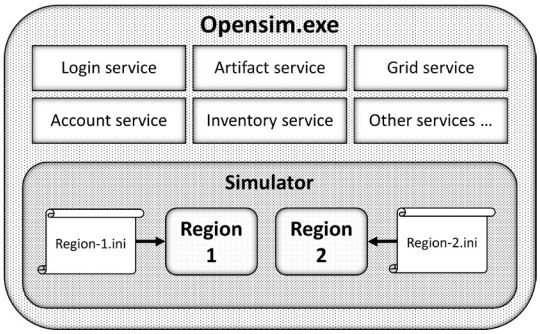


Fig. 1
Standalone configuration with two regions.

The Grid mode works differently. Data services and region simulators are separated into two or more computational processes. In this mode, data services are run by the *Robust.exe* process (*Redesigned OpenSimulator Basic Universal Server Technology – ROBUST*[6]). Region simulators continue to be run by the OpenSim.exe process, but now this process works only for the environment simulation service communicating with data services, running on separate instances (Fig. 2).

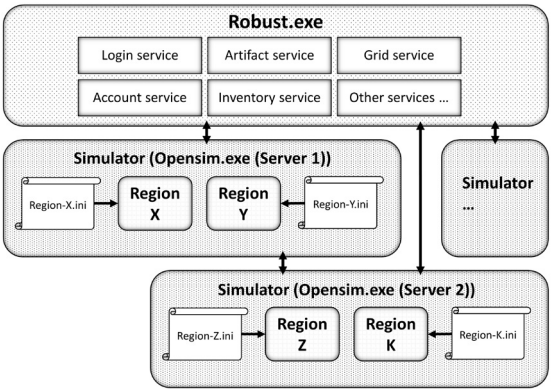


Fig. 2
Grid mode configuration with four regions on two processes.

The reason for having separate processes for regions is that this allows these services to run region simulators (established by users) that connect to other regions, outside the organization, such as public

[6] http://opensimulator.org/wiki/ROBUST/

Grids, while keeping data processes isolated from external servers. There is a specific protocol for this, called Hypergrid, with its own settings and management aspects to consider (Lopes, 2011).

OpenSim provides a way to manage the installation via the command line, without providing a graphical interface. The administration commands of the OpenSim servers are entered by typing in the terminal executing the process. These are of two types, those that apply to the simulator and those that apply to grid services. In a standalone installation, both run on the same console because the server is unique. In a grid architecture installation, the commands for the services work on the ROBUST server console and the simulator commands on the consoles of the various simulators (separately). The list of these commands can vary with the version of OpenSimulator used and the best way to find out which ones are available is with the "help" command in the region console.

3. AVAILABLE MANAGEMENT TOOLS

As stated in section 1, managing an OpenSim installation can be time-consuming. To ease this, some management tools have been developed by various parties. To identify existing management tools for this evaluation, we have searched for them in the following manner:

1. Querying the GitHub website with the search terms "OpenSimulator", "OpenSim", "OpenSimulator web" and "OpenSim web;
2. Querying the Research Gate website with the search terms "OpenSim", "OpenSimulator" and "managing OpenSim";
3. Browsing the OpenSimulator.org website for info on web interfaces for management.

By resorting to the first method, we have found 2 management systems: OSMW and MWI. By resorting to the second method, we did not encounter any work related to developing an administration tool for OpenSim. By employing the last method, we have encountered a web page with a list of management tools for OpenSim,[7] but only a few could be installed due to deprecation issues: most existing solutions were based on technologies that are either obsolete, deprecated, or the tool was just developed on a much-out-

[7] http://opensimulator.org/wiki/Webinterface

dated version of those technologies, sometimes as early as 9 years ago. We have attempted to contact the creators of said tools but failed to get support. Given the prevalence of the use of OpenSim, we were a bit surprised by this obsolescence of management tools, but this actually is consistent with the argument that widespread adoption is hindered by lack of adequate management tools (Morgado, 2013). The tools we were able to install and evaluate from this third source were: jOpenSim, Remote Admin, and OpenSimulator WiFi pages. Alongside the ones found at GitHub, these form our analysis batch.

The goal of the evaluation of the management tools was to be able to identify which features were present in each and how would they contribute to minimize the effort of a systems administrator conducting daily tasks. The identification of the features was done by reading the tools' descriptions and documentation (when available, such as for jOpenSim) and by installing and analyzing the web interface of each after we configured it to work with our OpenSim installation.

Next, we present the tools along with a brief description of each. The following section makes a comparison of the features available in these tools.

3.1 REMOTE ADMIN

To access OpenSim remotely, the installation package itself provides the Remote Admin[8] endpoint for the XML-RPC protocol.

Other than providing system administrators with remote access to the OpenSim services specifically (without having to open a remote terminal to the full machine) Remote Admin provides no further support, since its operation is identical to local administration tasks.

3.2 OPEN SIMULATOR MANAGER WEB

Open Simulator Manager Web,[9] or simply OSMW, is a management tool written in PHP that supplies the administrators of OpenSim installations with a web interface that enables user management, exportation of some data lists, monitoring and backup of regions,

[8] http://opensimulator.org/wiki/RemoteAdmin

[9] https://github.com/Nino85Whitman/OpenSim-Manager-WebV5

and some management of configuration files (table 1). This tool was developed 3 years ago and some of the code needs to be re-constructed due to the changes to PHP consecutively made from version 5.5.29 to version 7.1.14 that deprecated some functions and changed some general semantics in the PHP language.

3.3 MWI

MWI[10] is an open-source web front-end for OpenSim grids, also intended to be a full content management system (CMS).

It has two main parts: a front-end for visitors and an administration area for grid managers, where they can change most of the system characteristics. It provides system administrators with account management, user groups management, and more (table 1).

It is also possible to use it to automate some tasks, such as user registration and password recovery, and to easily access information about the bound regions on the grid.

3.4 OPEN SIMULATOR WiFi PAGES

Wifi pages[11] is a system constituted by a set of components that can be used in both standalone simulators and grid installations to manage OpenSim accounts, updates, passwords and basic aspects of users' inventories. It is said that its properties make it a good fit for small-to-medium OpenSimulator-based virtual worlds. It does not require the installation of a web server since it uses the built-in Open Simulator features.

3.5 jOpenSim WEB INTERFACE

jOpenSim[12] is an extension for Joomla!, a free and open-source CMS,[13] allowing interaction with an OpenSimulator server and 2 modules (grid status and friends online). This component can interact with grid or standalone mode installations, with MySQL as its database engine. Since it is an extension of Joomla!, the rationale is that the administrator can setup a website that suits his needs, design appeal and taste using the features made available by the components and modules provided by jOpenSim. It provides user

[10] http://mwi.myopengrid.com/page/home

[11] http://opensimulator.org/wiki/Wif

[12] https://www.jopensim.com/jopensim/thecomponent.html

[13] https://www.joomla.org/

management, user groups management, event management, etc. (table 1).

4. MANAGEMENT TOOLS COMPARISON

As shown in table 1, we can see that three types of features emerge: the ones we consider basic (features that are available on almost every studied tool); the ones that are specific to a certain topic, such as region management, account management, or configuration and administration related features; and features that are only available on a specific solution.

Some tools have a far more extensive range of features than others. Comparing OpenSim WiFi pages with other administrative tools we can see that while it is the only tool that enables inventory import. Beyond that it's the one with the least number of features.

WiFi pages is a very limited management tool since it only provides features related to account management.

Remote Admin, as mentioned, simply enables administrators to manage an OpenSim installation without having to provide full remote access to a machine (i.e. SSH, Remote Desktop). But it remains the only way to access a set of region managements features remotely, that no other tools provide, thus exposing the lack of feature coverage of other tools.

OSMW, along with jOpenSim, is one of the tools with the most features. The first has the basic set of features present on every tool and focuses on the maintenance of the installation. It has some unique features such as the ability to manage non-player characters (agents that are controlled by the computer, usually called bots by OpenSim users), save terrain, manage the system's logs and broadcast a message to all regions. jOpenSim is the only management tool that enables the creation of regions, although the other region-related functionalities are not supported. It was created to manage a grid, i.e. where each region may have its own administrator. It also provides the basic functionalities as well as some unique features such as listing virtual money transactions, event management and an in-world search that allows managers to find items within the virtual world.

MWI is one of the two analyzed tools that can manage user groups. This functionality may not be important for small OpenSim installations, but for more complex OpenSim grids it is very important, since groups can be formed by any set of 2 or more avatars. Its other features are like the ones provided by WiFi pages, and so we can say that this feature is its only advantage over the latter.

WiFi pages can be used to manage a small OpenSim installation, as it does not need an HTTP server to work and complements the

administrator commands with a web interface for account management.

The only tool that provides the ability to (or not to) authorize users to access certain parts of the virtual world through a graphical interface is MWI. This feature may be important if there are private sessions occurring somewhere in the virtual space.

With a more thorough analysis on table 1, we can see that the most adequate management tool for an administrator depends on the overall computational and usage environment of the OpenSim installation. For example, if one uses OpenSim only to explore a virtual form of socialization, with a few people connecting to a server, the only functionalities that are maybe needed are being able to create, to edit, and to delete users from the virtual world. If so, WiFi pages are enough to manage this system. On the other hand, if a training corporation or educational institution wants to use an OpenSim installation for training and education purposes, it is likely that none of the management tools explored in this article provides enough features, requiring some of the administrative work to be done at the console.

	REMOTE ADMIN	MANAGER WEB	MWI	WIFI PAGES	JOPENSIM
Remote access to OpenSim	yes	yes	yes	yes	yes
Create users	command line	yes	yes	yes	yes
Edit users	command line	yes	yes	yes	yes
Define default avatar				yes	yes
Export inventory		yes			
Import inventory				yes	
Manage user groups			yes		yes
Region Status	command line	yes	yes	yes	yes
View Map		yes			yes
Create region	command line				yes
Edit regions	command line	yes			
Restart regions	command line				
Get region access list	command line				
Add users to a region's access list	command line				
Remove users from a region's access list	command line				
Save region	command line	yes			
Load region	command line				
Non-player character management		yes			
Save land		yes			
File management		yes			
Log management		yes			
Edit configuration files		yes			
Edit simulators table		yes			
Define home location			yes		yes
Broadcast message to all regions		yes			yes
In-world object search					yes
Define default region			yes	yes	yes
Event management					yes
List money transactions					yes
Terminal management					yes
Get OpenSim version	command line				yes
Teleport agents	command line				

Table 1
Features available in the management tools.

5. CONCLUSIONS

As seen in section 4, none of the analyzed tools provides a superset of all services. There are always missing features in a tool that are available in others, and features that remain available only via the command line. If one considers the list of requirements identified

by Morgado *et al.* (2016), many aren't available at all. So, it is safe to say that there is not a management tool that fulfils the needs for practical organizational management of OpenSim installations. The analyzed tools were likely built with an ad hoc approach, focusing on individual managers' specific needs, and do not reflect an organizational requirements perspective of the management challenges of an OpenSim installation.

We encourage further research on identification and specification of administrative features required of OpenSim management tools, and their subsequent development, towards a more widespread deployment of virtual worlds in education.

ACKNOWLEDGEMENTS

This research has been partially financed by the European Commission [BEACONING H2020ICT-2015-687676].

REFERENCES

Barrett, R., Kandogan, E., Maglio, P. P., Haber, E. M., Takayama, L. A., & Prabaker, M. (2004, November). Field studies of computer system administrators: analysis of system management tools and practices. In Proceedings of the 2004 ACM conference on Computer supported cooperative work (pp. 388-395). ACM.

Cruz, G., Costa, A., Martins, P., Gonçalves, R., & Barroso, J. (2015). Toward educational virtual worlds: should identity federation be a concern?. Educational Technology & Society, 18(1), 27-36.

Fishwick, P. A. (2009, December). An introduction to OpenSimulator and virtual environment agent-based M&S applications. In Winter simulation conference (pp. 177-183). Winter Simulation Conference.

Lopes, C. (2011). Hypergrid: Architecture and protocol for virtual world interoperability. IEEE Internet Computing, 15(5), 22-29.

Morgado, L., Varajão, J., Coelho, D., Rodrigues, C., Sancin, C., & Castello, V. (2010). The attributes and advantages of virtual worlds for real world training. The Journal of Virtual Worlds and Education, 1 (1), 15-35.

Morgado, L. (2013). Technology challenges of virtual worlds in education and training-research directions. In Games and Virtual Worlds for Serious Applications (VS-GAMES), 2013 5th International Conference on (pp. 1-5). IEEE.

Morgado, L., Paredes, H., Fonseca, B., Martins, P., Almeida, Á., Vilela, A., ... & Santos, A. (2016, December). Integrating virtual worlds with learning management systems: the MULTIS approach. In Ubiquitous Computing and Communications and 2016 International Symposium on Cyberspace and Security (IUCC-CSS), International Conference on (pp. 167-172). IEEE.

Morgado, L., Paredes, H., Fonseca, B., Martins, P., Antunes, R., Moreira, L., ... & Santos, A. (2016). Requirements for the use of virtual worlds in corporate training: perspectives from the post-mortem of a corporate e-learning provider approach of Second Life and OpenSimulator. In iLRN 2016: Im-

mersive Learning Research Network Conference. Workshop, Short Paper and Poster Proceedings from the Second Immersive Learning Research Network Conference (pp. 18-29). Technischen Universit¨at Graz.

Vilela, A., Cardoso, M., Martins, D., Santos, A., Moreira, L., Paredes, H., ... & Morgado, L. (2010, March). Privacy challenges and methods for virtual classrooms in Second Life Grid and OpenSimulator. In Games and Virtual Worlds for Serious Applications (VS-GAMES), 2010 Second International Conference on (pp. 167-174). IEEE.

POSTERS

VIDEO JOGOS 2018
10th Conference on Videogame Sciences and Arts
Porto, 21 & 22 November
http://vj2018.fba.up.pt/

"Invasive Plants" – a Serious Game for Environmental Awareness

Liliana Santos[1]; Pedro Reis[2]; Filipe Costa[3]; Mário Esteves[4]; Ricardo Teixeira[5]
[1]Faculty of Engineering of the University of Porto (FEUP), l.a.rocksaints@gmail.com;
[2]FEUP, pedroreis.ad@gmail.com; [3]FEUP, joaofilipepereiracosta@gmail.com; [4]FEUP, up201607940@fe.up.pt; [5]FEUP, ricardomft@gmail.com

The "Invasive Plants" Game

Liliana Santos, Pedro Reis, Filipe Costa, Mário Esteves and Ricardo Teixeira

Keywords: Serious games, environmental awareness, invasive species.

Objectives: to inform and raise awareness to the general public, about invasive plant species in Portugal and to show proper ways of remove these plants.
The game was designed for Android mobile devices, using the Unity 3D engine and Adobe Illustrator.

The main focus of the game is to remove the invasive plants which consume oxygen from the lake's water, and due to their fast reproductive rate, can prevent sunlight from reaching the underwater flora.

To kill these plants, the player must choose the appropriate tool. If this is not done, the plants begin to reproduce, and the lake's oxygen level starts to decrease, causing fishes to die. Once the oxygen level reaches zero, the game is lost.

Only by removing invasive plants can the lake return to its healthy state.
If the player successfully removes all invasive plants, victory is accomplished.
To use a tool, the player can simply drag it from the bottom inventory onto the main playing area.

Figure 1. Main menu.

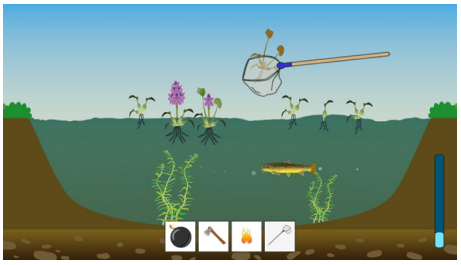
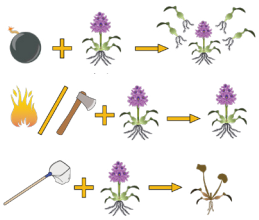


Figure 2. Interface: a lake ecosystem with some floating invasive plants (water hyacinths), underwater life, an inventory with tools and the oxygen level.



Bomb's explosion: increases reproduction rate and difficulty.

Fire and an axe: no effect on aquatic plant.

Net: removes water hyacinths to dry them to death!

Demo

Figure 3. Losing the game.

Figure 4. Winning the game.

User testing

July, 2018, during an event targeted at game developers.
This sample was chosen in order to gather more informed feedback and suggestions for future improvements.
Sample: 30 volunteers, ages between 22 to 45 years old.
Three android mobile devices were used. Each participant was lent one of them so that they could play and explore the game. After playing, participants were asked to fill a short questionnaire about their experience.

Results

50% believe the game needs a tutorial and/or an instruction book.
60% reported that the game's goal was clear enough.
80% believe that the game possesses an effective educative component.
80% thought the game was fun.
83% reported that they understood the message behind the game.
83% liked the visual component.
97% wanted to play more levels.

VIDEO JOGOS 2018
10th Conference on Videogame Sciences and Arts
Porto, 21 & 22 November
http://vj2018.fba.up.pt/

Digital Games in Portugal: Gender Asymmetries in Higher Education.

Luciana Lima[1]; Ricardo Queirós[2]
[1]Escola Superior de Media Artes e Design. lucianalima@esmad.ipp.pt
[2] Escola Superior de Media Artes e Design. ricardoqueiros@esmad.ipp.pt

Introduction

The theme of gender equality has mobilized a set of research agendas focusing on sectors of the economy in which the gender dimension has been neglected for a long time. One of them refers to the entertainment industry.

Until the 1990s, the female gamer figure was invisibilized, reinforcing the representation that women were not interested in it (Friman, 2015; Jenkins & Cassell, 2008 Richard, 2013).

There is no broad study in Portugal on the gender dimension and digital games, which hampers effective actions aimed at eliminating gender asymmetries both in terms of women's access to this training context and in the broad discussion on the perpetuation of gender stereotypes in video games produced in the country. In view of this gap, we are developing a scientific research that aims at mapping the gender dimension in the context of training and production of digital games. The research includes four stages:

1. To identify the number of men and women enrolled in higher education in the area of digital games in Portugal;

2. To identify how the female and male characters are represented in the digital games produced in the last 10 years in Portugal (2008-2018);

3. Focus group with students on the gender dimension in the culture of the game and the gaming industry;

4. To analyze the discourses of teachers and professionals of the digital games sector on gender asymmetries in the gaming industry.

In this poster we present the results of the first stage.

Methodology

We have carried out a quantitative survey of the number of men and women who carry out higher education in the area of digital games in Portugal. Based on data provided by the Directorate-General for Education and Science Statistics (DGEEC-PT), we selected all training offers in the 2016/17 school year which include the word "game(s)" in the instruction designation.

Results

We identified a total of twelve training offers, distributed as follows: six undergraduate degrees (1st cycle), two master's degrees (2ndcycle) and four professional higher technical courses (TeSP). Regarding the nature of the educational establishment, the courses were offered by three private universities, one public university, five public polytechnics and one private. Institutions located in different areas of the country: North, Center and South.

Among the classifications of the areas of education and training, courses were included in three areas: arts and humanities (audiovisual and media production), computer science (computer science) and engineering and related techniques (electronics and automation).

Regarding the gender distribution of enrollees, we identified that 82.9% (N: 648) were males and 17.1% (N: 134) were female, totaling 782 enrollees in that school year (see figure 1).

Conclusion

This first phase of the research allowed us to conclude that the training offer in the area of video games in Portugal has been increasing. In addition, the variety of these formations suggests that there is a market that needs professionals in the field of video games specialized in different fields: programming and game design, for example. We also conclude that, even with the increase in training, there is a low demand from the female audience, which suggests that there is a lack of awareness in order to stimulate the interest of girls in training in videogames. However, other factors may be associated with this phenomenon. Answers that we hope to get when we finish the next steps of the research.

Figure 1- Number of enrollees in the 2016/17 academic year

Institution	Type of IES	Cycle of study	Course designation	Male	Female	Total
Lusófona (Lisboa)	University-private	Graduation -1st cycle	Aplicações multimedia e videojogos	87	10	97
Lusófona (Porto)	University-private	Graduation -1st cycle	Aplicações multimedia e videojogos	42	28	70
IPLeiria	Polytechnic - public	Graduation -1st cycle	Jogos digitais e multimédia	116	27	143
IPBragança	Polytechnic - public	Graduation -1st cycle	Design de jogos digitais	101	22	123
IPCA	Polytechnic - public	Graduation -1st cycle	Engenharia em desenvolvimento de jogos digitais	106	6	112
Universidade Europeia	University-private	Graduation -1st cycle	Desenvolvimento de jogos e aplicações	33	1	34
IPCA	Polytechnic - public	Master degree-2nd cycle	Design e desenvolvimento de jogos digitais	21	4	25
Universidade da Beira Interior	University public	Master degree-2nd cycle	Engenharia em desenvolvimento de jogos digitais	28	9	37
ESMAD- IPP	Polytechnic - public	Professional higher technical courses	Design de jogos e animação digital	31	3	34
IPMaia	Polytechnic - private	Professional higher technical courses	Produção multimedia e jogos digitais	37	9	46
IPTomar	Polytechnic - public	Professional higher technical courses	Artes para jogos digitais	31	14	45
IPTomar	Polytechnic - public	Professional higher technical courses	Desenvolvimento para jogos digiais	15	1	16
Total				648 (82,9%)	134 (17,1%)	782

References

Cassell, J. and Jenkins, H. Chess for Girls? Feminism and Computer Games. In: Cassel, J. & Jenkins, H. (eds). *From Barbie to Mortal Kombat:* Gender and Computer Games (pp. 2-45). Cambridge: MIT Press. 1998a.
Cassell, J. and Jenkins, H. *From Barbie to Mortal Kombat*: Gender and Computer Games (pp. 2-45). Cambridge: MIT Press. 1998b.
Dietz, T. L. An Examination of Violence and Gender Role Portrayals in Video Games: Implications for Gender Socialization and Aggressive Behavior. Sex Roles, Volume 38 (pp.425-442). https://doi.org/10.1023/A:1018709905920. 1998.
Fortim, I. Mulheres e Games: uma revisão do tema. Em: Simpósio Brasileiro de Jogos e Entretenimento Digital - SB-Games, 7., 2008. p.31-38, Belo Horizonte. Disponível em: <http://www.sbgames.org/papers/sbgames08/Proceedings-SBGames-GC-2008-Final-CD.pdf. 2008.
Friman, U. The Concept and Research of Gendered Game Culture. In: Proceedings of DIGRA 2015. *Diversity of Play: Games- Cultures- Identities*. 2015.
Jenkins, H. and Cassell, J. From Quake Girls to Desperate Housewives: a Decade of Gender and Computer Games. In: Kafai, Y.B.; Heeter, C.; Denner, J.; Sun, J.Y. (eds.). *Beyond Barbie and Mortal Kombat: New Perspectives on Gender and Gaming* (p. 5-20). Cambridge: MIT Press, 2008.
Richard, G.T. Gender and gameplay: Research and future directions. In: Bigl, B. and Stoppe, S. (eds.) *Playing with virtuality: Theories and methods of computer game studies* (p. 269-284). Frankfurt: Peter Lang Academic, 2013.

VIDEO JOGOS 2018
10th Conference on Videogame Sciences and Arts
Porto, 21 & 22 November
http://vj2018.fba.up.pt/

Hüpata

Carolina Bonzinho[1]; Aurora Peixoto[2]; Marta Rodrigues[3]; Pedro Amado[4]

[1]FBAUP, carolina.bonzinho@gmail.com; [2]FBAUP, auroraapeixoto97@gmail.com; [3]FBAUP, martaareosar@gmail.com; [4]FBAUP/i2ADS, pamado@fba.up.pt

Image 1

Prototype of a Platform Game as an Interactive Typographic Model

This project emerged in the context of a Communication Design course with the purpose of creating a kinetic typography interactive application. The solution developed explores the theme in an innovative way – using an interactive game to disclose and promote a typographic specimen (Porchez, 2014; Amado & Silva, 2016) giving a new purpose to the characters. A Processing app was created with the goal of entertaining while fulfilling its main type specimen role – publicize the launch of a digital typography and its characteristics. In the game the glyphs are shown as elements that communicate through their shape, and its formal components make up all the scenario and objects in the game.

The central idea was to build a game's universe based on typography only. As defined by Salen & Zimmerman (2004), the current game elements of the interactive specimen are: the player who is transported into the game in the form an animated character (img. 4); the rules system that allow to move and overcome conflicts or obstacles in an uneven path; the purpose of completing the course without letting the character fall through the path; in the exploration activity that ultimately reveals the total form of the micro-typographic details or the full logo (img. 2).

Image 2

As a proof of concept, the logo created to prototype this game was based on concepts such as movement and interactivity – the name of the game "HÜPATA", which means "*jump*" in Estonian –, and the chosen character is composed by elements that convey the dynamics of the game. The mechanics are mainly based on three UX pillars for videogames (Hodent, 2017): clarity; minimum cognitive load and flexibility (for future applications with other logos or typographies). Nonetheless however having as a focus, the concept and its own aesthetics. Aesthetically, it is artificial and abstract. But it is this graphical nature that promotes the game's immersive properties and enhances the interaction.

We created this game as a possible context for the launching of a new font, for example, the typography we used for the title. The game's structure was designed considering an initial cut scene (img. 2) – an animation as means to expose its details and the way it is built –, the playable platform level (img. 3), a transition of levels or final cut scene through a zoom out to reveal the singularities of the typography or logo (img. 1, 5 & 6). In this context, the app emerges to show an easy adaptation of the type to any scenario as well as its utility or relevance for future design or marketing applications.

With this in mind, we used as reference games that were present in our childhood. The way the character moves, falling gradually, is related with the game Flappy Bird – where a simple rules system is privileged; as well as Super Mario from which we also used the character's movement and its relationship with the platforms and obstacles.

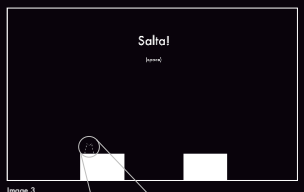


Image 3


Image 4

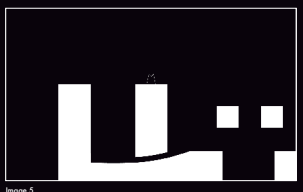


Image 5


Image 6

Referências:

Amado, Pedro, and Ana Catarina Silva. 2016. "The Evolution of the Type Specimen Book: From Early XX Century Letterpress Books to Interactive Web Applications." In ATypI Anual Conference. Warsaw: ATypI. https://www.atypi.org/conferences/atypi-warsaw-2016/programme/activity?a=587.

Hodent, Celia. 2017. The Gamer's Brain: How Neuroscience and UX Can Impact Video Game Design. Boca Raton: CRC Press.

Salen, Katie, Katie Salen Tekinbaş, and Eric Zimmerman. 2004. Rules of Play: Game Design Fundamentals. MIT press.

Porchez, Jean-François. 2014. The Typofonderie type specimens collection. In https://typofonderie.com/gazette/post/typofonderie-type-specimen-collection-20-years-anniversary/

VIDEO JOGOS 2018
10th Conference on Videogame Sciences and Arts
Porto, 21 & 22 November
http://vj2018.fba.up.pt/

Gamers4Nature: Game creation tools to promote Environment and Biodiversity preservation awareness

Pedro Beça[1]; Rita Santos[2]; Gonçalo Gomes[3]; Ana Veloso[4]; Eduardo Ferreira[5]; Milene Matos[6]
[1]Universidade de Aveiro, pedrobeca@ua.pt; [2]UA, rita.santos@; [3]UA, goncalo@; [4]UA, aiv@; [5]UA, elferreira@; [6]BioLiving, milenematos@gmail.com

Abstract. The Gamers4Nature project aims to design and operationalize a set of strategies that prepare and encourage an active participation of the youngest audience in game creation, while promoting knowledge about environmental preservation and biodiversity conservation.
In the first phase, a game creation toolkit will be developed, which will include guidelines on the various phases necessary to achieve this goal, as well as resources and tools that may be useful during the process. Besides being foreseen the evaluation and application of this toolkit in a set of secondary schools, by students of different areas, the toolkit will be used by other public, such as university, allowing people with different backgrounds to be involved in the process of creating games.
The project also includes the organization of game jam events with the goal of developing games around the environment and natural conservation issues. In these events, participants will have the opportunity to apply the knowledge derived from contact with the toolkit and, in multidisciplinary teams, create a set of games that reach the target audience, communicate important messages around the preservation of the environment and conservation of biodiversity and with the potential to awaken consciousness and change behaviors.
With this project, it is considered that an important contribution is made to the promotion of the environment and biodiversity, by proposing a set of strategies to create games that can be used by schools, universities, environmental organizations, public bodies, among others, to improve their communication and educational strategies on the importance of preserving the environment. Finally, it is considered that the project's activities also contribute to the development of a set of soft skills in the participants, such as the ability to work in teams and solve problems, as well as creativity, skills that are increasingly valued in society.

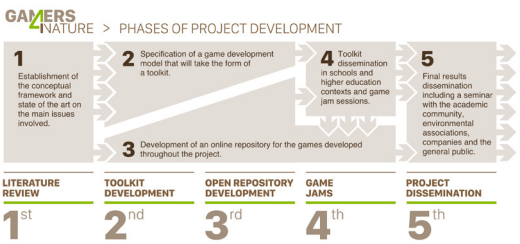
Keywords: Mobile games, Game Jams, Game Design Tools and Techniques

Background Information and objectives

Given the familiarity of a large number of young people with mobile games, these are increasingly being used in contexts other than the merely entertainment context, such as in the educational, professional, advertising, among others. The relevant use of digital games in education has been recognized a few years to this part (Brewer 2003; Earp, Dagnino, and Ott 2014; Gee 2008; McGonigal 2011). Digital games also had proved to be effective in promoting communication about environmental conservation and behaviour change. Against this background, to which are added the growth of the Do-It-Yourself (DIY) culture and several initiatives that aim to broaden participation in the programming area (Coding - the 21st century skill | Digital Single Market 2017), several researchers and practitioners are encouraging users to create their own digital games, which they can subsequently share with the community (Earp, Dagnino, and Ott 2014). This strategy can empower users and offer opportunities for building a range of knowledge and skills not just within specific subject areas, but skills like creativity, problem solving and collaboration, that are part of Twenty-First Century Skills (Earp, Dagnino, and Ott 2014).
The game making can also be undertaken in a collaborative environment, involving people with different backgrounds, which could result in a richer game. One of the strategies to achieve this are game jams. Game jams had been used to help solving scientific problems, expose and overcome sensitive issues and for inclusivity (Kultima 2015; Myerscough et al. 2017). In this way, game jams are often seen as tools for learning different kinds of subject matters and skills (Kultima 2015). One aspect that seems to be lacking is reflection about the importance of a phase of encouraging and preparing people of different skills and backgrounds to participate in these events, with the idea that this could lead to more complete and better games.
The Gamers4Nature project aims to design and operationalize a set of strategies that prepare and encourage an active participation of the youngest audience in game creation, while promoting knowledge about environmental preservation and biodiversity conservation. Being involved in creating games promotes the learning of skills that are necessary to achieve this goal (related to game development tools, programming languages, art styles) but also presents an opportunity to develop knowledge and skills that are not merely technical. In addition, by engaging potential players themselves as creators of games, there is a greater prospect that this message reaches the intended audience and with far greater relevance.

Project activities

The project gamers4Nature will be organized in five stages described in the picture below.



Main results and Contribute

- one book comprising the toolkit to game design strategies;
- a toolkit to game design strategies;
- an open online repository;
- scientific publications;
- a final seminar, enclosing the final project's remarks, involving schools and universities, which will result in a set of recommendations that stimulates investment and innovation practices using technologies;
- thesis (masters and doctoral) developed within the aims of the project;
- a digital repository to securely store and distribute the games.

With this project, it is considered that an important contribution is made to the promotion of the environment and biodiversity, by proposing a set of strategies to create games that can be used by schools, universities, environmental organizations, public bodies, among others, to improve their communication and educational strategies on the importance of preserving the environment. Finally, it is considered that the project's activities also contribute to the development of a set of soft skills in the participants, such as the ability to work in teams and solve problems, as well as creativity, skills that are increasingly valued in society.

References

Brewer, Carol. 2003. "Computers in the Classroom: How Information Technology Can Improve Conservation Education." Conservation Biology 17(3): 657–60. http://onlinelibrary.wiley.com/doi/10.1046/j.1523-1739.2003.01739.x/full.
"Coding - the 21st Century Skill | Digital Single Market." 2017. https://ec.europa.eu/digital-single-market/en/coding-21st-century-skill (May 30, 2017).
Earp, Jeffrey, Francesca Maria Dagnino, and Michela Ott. 2014. "Learning through Game Making: An HCI Perspective." In Universal Access in Human-Computer Interaction. Universal Access to Information and Knowledge, eds. Constantine Stephanidis and Margherita Antona. Springer International Publishing, 513–24. http://dx.doi.org/10.1007/978-3-319-07440-5_47.
Gee, James Paul. 2008. "Learning and Games." The ecology of games: Connecting youth, games, and learning 3: 21–40.
Goddard, William, Richard Byrne, and Florian "Floyd" Mueller. 2014. "Playful Game Jams: Guidelines for Designed Outcomes." In Proceedings of the 2014 Conference on Interactive Entertainment, IE2014, New York, NY, USA: ACM, 6:1--6:10. http://doi.acm.org/10.1145/2677758.2677778.
Kultima, Annakaisa. 2015. "Defining Game Jam." In 10th International Conference on the Foundations of Digital Games (FDG 2015),.
McGonigal, Jane. 2011. Reality Is Broken: Why Games Make Us Better and How They Can Change the World. Penguin.
Myerscough, Kaelan Doyle, Richard Eberhardt, Mikael Jakobsson, and Claudia Lo. 2017. "Jamming for Allies: Finding a Formula for Inclusive Design Exploration Collaborations." In Proceedings of the Second International Conference on Game Jams, Hackathons, and Game Creation Events, ICGJ '17, New York, NY, USA: ACM, 26–32. http://doi.acm.org/10.1145/3055116.3055121.
Sandbrook, Chris, William M Adams, and Bruno Monteferri. 2015. "Digital Games and Biodiversity Conservation." Conservation Letters 8(2): 118–24. http://dx.doi.org/10.1111/conl.12113.

Cofinanciado por: FCT Fundação para a Ciência e a Tecnologia · COMPETE 2020 · PORTUGAL 2020 · UNIÃO EUROPEIA Fundo Europeu de Desenvolvimento Regional

DEMOS

VIDEO JOGOS 2018
10th Conference on Videogame Sciences and Arts
Porto, 21 & 22 November
http://vj2018.fba.up.pt/

Noughts and Crosses: A Monopoly Game

Inês Ferreira[1]
[1]Universidade do Porto, up200601296@fba.up.pt

Introduction

This is a ongoing project that started as an exercise to introduce the concepts and methods of game design.

The objective was to turn a just-for-fun game into a serious game. The chosen game was Noughts and Crosses (NaC).

The process started by choosing and classifying a well-known game in terms of its basic elements (e.g. rules, objectives, number of players) to better visualize its scope. After this, it was about to change some of those elements, while using an iterative process: define, play (test), evaluate and repeat.

Changing the Rules

Original NaC

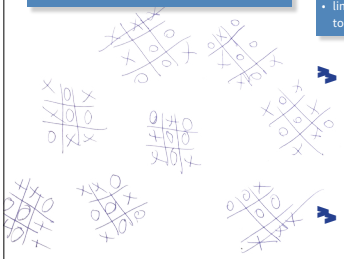
Very stiff and static

- usually played as paper-and-pencil game
- played symbols not move

Adapted NaC

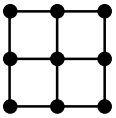
Flexible and loose

- physical game: in a board and with two sets of game pieces
- allow the players to move the game pieces played
- limit the number of the game pieces (three for each player) to allow more movement



Similar to one variation known as "Three Men's Morris":

This game uses a different board with lines and dots, and can have an optional rule in which played pieces can only move to an adjacent point.



This optional rule is interesting, as while playing the NaC with the above rules, it was felt the necessity to change something to keep the game amusing as it was starting to be monotonous.

New Rule

- Restrict the time a game piece can be in the central square of the board by 2 turns (on the 3rd turn, the player has to move it out).
  - More dynamic, as the central place is very desired and one needs to think two turns ahead

Finding the Theme and Genre

A serious game implies a purpose besides entertainment.

This game was adapted to critique money accumulation, and the concept of wealth generates wealth. A real-life positive feedback loop.

New Rules

- the game would need to have more than one match
- each time a player wins a match it wins a new game piece to play

In this new game, when a player wins a match, he earns a new piece, i.e. earn more wealth, that will help him "invest" and win again. The loser will keep being "poor", and even if his condition could allow him to have some advantages (like play first, no center-place piece restriction), they would be artificial as they do not leverage the outcome of the game.

Although its rules are very simple to follow, it added a stressful layer to the first matches as they define the course of the game.

One could argue that as the game is resolved in the first matches it loses interest in continue to play, because the players do not "have an ongoing emotional investment in defeating each other" (LeBlanc, M. 2004). But that is the reflective part: knowing forehead that you will be losing but "have" to keep playing.

Conclusion

A few changes on a simple game were able to draw attention to a situation and question its players.

This is a work in progress, where the cycle of define-test-evaluate was essential to spot potential problems and evolve the gameplay.

References

Hunicke, Robin, Marc LeBlanc, and Robert Zubek. MDA: A Formal Approach to Game Design and Game Research. Paper presented at the AAAI-04 Workshop on Challenges in Game AI, 2004.

LeBlanc, Marc. Mechanics, Dynamics, Aesthetics: A Formal Approach to Game Design. Lecture at Northwestern University, 2004. Available at: http://algorithmancy.8kindsoffun.com/MDAnwu.ppt

Norman, Donald. and Ortony, Andrew. Designers and Users: Two Perspectives on Emotion and Design. In Proceedings of the the Symposium on Foundations of Interaction Design, 2003.

New Rules (On Going..)

- Game with multiple matches that ends when one of the players goes bankrupt, i.e. one of the players have all the game pieces.
- Each player has three wealth tokens - golden X's and O's - and alternate at placing them on any of the nine spots of the board
- A game piece can be in the central square only two turns
- When someone wins a match, they earn an extra piece to play
- The players can have up to 5 game pieces to play. When they reach this limit, they receive a a game piece of the opponent set: one that the opponent hasn't won yet, and if those aren't available, he receives one that is in possession of its opponent

Variation 1

When a player have pieces of the opponent's set, he can opt to play them and try to do a "3 in-a-row" with those pieces.

But..

- How can the players be rewarded if they both win?
- How can the prize be divided?
- Should the player that places the last piece that makes the 3 in-a-row get a larger prize?
- Or should, be the player that already had the pieces on the board?
- Doesn't this conflicts with the objective of the game and ending the game fast? So why the winner should use the earned opponent's pieces?

Variation 2

Using real money to play: game pieces as 1€ coins, heads for one player and tails for the other.

Though both players game pieces' sets are equal, the distinction remains when a player earns his opponent piece, if he chooses to play it, the opponent's symbol should be turned up.

To get the opponents money you have to play with his pieces. So, it gives an "opportunity" to the losing/poorer player to "climb the ladder".

But..

- Do the players use their own money to play?
- Or it is provided as part of the game set?
- When someone ends the game, can the winner keep it?

- When both players win a match, as money can be divided, the available money can be exchanged and distributed.
- Can the exchanged money be played as the original coins?
- Should exist a "bank", to change the money?

- Using real money, is more engaging, but socially questionable, as money-related games are subject to regulamentation. Also, distinguish players' game pieces using their position is hard to tell them apart.
- Should the game use fake money?
- Does the game loses meaning?

VIDEO JOGOS 2018
10th Conference on Videogame Sciences and Arts
Porto, 21 & 22 November
http://vj2018.fba.up.pt/

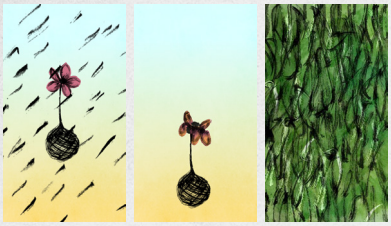
Fellowers

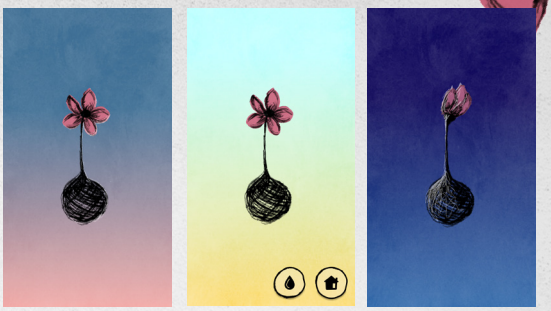
Claudia Gomes[1]; Gaya Rabello[2]; Inês Ferreira[3]
[1]Universidade do Porto, up200501550@fba.up.pt; [2]Universidade do Porto, up201803210@fba.up.pt; [3]Universidade do Porto, up200601296@fba.up.pt

ABSTRACT

The poster describes the development of a game for older adults (i.e. over 65 years old). The main element of the game is a plant. The game uses the plant physiological and emotional needs to establish a relationship with the player based on trust and pleasure. The goal of the game is to keep the plant alive and happy, by regularly performing a set of actions like watering, sheltering and talking to it. When these actions do not take place as often as necessary, the plant begins to wither, and can die in case of total abandonment. This game is an ongoing process.

Keywords: Simulation game, Art game, Discovery





CONCEPT

A fellow flower to take care and watch it grow within a calm and meditative environment. A mixture between a simulator and ambient game.

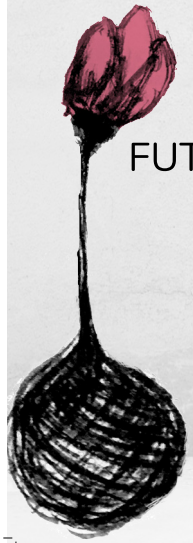
OBJECTIVE

To keep the plant alive and well.

DESCRIPTION

The player must take care of the plant daily, responding to its physiological and emotional needs. The player's location climate also influences the environment in the game's world.

The emotional needs of the plant, add an extra entertainment layer to the game. To fulfill those needs, the player has to talk with the plant. The plant is very friendly, trustful and smart in order to provide a pleasant conversation with the player.



FUTURE **WORK**

- Multiplayer
- Multiplants
- Exchange plants
- Send bugs and pests to other player's plants
- Chat randomly with another player
- Own several plants
  Different plants have different needs for light, water and attention

HOW TO KNOW THE **NEEDS OF THE PLANT**

When the plant starts to wither, its form and colours change and can lose petals or leaves. As it is floating in the screen, it also starts to go down. This means it is not healthy and needs help. When the player ignores these signs for a long time, the plant will ask him directly for help.

WATERING

- **Dryness:** dry soil and fallen petals/leafs of the pot
- **Wetness:** the water drips from the pot and makes a puddle under it
- **Healthy:** dark and homogenous soil

SHELTER

- If there is too much sun or rain, and the plant presents some of the previous signifiers, it can help it to shelter it. The same, if there is too much wind and the plant can bend and break by the strong wind.
- Spending too much time indoors can also harm the plant

ATTENTION

- The plant starts a conversation with the player to have his attention. It can ask him open-answer questions or multiple-choice ones.

REFERENCES Norman, Donald; and Ortony, Andrew. Designers and Users: Two Perspectives on Emotion and Design. In Proceedings of the the Symposium on Foundations of Interaction Design, 2003.
Hunicke, Robin, Marc LeBlanc, and Robert Zubek. MDA: A Formal Approach to Game Design and Game Research. Paper presented at the AAAI-04 Workshop on Challenges in Game AI, 2004.
Tamagotchi. Bandai, WiZ, 1997. Neko Atsume. Cat game. Hit-Point Co. Ltd, 2014. Mountain. Double Fine Productions, 2014

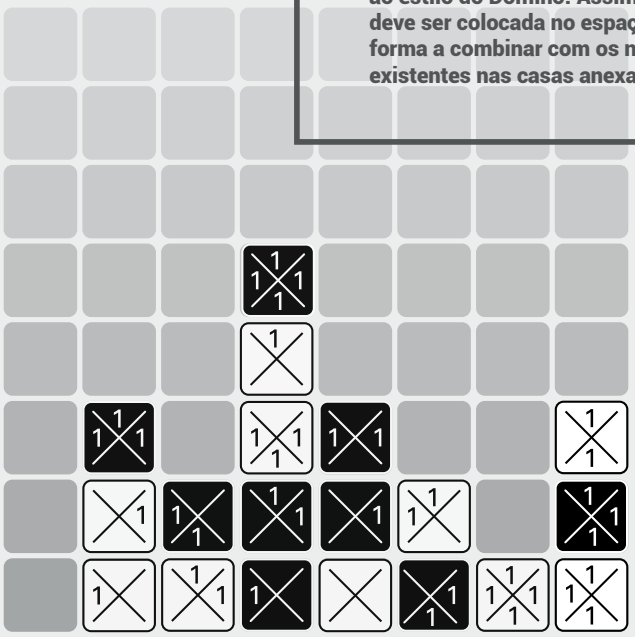
VIDEO JOGOS 2018
10th Conference on Videogame Sciences and Arts
Porto, 21 & 22 November
http://vj2018.fba.up.pt/

Quatro em Dominó

Clara Agustí
FBAUP, clara.junqueira5@gmail.com

q-u-a-t-r-o e-m---d-o-m-i-n-ó

Quatro em Dominó surge da união entre os jogos Quatro em Linha e Dominó. Com base no primeiro, as peças são modificadas de forma a exibir números, ao estilo do Dominó. Assim, cada peça deve ser colocada no espaço de jogo de forma a combinar com os números já existentes nas casas anexas.



O jogo ocorre entre dois jogadores, aos quais são atribuídas peças de uma cor distinta. No seu turno, o jogador deve inserir uma única peça na grelha, de forma a cair no fundo da coluna em que foi inserida (ou, se for o caso, na casa imediatamente acima a outra peça anteriormente colocada nessa coluna). Cada peça deve ser colocada na grelha de modo a que os números e os espaços em branco da mesma combinem com o das peças à sua volta. Vence o primeiro jogador a criar uma linha vertical, horizontal ou oblíqua de, pelo menos, quatro peças da sua cor consecutivas. Caso isso não se observe antes de a grelha estar preenchida, termina em empate.

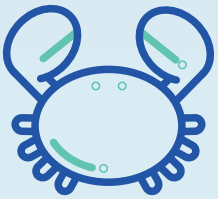
VIDEO JOGOS 2018
10th Conference on Videogame Sciences and Arts
Porto, 21 & 22 November
http://vj2018.fba.up.pt/

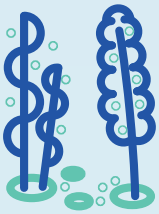
Mythos

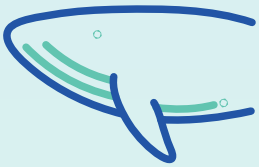
Clara Agustí
FBAUP, clara.junqueira5@gmail.com

mythos

Mythos é um jogo de tabuleiro dedicado ao Oceano e respetiva Mitologia, cujo objetivo é o de provar a existência de certas criaturas mitológicas, desde a sereia ao Adamastor. Para tal, o jogador deve percorrer o mapa do tabuleiro, catalogar espécies aquáticas comuns e espécies em vias de extinção, completar desafios em realidade aumentada e cumprir missões que duram toda a partida.







VIDEO JOGOS 2018
10th Conference on Videogame Sciences and Arts
Porto, 21 & 22 November
http://vj2018.fba.up.pt/

Let's Build a Meal!
Ana Miriam Rebelo; Mariana Leal Rato
PhD Design FBAUP, ana.miriam.rebelo@gmail.com; PhD Design FBAUP, mariana.leal.rato@gmail.com

Let's build a meal!

Let's Build a Meal is a collaborative board game, designed to promote food literacy through the playful elaboration of healthy and appetizing recipes.

The concept of construction – in the broad sense of selecting and associating elements to build something new - sets the fundamental dynamic of the game. By associating building blocks to nutrients and food portions, the game provides a tool for the collective construction of a meal, setting informed choice as the basis of a healthy diet. Budgetary restrictions constraints are introduce to simulate real conditions, but also to promote improvisation and creativity.

The dynamics of the game develop in 3 moments: choice of ingredients limited to a given budget, creative use of the chosen ingredients in the collective construction of a meal and evaluation of the resulting recipe. If the recipe proves both healthy and appetizing it should motivate the players to test in the kitchen!

Set up

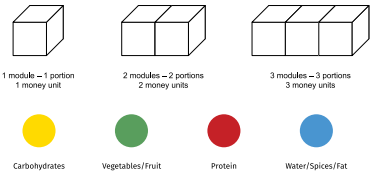
1. The oldest player sets up the game. Next to the board, place the appliances cards, the market card and the fridge card.

2. Next to the market card, place all blocks facing the icons down, so that only the food group colour is visible. Olive oil, Water, Salt and Spices should be placed near the board, available for use anytime in the game. These can be freely placed as part of any dish.

3. The youngest player rolls the dice twice, adding the numbers. The resultant value is the amount of money units each player has available to buy ingredients. Each ingredient module (cube) is worth 1 money unit.

4. Together the players buy the ingredients from the market, without knowing the specific ingredient, only the food group colour. The bought ingredients are placed next to the fridge card.

5. Game begins!



Rules

1. The youngest player starts the game, picking up an ingredient from the fridge and placing it on the board, explaining how he will use that ingredient and how it contributes to the recipe being created. The next player does the same, clockwise, until there are no more ingredients left on the fridge.

2. The blocks must be placed according to the grid layout, each module limited by 4 dots on the corners. Each block must be placed contiguous to at least one of the blocks already placed on the board. Connected blocks form one dish. You must elaborate at least two dishes during the game.

3. If the block is placed over a "?" sign, the player picks up a card from the lucky card deck

4. When there are no ingredients left in the fridge, players write down their recipe on the recipe booklet, and evaluate it. If the recipe proves both healthy and appetizing it can then be tested in the kitchen! ;)

10th Conference on Videogame Sciences and Arts
Porto, 21 & 22 November
http://vj2018.fba.up.pt/

Collateral Damage

A Critical Game adaptation of MrGun

André Ferreira - FBAUP & FEUP, ei10004@fe.up.pt

Concept

Over the last 50+ years, Israel and Palestine have been at war over territory. It's a war without an end in sight that has killed hundreds of thousands and is stuck in an ever-lasting cycle of cease-fires and retaliations, where each casualty on one side implies a number of kills on the other.

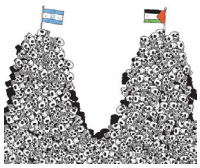


Figure 1 – "Now we are even" cartoon. Manila Times, 2014

Collateral Damage is a critical game that focusses on this conflict and the unspoken, and many times, disregarded amount of innocent lives lost during the confrontations between both sides. The game was created as a part of the Game Design Introduction Module of the Interaction Design, Web and Games Specialization as an adaptation of the mobile game MrGun.

References

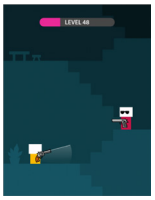


Figure 2 – MrGun game

MrGun is a mobile game by Ketchapp where the player controls a character that automatically goes up a flight of stairs to fight a wave of enemies.

The game uses a simplistic aim-and-shoot system where the gun aims automatically in a pendulum motion and the user is only in charge of the shooting command, by tapping anywhere on the screen.

How to play

In order to better convey the duality of the Israel-Palestine war of two sides fighting with each other, and as a way to avoid forcing players to play as one side alone, the game was adapted to have two active players, each controlling one of the conflicting countries.

The main control remains a single click to shoot, but there is now a dedicated shoot button that also serves as an indicator of which side belongs to each player. The game area was replaced with the representation of a street with the ends representing the borders of the countries, and multiple pedestrians and soldiers crossing from one side to the other.

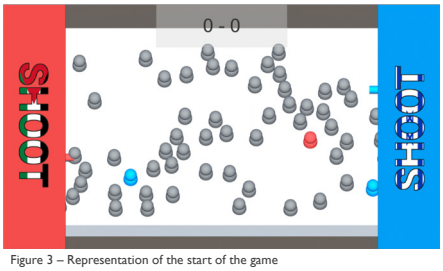


Figure 3 – Representation of the start of the game

Each player has to shoot the soldiers of the opposite country (represented in the country's color) and get an advantage of 4 kills over the opponent, in order to win the game. The current score is represented in the top of the screen and shows how many more kills each side has than the other, meaning that in the following image, if Palestine on the left is able to kill a blue soldier, the score will be 0 – 1.

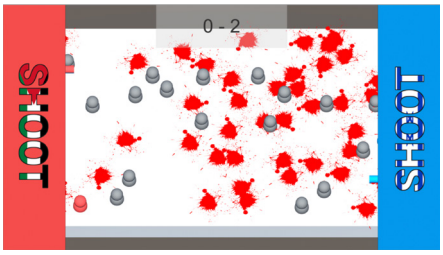


Figure 4 – Mid-game showing multiple casualties and Israel winning by 2 kills

The grey pedestrians represent people that have nothing to do with the ongoing war, but are inevitably caught in the conflicts. There is no penalty for killing them during the game which results in players completely disregarding them in order to better achieve their goal.

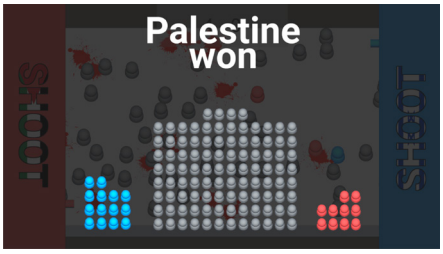


Figure 5 – End-game depicting the collateral damage necessary for Palestine to win by 4 kills

When eventually one of the players reaches an advantage of 4 kills, the winning screen is shown and for the first time the players see the total casualties of the game. Due to the nature of the game, the amount of innocent casualties will by far surpass the sum of both sides.

You can try the game by scanning the QR code or by visiting this website: tiny.cc/ky4u0y

Conclusion

The Israel-Palestine conflict is a controversial subject with multiple supporters on both sides and each side blaming the other for unnecessary use of force and innocent casualties.

Collateral Damage aims to convey 3 main messages:

- how easily civilians are not accounted for in times of war
- how both parties are equally responsible for the death toll
- how many lives need to be sacrificed for a slight advantage over the opponent

VIDEO JOGOS 2018
10th Conference on Videogame Sciences and Arts
Porto, 21 & 22 November
http://vj2018.fba.up.pt/

Critical Game: Fish the Migrants

Elizabeth Larez[1]
[1]FBAUP, FEUP & UPTEC; up201808831@fba.up.pt

Concept

The current migrant situation is one of the biggest social, political, and humanitarian problems we face today. However, they are alien and anonymous to European, making it easier for Europe to deny access, refuse help, and ignore them altogether.

In this game, players will be confronted with the migratory crisis and xenophobia issues by stepping into the shoes of an European country, particularly one directly affected by this crisis (Greece, Italy, Turkey), and will decide what to do with the migrants, provided that players play by the rules.

Image 1 – Suggestion of representation of 4-card books and a Joker: first four cards are family members and the card on the far right is the terrorist. The cards have written descriptions of the people's personal characteristics.

Image 2 – Suggestions of representation of 4-card books and a Joker: first four cards are family members and the card on the far right is the terrorist. The cards have visual representations of many of the migrants' fate.

Rules

The rules of the game are based on the Go Fish Game, where each player is given 5 initial cards from a 52-card pooled deck with the goal of collecting 4-card books by asking the opponents for the intended cards. A player asks for a specific card instead of a rank – provided that s/he has at least one of the cards of that rank in his/her possession. If the player that was asked the card has one in his/her possession, s/he must give them, otherwise the asking player must try to fish one of those cards from the pooled deck. If succeeded, s/he plays again, otherwise his/her turn is over. Wins the player without cards in his hands and with the greatest amount of 4-card books collected.

Fishing the Migrants is a turn-based card game that differs from Go Fish in the way that the winner ends up with the least amount of cards collected and the two Jokers are also included in the game.

A 4-card book collected represents a family of refugees and the Joker represents a terrorist.

Notes:
- Some cards are intentionally missing to represent the family fraction
- A Joker card represents a terrorist (no points awarded)
- If the Player fishes a Joker, he must return the Joker to the deck, as well as his cards that compose an incomplete 4-card book of his choice
- If the Player runs out of cards in his hand, he must pick one from the pooled deck
- When there are less than 10 cards remaining in the pooled deck, every Player that fishes a Joker should return his cards that compose an incomplete 4-card book of his choice, and should remove the Joker from the game.

Conclusion

Fishing the Migrants is a Critical Game challenging the migratory crisis and xenophobia view, setting up the ideal environment for players to see how well they would perform in front of other world powers that judge the ethics and social consciousness of other countries.

This game intends to represent the situation depicted by the large wave of people abandoning countries facing war or poverty, and the developed countries that should be in the position of helping out more. The game unfolds in the perspective of these European countries wanting to (publicly) rescue refugees from certain death, but internally wishing that other countries would take the refugees and save them the trouble and the "waste" of resources.

Noteworthy aspect in the game is the presence of terrorists who intend to emphasize Europe's reluctance to accept incoming migrants by enabling and inflaming mistrust, xenophobia and generalization when a terrorist is discovered among the rescued people, passing on the idea that "they are all alike" and propagating the lack of help given to these people.

Another important characteristic is the fact that every 4-card book represents a 4-member family who packed their bags on their desperate attempt to flee war or poverty. Consequently, and as a result of the real-word situation, some card books consist of less than 3 cards, representing the people who, unfortunately, die from consequences of the dangerous trip, fractioning families, homes and future stability for children.

Fishing the Migrants was created under the Game Design Introduction Module of the Interaction Design, Web and Games Specialization at the Faculty of Fine Arts from the University of Porto.

VIDEO JOGOS 2018
10th Conference on Videogame Sciences and Arts
Porto, 21 & 22 November
http://vj2018.fba.up.pt/

Marxism Quest

Joana Silva
joanacavlis@gmail.com

Quatro ideologias políticas confrontam-se pela conquista de cidadãos, com o objetivo de formar uma sociedade que se conforme pelos seus princípios e valores. Contudo, estas batalhas não serão brandas; geram turbulências e motins que levam as peças a saltar pelo espaço de jogo. Ergue-se a revolta tumultuosa dos vários líderes políticos num duelo de precisão, onde a concentração e a confiança são condições para o triunfo.

VIDEO JOGOS 2018
10th Conference on Videogame Sciences and Arts
Porto, 21 & 22 November
http://vj2018.fba.up.pt/

POLYOMINOES & AMOEBAS: A collaborative-competitive game

José Raimundo[1]; Pedro Cardoso[2]; Miguel Carvalhais[3]; Antonio Coelho[4]
[1]University of Porto, joseraimundo3d@gmail.com; [2]INESC TEC / Faculty of Fine Arts, University of Porto, ordep.osodrac@gmail.com;
[3]INESC TEC / Faculty of Fine Arts, University of Porto, miguel@carvalhais.org; [4]University of Porto, acoelho@fe.up.pt;

CONCEPT

This poster presents a game prototype aimed at raising awareness for the value of collaboration to solve challeenges (fig. 1). To stimulate such awareness the game allows players the freedom to accomplish goals single-handedly or combined as a group, while giving immediate feedback on the consequences of opting for either course of action.

INSTRUCTIONS

BASICS: P&A is two-player, turn-based game whose win condition is to collect five tokens and where each player is represented by a four-cell polyomino piece. Gameplay takes place on a board, divided into a grid of 9x6 square cells (fig. 2). A scoreboard features the tokens collected (fig. 3). Players move in turns, translating along the x and/or y axis and rotating freely but in descrite movements aligned with the grid (fig. 4).

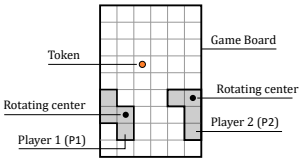


Fig.2. Game board, polyomino player pieces and tokens.

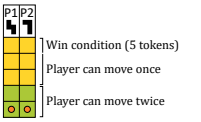


Fig.3. Scoreboard. Both players can move twice. Translation and rotation accounts as the same move.

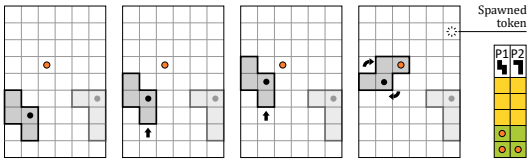


Fig.4. Player1 turn sequence - two moves - scores in the end of the turn and a token is spawned.

BOUNDARIES & COLLABORATION: Polyominoes rotate around a center marked as dot in each piece. The polyomino outline can move beyond the game bounds, as long as its center remains within the play area (fig. 5). Collaboration happens when edges from distinct player pieces touch one another, gluing them temporarily into one combined polyomino. This single player can only move once per turn, yet, it can choose between two centers to rotate, thus increasing its range (fig. 6).

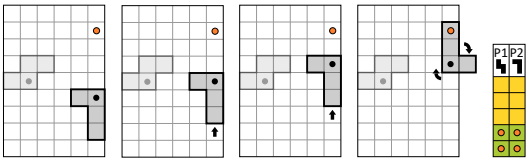


Fig.5. Player2 turn sequence - two moves - scores at the end of the turn.

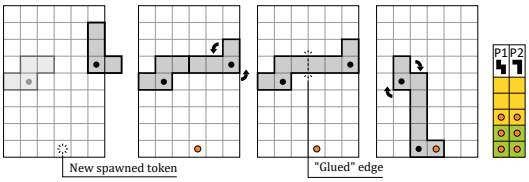


Fig.6. Players join and the combined polyomino shape overlaps the token granting an equal score for each player.

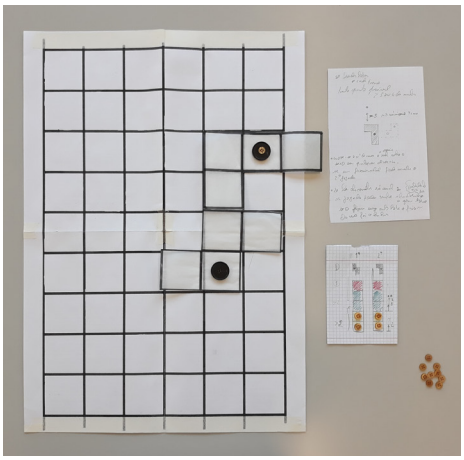


Fig.1. Photo of the prototype with game board, polyomino player pieces and tokens.

TOKENS: Each player starts its score with one token and stops playing when run out of these. Tokens are collected when overlapped by the player piece, failure to collect loses the previous token. Players move twice until three tokens are scored, after that they move only once. Translating and rotating accounts as the same move. The game allows the presence of a single token at any given time, a new one is re-spawned each time the previous is collected. Tokens are spawned into random positions, yet they must remain within player's reach as possible to increase the chances of survival.

SEPARATION: Separated or combined, players are encouraged to discuss and agree, negotiating the actions to take next. Players stop collaborating by moving their corresponding original polyomino pieces apart, following a different course (fig. 7) and resuming individual play (fig. 8).

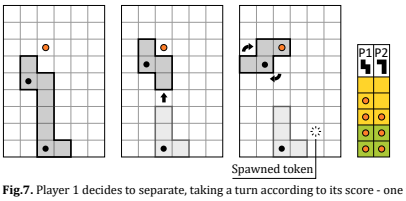


Fig.7. Player 1 decides to separate, taking a turn according to its score - one move. The player scores individually and another token is spawned.

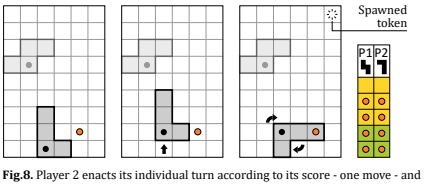


Fig.8. Player 2 enacts its individual turn according to its score - one move - and scores individually. Another token is spawned and the game continues until conditions for success or loss are met.

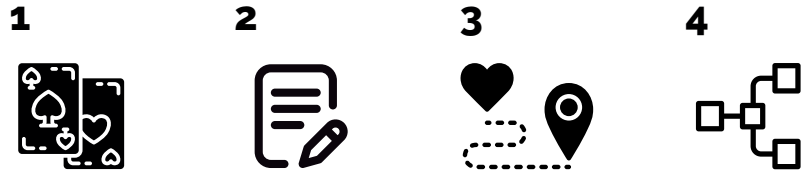
VIDEO JOGOS 2018
10th Conference on Videogame Sciences and Arts
Porto, 21 & 22 November
http://vj2018.fba.up.pt/

Speculative prototypes of Serious Games in the context of Anorexia Nervosa

Anorexia is a complex disease, often fatal, that has no cure and mainly affects worldwide young population. The beginning of treatment is hard because the patients do not assume their own pathology. By resorting to a Speculative Design methodology in alliance with a Game Design practice, we developed two speculative game prototypes that seek to help find new answers about behaviours, life models, interactions, needs and knowledge about this disease. This second prototype called ANgame Collab aims to support the investigation and sharing of knowledge about the disease, more specifically in focus group sessions or interviews.

Prototype #2
ANgame COLLAB

HOW DOES IT WORK?



VIVIANE PEÇAIBES | PEDRO CARDOSO | BRUNO GIESTEIRA
ID+ / Faculty of Fine Arts, University of Porto, Portugal
vivianepecaibes@gmail.com

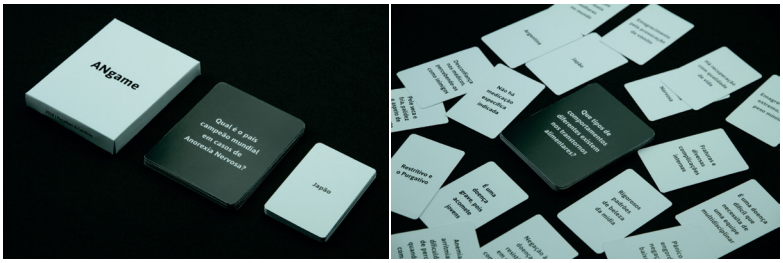
U.PORTO FACULDADE DE BELAS ARTES UNIVERSIDADE DO PORTO
ID+ RESEARCH INSTITUTE FOR DESIGN, MEDIA AND CULTURE PORTUGAL

VIDEO JOGOS 2018
10th Conference on Videogame Sciences and Arts
Porto, 21 & 22 November
http://vj2018.fba.up.pt/

Speculative prototypes of Serious Games in the context of Anorexia Nervosa

Anorexia is a complex disease, often fatal, that has no cure and mainly affects worldwide young population. The beginning of treatment is hard because the patients do not assume their own pathology. By resorting to a Speculative Design methodology in alliance with a Game Design practice, we developed two speculative game prototypes that seek to help find new answers about behaviours, life models, interactions, needs and knowledge about this disease. The first prototype called ANgame Competitive focuses on the psychoeducation of school-age youth.

Prototype #1
ANgame COMPETITIVE



HOW DOES IT WORK?

1 **SHUFFLE** and **SPREAD**

2 **SEARCH** and **ANSWER**

3 **READ ALOUD**

4 **WINS** who gets **MORE CARDS**

VIVIANE PEÇAIBES | PEDRO CARDOSO | BRUNO GIESTEIRA
ID+ / Faculty of Fine Arts, University of Porto, Portugal
vivianepecaibes@gmail.com

U.PORTO FACULDADE DE BELAS ARTES UNIVERSIDADE DO PORTO
ID+ RESEARCH INSTITUTE FOR DESIGN, MEDIA AND CULTURE PORTUGAL

Thank you all.