FACULDADE DE ENGENHARIA DA UNIVERSIDADE DO PORTO

An empirical platform for behavioural modelling using serious games

Daniel dos Santos Teixeira

Mestrado Integrado em Engenharia Informática e Computação

Supervisor: Professor Doutor Rosaldo José Fernandes Rossetti

Second Supervisor: Professor Doutor João Emilio Santos Carvalho de Almeida

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Approved in oral examination by the committee:

Chair: Professor Doutor Daniel Augusto Gama de Castro Silva
External Examiner: Professor Doutor Luis Paulo Reis
Supervisor: Professor Doutor Rosaldo José Fernandes Rossetti
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Abstract

Each day serious games are becoming more relevant and taken seriously by responsible institutions. Although the overall society is still not truly familiar with this concept, there are great benefits that can be achieved with these games. As said by *Marcos Oliveira et al.* , applications have a wide range of domains, naturally including social simulation, where data collection of player attitudes can be later used for statistical analysis, and behavioral pattern recognition [OPO+15]. This makes them an important tool to both educational and social intervention. But how can we use this concept with behavior elicitation? How can we make a game, with mechanics that allow decision points and use this to both collect data and simulate emergency situations?

In *João Ribeiro et al.*, we learn that Video games present some characteristics that make them helpful as a resource [RAR+12b]. As sentiments like enjoyment and fulfillment are felt, users are more likely to stay motivated while doing their tasks. Also it is much easier for the human being to assimilate mechanics or techniques rather than theoretic knowledge.

The main goal of this master thesis is to make a game platform for research and development in the field of behavior modeling. The data collection needed can be done using the game and its mechanics, and then improve the game to make it more realistic and immersive. Being a simulation of emergency situations the realism helps the elicitation, assimilation and persuasion wanted for the project.

The solution must be adaptive to the need of the subject. There must be alternative scenarios and mechanics to chose from. This way, not only the game can reach more kinds of people and situations, but also, represent more accurately their required need.

Resumo

A cada dia que passa, os jogos sérios tornam-se mais relevantes e levados a sério pelas instituições responsáveis. Apesar de a sociedade em geral não estar totalmente familiar com o conceito, existem muitos benefícios que podem ser alcançados com o uso destes jogos. Segundo *Marcos Oliveira et al.*, estas aplicações têm uma vasta gama de domínios, naturalmente incluindo simulação social, onde a recolha de dados das atitudes dos jogadores podem ser posteriormente usados em análise estatística, e reconhecimento de padrões comportamentais [OPO+15]. Isto faz destas aplicações uma ferramenta importante para intervenção social e educacional. Mas como podemos usar este conceito com eliciação comportamental? Como é possivel construir um jogo, com mecânicas que permitam pontos de decisão e usar isto para colectar dados e simular situações de emergência?

É referido por *João Ribeiro et al.* que os vídeo jogos apresentam algumas características que os tornam úteis como um recurso [RAR+12b]. À medida que emoções tais como prazer e satisfação são sentidos, é mais provável que os utilizadores permaneçam motivados enquanto realizam as suas tarefas. Para além disso, é muito mais fácil para o ser humano, assimilar mecânicas e técnicas em vez de conhecimento teórico.

O principal objectivo desta dissertação de mestrado é contruir uma plataforma de jogos para pesquisa de desenvolvimento na área de modelação de comportamento. A recolha dos dados necessários pode ser feita através dos jogos e das suas mecânicas, e posteriormente melhorar o jogo para o tornar mais realista e imersivo. Sendo uma simulação de situações de emergência, o realismo ajuda na eliciação, assimilação e persuasão pretendidas no projecto.

A solução deve ser adaptativa às necessidades do sujeito. Devem haver mecânicas e cenários alternativos para escolher. Desta forma, não só o jogo consegue atingir um maior número de pessoas e situações, mas também, representar mais fielmente as suas necessidades.

Acknowledgements

I would like to thank Professor Rosaldo José Fernandes Rossetti for letting me have the opportunity to participate in this dissertation as well as Professor Maria Cristina de Carvalho Alves Ribeiro responsible for the course unit Dissertation Planing. I would also like to thank all the people friends or colleagues that helped along the way of this project.

Daniel dos Santos Teixeira

"Video games are bad for you?
That's what they said about rock-n-roll."

Shigeru Miyamoto

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Abbreviations

FEUP	Faculdade de Engenharia da Universidade do Porto
LIACC	Artificial Intelligence and Computer Science Laboratory
FPS	First-Person Shooter
NPC	Non-Playable Character
SPEED	Simulation of Pedestrians and Elicitation of their Emergent Dynamics

Chapter 1

Introduction

1.1 Motivation

This dissertation has one main motivation, to gather techniques of behavior experimentation with serious games to make a meta-model capable of representing a various number of experiences. With the obvious scientific appeal, this project adds some social and educational concerns; such as the behavior elicitation wanted for the game and the behavior persuasion wanted as a result for playing the game.

Making the life easier for psychologists and other researchers that want to use serious games and simulations to conduct experiments is the appeal for this work.

1.2 Scope

This dissertation is produced in collaboration with LIACC, the Artificial Intelligence and Computer Science Laboratory from FEUP, that has some work related with serious games and behavior modeling which I will address in chapter 3.

One important collaboration is Professor Alex Peng, from the University of Sheffield, that will use the prototype implemented in this dissertation on some behavioral experiences. It is expected that this collaboration can allow the gathering of some user stories and requirements for the meta-model. Besides that, the feedback from the results achieved by the experiments will have extra value for the predicted conclusion of this dissertation.

1.3 Problem statement

The gathering of the requirements will give a better idea of the challenges that need to be pursued. But generally, the main question will be if it is possible to use behavior modeling with serious

games in a way that will allow a creation of a meta-model able to generalize the experience creation.

Is it possible to use the meta-model to dynamically generate the game mechanics and scenes? And how can we use the wanted elicitation? Will this randomly generated game be entertaining enough to be motivating and at the same time accomplish the wanted results?

1.4 Aim and goals

This dissertation aims to create an innovative meta-model that can be representative of as much user stories as possible. The user stories are related to social, educative and psychological testing, as well as behavior elicitation and persuasion.

The main goal is to create a meta-model uniting two concepts: serious games and behavior modeling. Both this subjects are introduced in chapter 2.

Another goal is to create a prototype, implementing said meta-model to, not only test it, but also improve it with the data collected.

1.5 Methodological approach

This dissertation aims to create a meta-model that can, in quite a general way, be a representation of various behavior experiences. This meta-model must aggregate a considerable number of choices and requirements of these same experiences. But this is not enough. The meta-model is a more theoretical approach, one that can be implemented in any technology wanted. However, a prototype must be made to prove the concept works.

The prototype will be made in Unity3D, a game engine. It must use the meta-model to generate dynamically the game wanted by the researcher [RLT11]. This prototype will be used not only to prove the concept but also to do the data collection needed to improve, not only the game but also the meta-model.

1.6 Expected contributions

This project expects not only to make life easier to the people and institutions interested in these game experiences and simulations, but also to improve the quality of the elicitation. With the collaboration of LIACC it will be possible to integrate other related works with this project improving also the software available for experiences in this department.

1.7 Organization of the document

Beyond the introduction, this dissertation has more 6 chapters. In chapter 2 the background for this project is described with insight into some particular concepts. In chapter 3 some of the work already done in the same context of this thesis is analyzed. Chapter 4 will explain the architecture

of the experience and its connection with the behavior elicitation. In the chapter 5 the prototype will be presented and explained. Chapter 6 is about how the application can be evaluated and the analysis of its results. Finally in chapter 7 we can found some final remarks about the dissertation as well as the suggested future work.

Chapter 2

Literature Review: Background

In this section is presented some of the important concepts related with this dissertation. From behavior modeling to serious games, this chapter should give some insight on the background for this dissertation and why it aims to solve some problems in this state of art.

2.1 Serious Games

2.1.1 Video Games

According to *Garris et al.*, computer games can provoke different reactions in the general population. Some are concerned about the violent themes of certain games, and others worry about the time spent, or the sense and intensity of player involvement in computer games [GAD02]. However both these arguments can easily be refuted.

First, we have violence as a alleged reason to stop youth from playing, but is it really? Violence can be seen and experienced through cinematic movies, television and even books. Is the interactivity incremented by the subject-game relation enough to say that violent video games really promote violence? In fact there are studies that state the inverse effect can actually happen. *Nicholas L Carnagey et al.* clearly state that "playing a violent video game, even for just 20 min, can cause people to become less physiologically aroused by real violence" [CAB07].

Then we address the issue of the time spent playing by the youths. Time that some state should instead be used to play outside, study, read and other more conventional activities. However we are not having a discussion about video games per say, but the time management. Management that should always be smart, whether it is about playing video games, watching television or even reading. Of course there might be negative side effects, as any activity has, but video games also have several benefits, which we will explore in the next section.

2.1.2 Serious Games

João Ribeiro et al, state that despite video games origins were purely based in entertainment, they have been used recently with other objectives and goals in mind [SARC13a] [RAR+12b] [SARC13b]. Video games can be used to support activities like education, training, health, advertising, or social change. This can happen because video games have some particular characteristics that allows them to be an important resource. User interaction is essential in video games and they have multimedia components that makes them quite immersive, such as video, audio and sometimes even haptic feedback [RAR+12a].

In section 2.1.1, the sense and intensity of player involvement in the game is seen as a possible disadvantage, but in fact, is one of the primary benefits when you need to keep the subject motivated and involved in the experience. *J Kirriemuir et al.* explain that the level of engagement computer games allow, can be a concern when neglecting other activities, but can also be valuable when leading to a development of skills and competences [KM04]. It is possible to take advantage of these benefits, that's called Serious Games [SARC13b].

T Susi et al. state that "serious games are (digital) games used for purposes other than mere entertainment" [SJB07]. This doesn't necessary mean that entertainment is not present, in fact it is essential, it is just not the only focus. The entertainment and involvement allows serious games to be a good alternative to previously more conventional ways of learning and training.

2.2 Behavior Modeling

2.2.1 Behavior Assimilation

Assimilation might be defined as the absorption of knowledge. *Rossetti et al.* refer behavior assimilation as the basis for game base learning [RAKG13]. In the context of serious games, it can be used to instruct players on new skills, training and improve abilities.

2.2.2 Behavior Elicitation

Elicitation is a set of techniques to gather data. In *Rossetti et al.* we can learn that this behavior elicitation doesn't relate only to the motorization of players during the game [RAKG13]. It intends to capture the players decisions and way of thinking, to disclosure the subjects' cognitive abilities. It is important to realize the decision-making process behind the performance of the player to better understand how the persuasion techniques could be used.

2.2.3 Behavior Persuasion

Persuasion can be defined as ways of change and induce behavior and beliefs of a subject. *Rossetti et al.* state that, in the context of serious games, persuasion is needed to induce the players to perform certain actions [RAKG13]. The game must be able to influence the behavior of the player and if needed change it.

2.3 Conclusions

Amri Yusoff et al. state that the growth of serious games in education can be explained by the digital environment that surrounds the current generation of learners[YCGW09].

High school teachers have now a harder job to catch students attention. As all the youngsters have all day access to great pieces of technology it is hard to show something new that can surprise the students and motivate them. Serious Games have this power, according to *Rosemary Garris et al.* as they can be mixed with the more traditional learning techniques to create an involvement and motivation otherwise hard to get [GAD02].

This dissertation aims to combine these two concepts of serious games and behavior modeling to create a meta-model capable of represent in a set of parameters, various behavioral experiences and simulations capable of improving the training and learning of the subjects. Improve the quality of elicitation using the benefits that video games have to offer.

Chapter 3

Literature Review: Related Works

In this section some work already done in the elicitation of human behavior is presented. I choose to introduce some of the projects available at LIACC [dIADeR]. These projects are relevant to this dissertation not only because of their similar goals, but also because of the data already collected by them, that can be use to improve the quality of this dissertation. The behavior modeling and elicitation is the main issue on both these works and the thesis.

3.1 Rain in Indoor Rescue Training

In *João Ulisses et al.* we learn about a serious game for fire evacuation drills that uses a plug-in for Unity3D called RAIN [UAR15]. This tool is used for Artificial Intelligence and helps modeling character's movement and behaviors. Another important benefit of this plug-in is that allows the creation of vision sensors which basically means that we can implement different reactions and decisions based on what the character is seeing, in this case, the firefighters and people.

In this project, conducted with the collaboration of LIACC, a serious game that simulates a fire evacuation drill was implemented. There are three characters: the player, the people and the firefighters. The player is the character controlled by the human playing the game, uses the same keyboard as the general FPS games. It is also possible for the player to rescue people and put out the fires; the game tells the player what he can do.

The people are a group of NPCs that simulates the behavior of a normal person in the event of a fire: run away from a fire and report to the firefighters about people he saw in need of help or even fires.

The firefighters are very similar to the person NPC but have more behaviors. He can put out fires and help other people in need. To help this firefighter agents decide what to do, the author created a firefighter commander, a mission guide that tells the firefighter what he can do. Since the MissionGuide sorts the missions according to their importance, it helps the firefighter

deciding what mission to follow. Usually saving people and putting special fires out first have higher priority.

The project "Rain in indoor rescue training" [UAR15] is related with the motivation for this dissertation, as it has the same objectives of combining simulation for behavior modeling (in this case fire simulation) with the multi-agent systems needed to implement that behavior and the elicitation.

3.2 SPEED and IC-Deep

SPEED and IC-Deep are simulations made in LIACC that allow the elicitation of human behavior on certain stress situations.

In the figure 3.1 we can see the beginning of SPEED simulation, where the player is sitting in a computer desk and suddenly the fire alarm rings. The game instructs the player to exit the building immediately and the player needs to find the closest exit. In this case, goes right and right again and there it is.

In the second scene, the player is standing in a room and once again the fire alarm rings. There's a sign saying that the fire escape is to the left but when the player turns that direction he sees smoke, what will be the players reaction? How will he deal with this problem?

The third scene start exactly like the second but this time instead of only smoke, the hall is obstructed by fire. How will the player react? In this case, the player turns around and finds another exit.

In the forth scene, the player start in the same situation as the second and third, sees the sign that says the fire escape is to the left, but when he reaches the hall he sees a great number of people running away from that direction [ERFO09]. Will we go left as the sign says? Will he follow the rest of the population?

In the final scene, the player needs to escape a movie theater after some alarm sounds. This time, the game doesn't tell the player what kind of alarm is playing. The subject needs to identify the sound and proceed with the most appropriate action for each different emergency situation.

Figure 3.1: SPEED: Fire Drill Simulator

In 3.2 we can see a screen shot of the IC-Deep platform, which is basically a driving simulator. In this game the driver must drive the car through some roads following the basic rules of traffic known by every licensed driver [AGR+13]. The game sometimes informs the player of what he is doing wrong by displaying some signs and labels, like: "Excessive Velocity" and such [GROM12].

It is an important simulation for the elicitation of the behavior humans have when driving a car and receiving instructions from the game.

Figure 3.2: IC-Deep: Driving Simulator and Human-Factor Analysis

3.3 Conclusions

All the projects presented in this chapter are related with this dissertation in the motivation for behavior elicitation and modeling, and the use of serious games to do so. One of the objectives of this thesis is to integrate some of this work or at least, make these kind of simulation games easier to make and test.

The technologies used in these different works are going to be also used on this dissertation (explained in section 5.4). As well, as the ideas and concepts presented by them.

Chapter 4

Architecture

In this project the architecture involves more than just the prototype. The meta-model behind it must also be covered by the same logic and design. In this chapter some light will be put into the connection between the prototype and the experience *per se*, and therefore between the meta-model and what can be achieved by the prototype.

4.1 Behavioral Experience

As stated by *Cooke*, the elicitation is the process of collecting relevant information from a human source of knowledge [Coo94]. This is the intended role of the behavioral experience. In *Glasser* we learn that there are four components for successful behavior modeling: attention, retention, reproduction and motivation [Gla07]. This is an advantage for serious games as they are able to accommodate all these components. They can motivate the player and captivate his attention, which is a step closer for the player to retain what he is learning. Then the player can reproduce this behavior in a next level or stage of the game, or even in real life.

In the figure 4.1, it is possible to understand better the context of the behavioral elicitation in the intended experience. This dissertation should be allocated on the left low corner of the image, with serious games interaction with behavior elicitation and the digital games design and gamification.

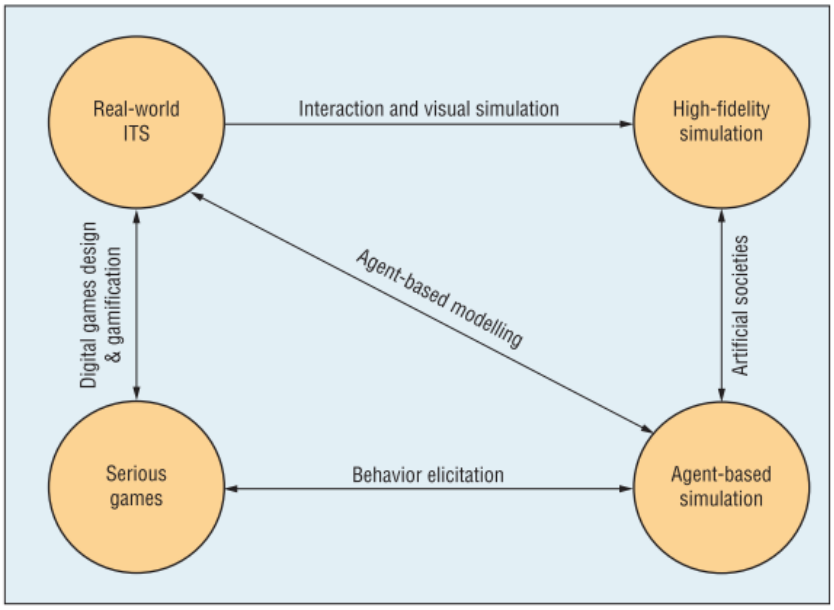

Figure 4.1: Methodological perspective for the serious game and artificial transportation system integration [RAKG13].

One of the hardest parts to successfully complete a behavioral experience is to make sure that the data collected is the most accurate and similar to reality as possible [PRG11]. As said by *João Emílio et al.* the choices that pedestrians make in a evacuation simulation can be affected by any cultural or historical aspects, and even social, economic or environmental reasons [ARF+14]. To a proper study be conducted, the simulation must be as close to reality as possible which would be too dangerous in a real life simulation. That is why serious games are such a good way of conducting these experiments. They can approximate the simulation to the real life evacuation without the inherent danger of these situations. Besides that, as said by *Almeida et al.*, the elicitation of the behavior in such situations will provide the necessary information to help the responsible institutions to predict dangerous behavior and prepare preventive actions in case of an emergency [AJF+14].

Besides the elicitation, the assimilation of behaviors is also important. As stated by *Cordeiro et al.*, through the elicitation it is possible to understand how to change people behaviors and attitudes [CCRA11]. Therefore building a training platform to improve their performance both in the game and real life situations.

4.2 Meta-model

The meta-model is an important part of this dissertation, if done correctly it will provide a way to make serious games adaptable to most technologies and reunite some guidelines to be followed by researchers in order to assemble behavior related experiences in a easier way. Before the start of the making of the meta-model, the requirements must be defined. For that, there was a

collaboration with Professor Alex Peng from Sheffield University. This cooperation allowed the gathering of some essential user stories that were used as a reference for the meta-model creation.

In the figure 4.2 it is possible to see an example of a diagram that tries to specify the parameters needed for different types of evacuation simulations. The objective of the creation of this diagram was the attempt to find a common ground to exploit. In other words, to find out if it was possible to find the similarities between the different scenarios. From that, theorize the creation of one unique framework that could cover all these situations without losing their identity [RL14].

The prototype created can be contextualized on the fire simulation drill, however does not cover all the parameters shown in the diagram 4.2.

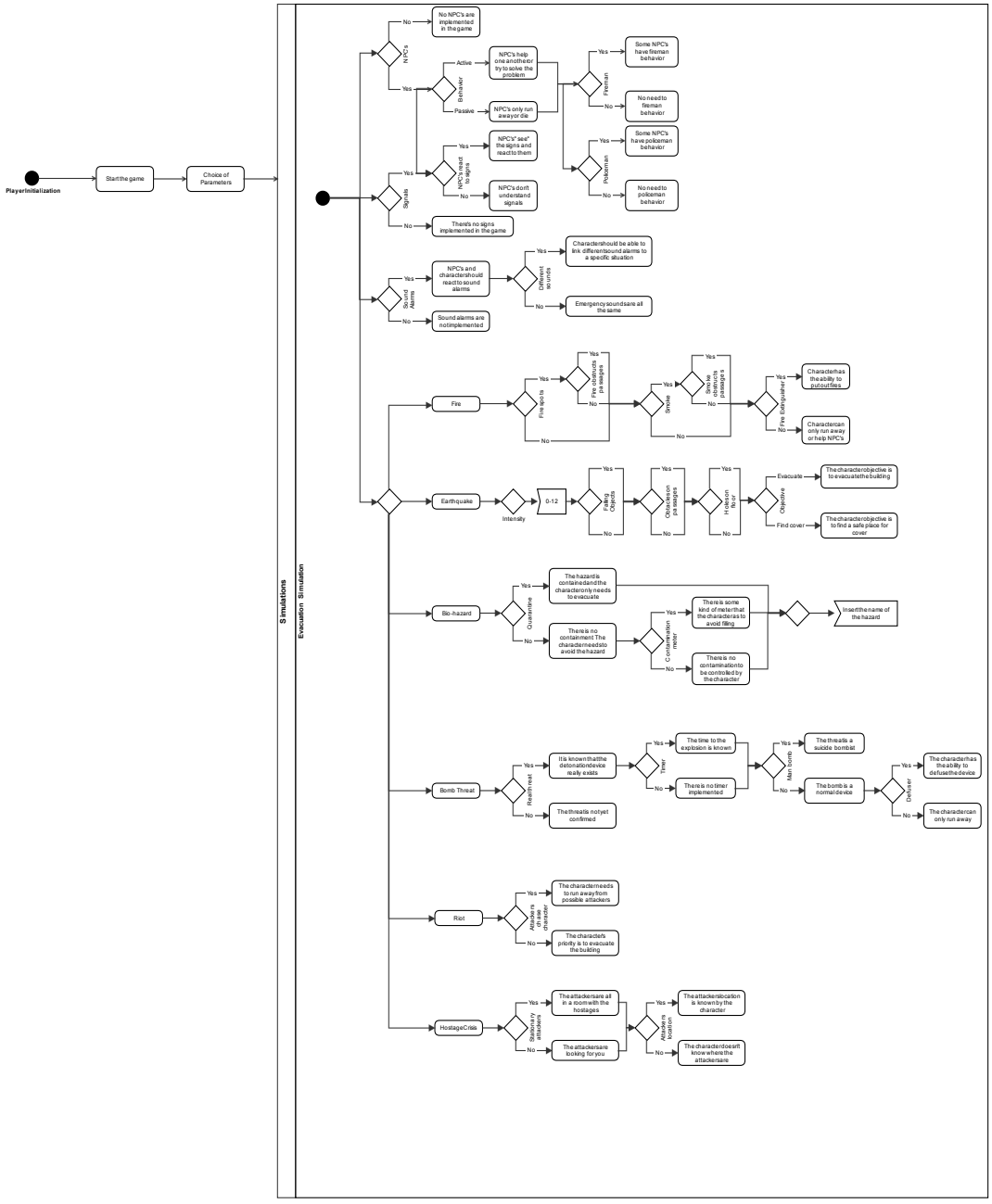

Figure 4.2: Some possible parameters of different types of evacuation simulations.

4.3 Decision Points

In the game world, the researcher should be able to mark specific points to question the player or to give him an important piece of information. These are called decision points. The objective here is making the player have a decision or just gather data about his choice or what he sees or hears. In the figure 4.3, it is possible to see an example of what this kind of interface could look like. The objective is to inquire the player on certain key moments of the simulation to obtain some insight on the reasons behind his choices. It is also a good idea to just use these points to send some information to the player giving him a specific path to take or even helping him accomplish the objective.

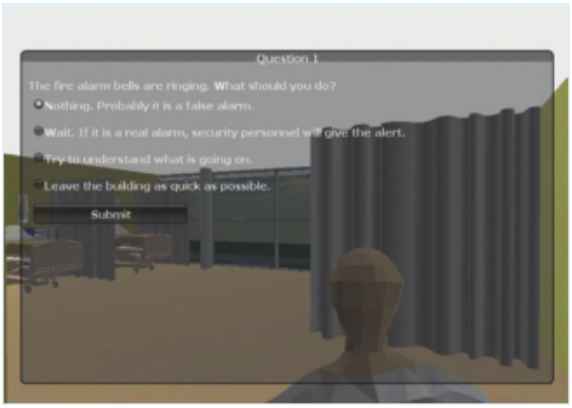

Figure 4.3: An example of a decision point and the question asked from the platform SPEED [RAKG13].

It is important not to over commit to the creation of these decision points. Too many of them could disrupt the flow of the game, harming the results of the experiment.

4.4 Decision Tree

The decision tree represents all the decisions made by the player through the course of the game. This tree will not only gather the information related to the decision points, but also to any other kind of place where a decision must be taken by the player. An intersection, an obstacle or even which path the player takes are all examples of what this tree will represent.

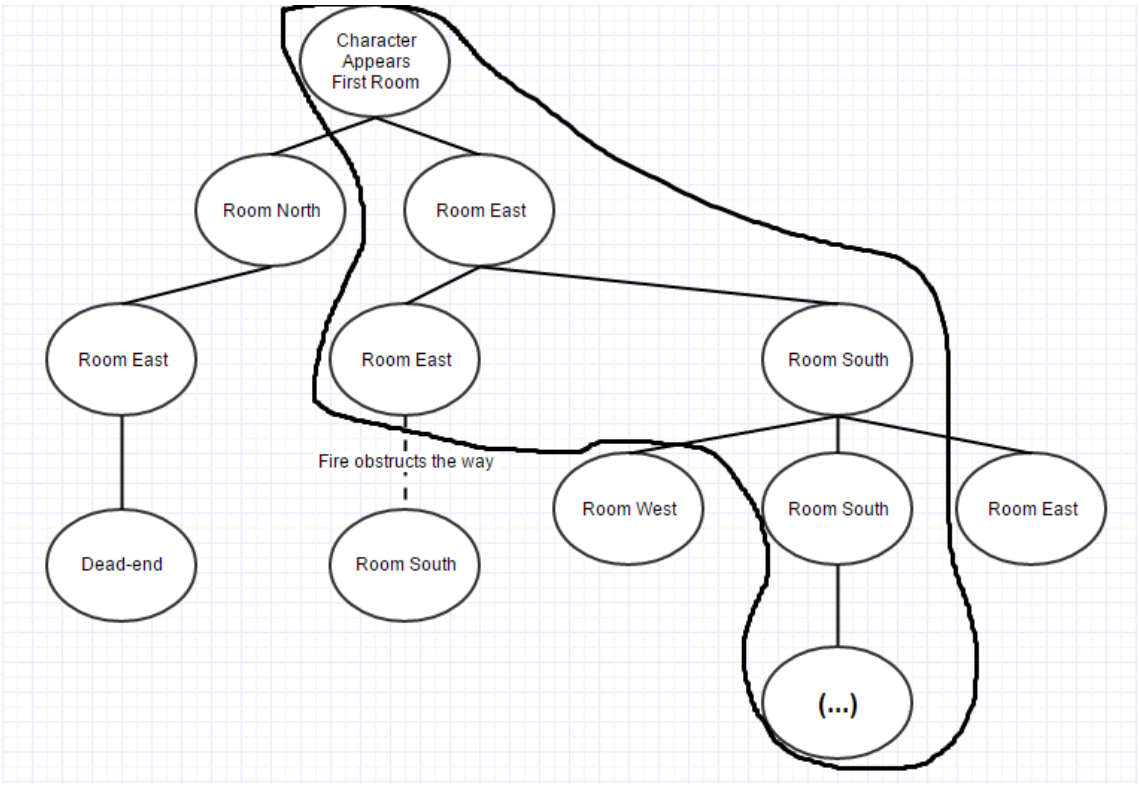

Figure 4.4: A small example of a possible tree of decisions. The surrounded area represents the decisions made by the player. All the lines represent bidirectional paths.

Although it is only a small example, is still possible to see in the figure 4.4 some decisions that the player might have to make and the ones that he does. In this case only the different rooms choices are represented, so this is a decision tree about the path that the player takes. However several of these trees can be built thanks to the collecting of information from the experience. Another interesting one would be the representation of all the answers to the decision points.

4.5 Data Collection

To analyze all the data that the experience can provide, first it must be gathered. This is called data collection. This is important so that the game can be considered a proper behavioral experience.

The decision points play a primary role here, as the answers from all the questions are saved and therefore are the easiest way to collect data. However there are many more situations that are important for the investigators. Even the path that the player takes can be used effectively to study human behavior.

As said by *Cordeiro et al.* several factors can change the people's response to fire situations, and these factors are not always easy to predict [CCRA11]. This means that a tool capable of collecting all the information that the game can provide will be very useful. And this information is not only paths or decision taking, but also what the players hears, sees or feels during the

experiment. For instance it is easy to realize that a player turns left on a intersection, the hard part is to determine why. If the investigator has an idea of what the player is experiencing at the specific moment of the decision making, he can speculate several theories about what happened. The more information he has, the more accurate and realistic his theories will be.

Chapter 5

Prototype

The reason behind the development of a prototype is not only to prove the concept true but also to collect pieces of important data about the players' decisions, choices, behavior and also the motivation and entertainment of such simulations. The level of the game must be dynamically generated with the information present in the meta-model, allowing an easier way to make behavior experiences.

Another important part of this prototype will be to test the usage of the choices allowed by the meta-model; how easy it is for a investigator that is not familiar with the project, to use this platform. Besides this, the performance of the game will also be evaluated, both in the technical ways to make serious games and the elicitation component.

As the prototype started to get developed, some requirements for it became more obvious, as well as some useful features. The prototype can be divided in three major parts: .

- The building creator - a drag and drop interface that allows the user to design the blueprint of the building in which he wants the experience to occur;
- The building generator - which transforms the 2D blueprint in a interactive 3D building;
- The game - which is the experience *per se*.

5.1 Building Creator

The objective of the prototype was to allow the investigator to create his own experience. To do so, some form of building designer needed to be developed. The solution found was to make an user interface that easily allowed the creation of the blueprint for the building. As it needed to be as intuitive, fast and easy as possible, a drag and drop interface was the chosen model. The interface is represented in the figure 5.1.

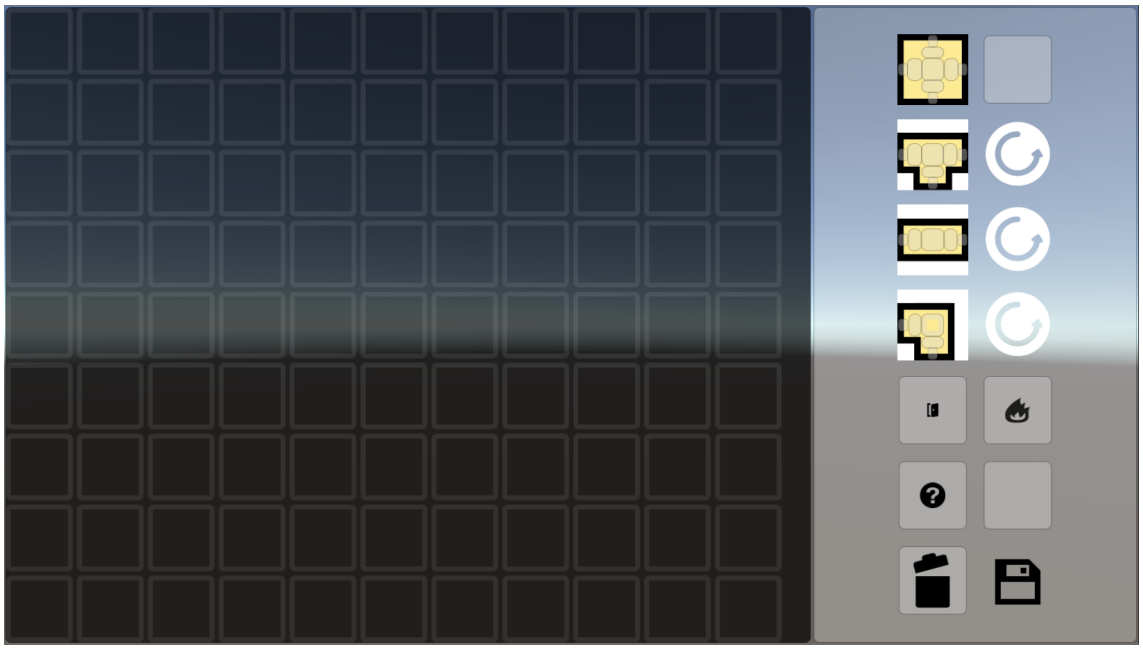

Figure 5.1: The building creator screen

In the left part of the screen it is possible to see a 9x11 grid of tiles. These are the spaces where the user can design the building. In each one of these tiles one type of room can be dropped, creating the blueprint for the intended building.

Figure 5.2: The four different types of rooms

The right part of the screen is where the interactive objects and buttons are located. The first four on the left column represent the four types of room, also in the figure 5.2. These rooms can be rotated with the help of the buttons directly allocated on the right side, respectively. To create the blueprint, all the user needs to do is to drag the rooms to the tiles on the grid, as seen in the figure 5.3.

The two rows below the rooms have another three objects: a door, a fire and a question mark. The door allows the user to create the connections between the displayed rooms. This way, the investigator can deploy rooms next to one another and they may still not connect through a door. This allows the user to force the gamer to choose a desired path or give him more than one choice. The fire element allows the investigator to choose the places where the building will be on fire.

These conflagrations will not propagate through the building. This way the investigator has the ability to choose where the fires will be seen and they will not be unpredictable. The question mark creates points of interest or decision points. Both these interactions are explained in chapter 4.

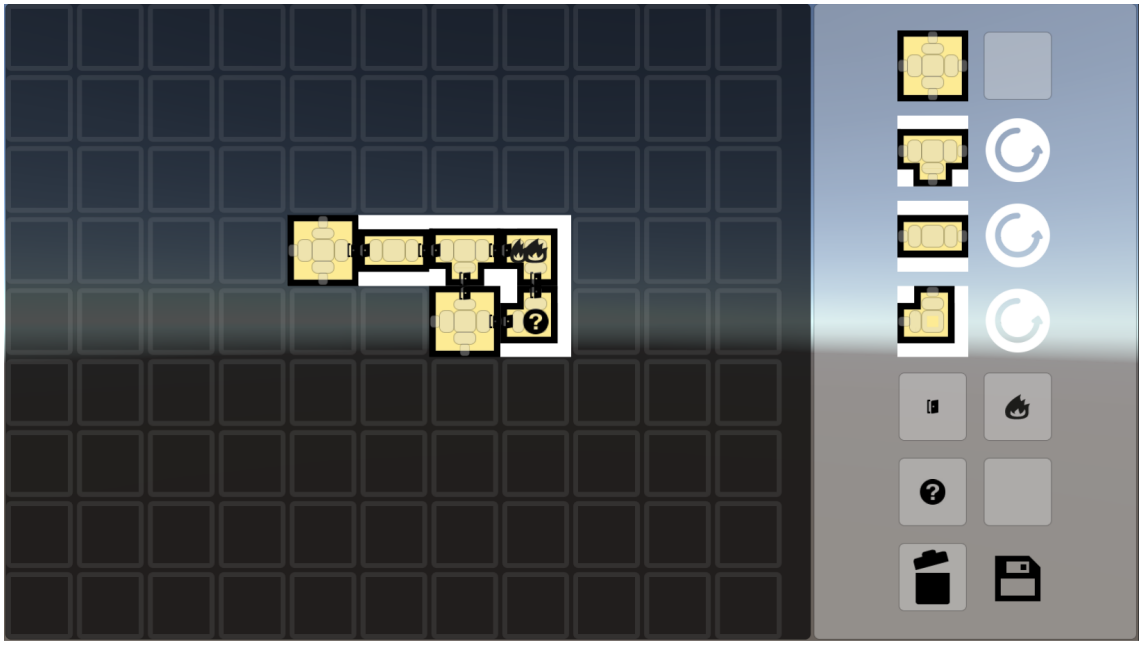

Figure 5.3: The grid with some rooms already placed

To delete a room from the grid, just drag it to the garbage can on the lower left corner of the UI. This will also delete all the other objects associated with it. To the right of this tile there is a save button that will read all the tiles and save the blueprint in a xml file later used to generate the building in 3D.

5.2 Building Generator

After the user saves the blueprint, a xml file is written with all the information needed for the 3D generation of the building. This xml is organized as shown in 5.4.

```
<?xml version="1.0" encoding="Windows-1252"?>
    <BuilderGrid xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
        xmlns:xsd="http://www.w3.org/2001/XMLSchema">
      <BuilderSpots>
        <BuilderSpot TypeOfRoom="N">
          <Positionx>3</Positionx>
          <Positiony>6</Positiony>
          <Rotation>0</Rotation>
          <Doors>
            <Door Position="E" />
            <Door Position="S" />
          </Doors>
          <FireSpots />
          <Questions />
        </BuilderSpot>
        <BuilderSpot TypeOfRoom="T">
          <Positionx>3</Positionx>
          <Positiony>7</Positiony>
          <Rotation>0</Rotation>
          <Doors>
            <Door Position="W" />
            <Door Position="S" />
            <Door Position="E" />
          </Doors>
          <FireSpots />
          <Questions />
        </BuilderSpot>
      </BuilderSpots>
    </BuilderGrid>
```

Figure 5.4: An example of the structure of the xml file

It is possible to see that the "**Builder Grid**" is divided in "**Builder Spots**" that represent each of the rooms wanted in the building. For each room, there are three types of content: doors, fire spots and questions. This allows the building generator to know the room and position of each one of these interactions.

For an easy integration, the 3D scenario is as a 9x11 grid of tiles just like the 2D user interface. As the xml file is read, each one of the tiles is filled with the intended room and the intended features. This type of layout was based on some strategy games like Sid Meiers's *Civilization*[1] franchise. However instead of the hexagonal tiles from these games, the "**Builder Spots**" are square to better feature the dimensions of the rooms.

[1] http://franchise.civilization.com/en/home/

As the xml file is read, the rooms are created using a set of models previously added to the project that represent each type of room available. The fires and points of interest are added and the building takes its final form as can be seen in 5.5.

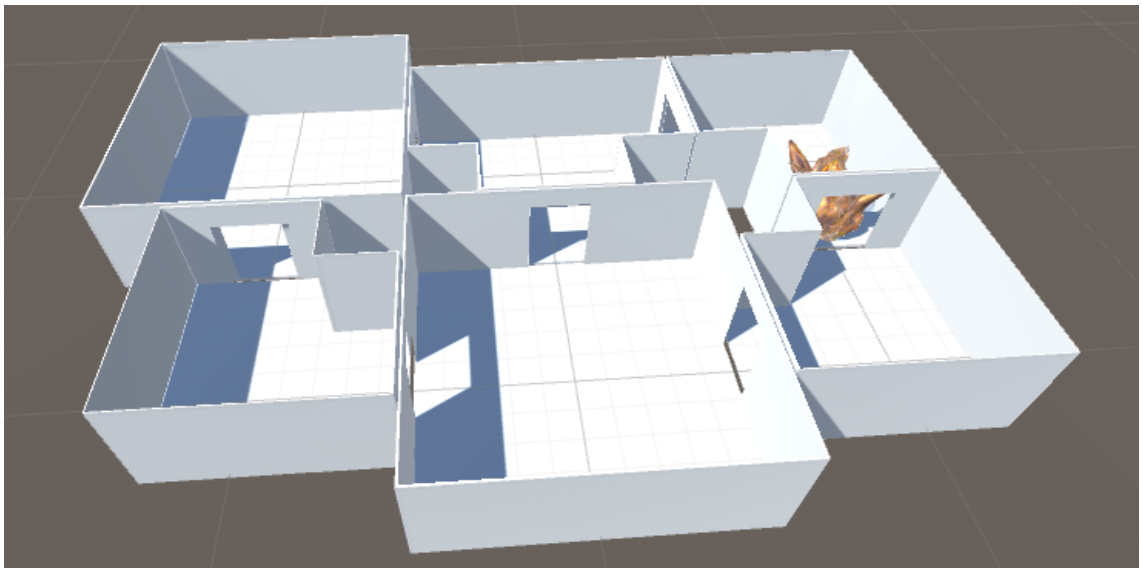

Figure 5.5: The 3D version of the building after being generated by the script (no ceiling attached to better understanding of the blueprint)

5.3 The Game

The game is a first person maze where the character can freely walk through the building choosing its path. This can be changed according to several variables decided by the creator of the game. Fires can obstruct paths, doors can connect only the desired rooms and decision points may tell the player to go a specific way. In 5.6 the character can see a fire ahead obstructing the way and needs to find another path.

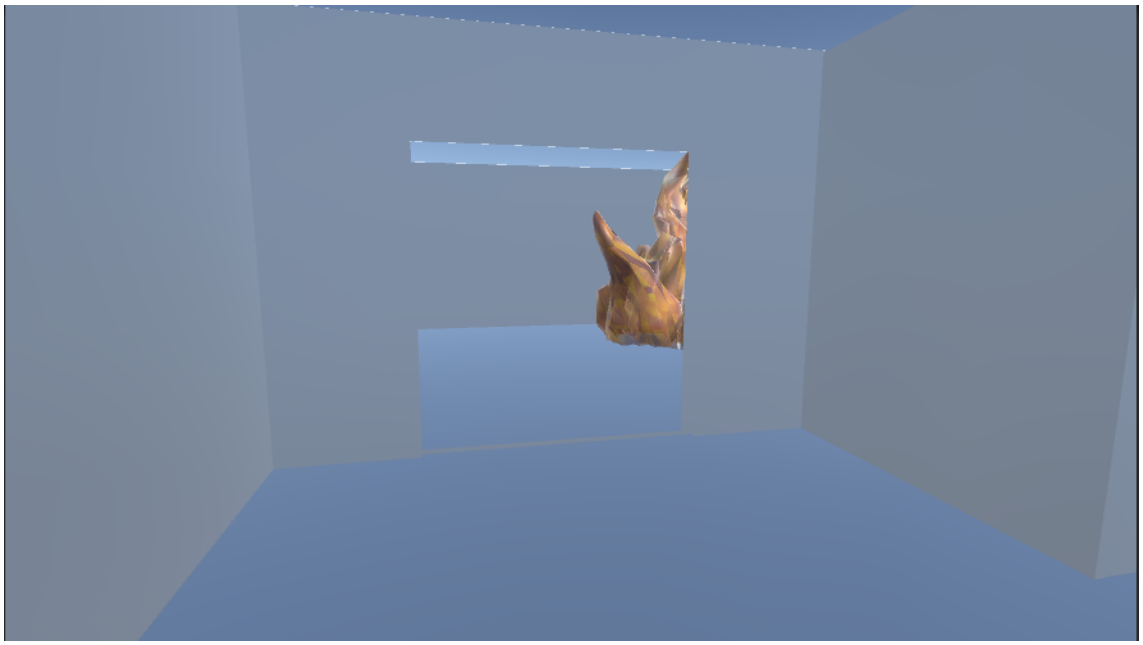

Figure 5.6: The view from the player

The main objective of this game is to act like an experiment and register the movements and decisions of the player as explained in chapter 4.

5.4 Technologies

Unity3D was used to make the prototype implemented in this work, following other related works made by LIACC. For some of the room models Blender was also used.

Chapter 6

Results and Analysis

At the start of the dissertation there was a general idea of the expected results to be achieved:

- Elicitation - It is important for this platform to be able to collect a large amount of data about the players. Not only quantity, but also the quality of the data. The prototype should be able to prove the effectiveness of both the data-model and the implemented game mechanics;

- Motivation - For a serious game to be a valuable asset, it should be entertaining, to motivate and involve the subjects. The game should be as immersive as possible to make the players feel they are living a real experiment. This also helps the previous point, since the realism of the game helps the quality of the data gathered;

- Meta-model - An important part of the dissertation. The amount of choices and decisions can be a possible way to evaluate its performance. Besides that, it must be easy to learn how to use and integrate on various technologies. The next point will also help to evaluate the quality of the meta-model;

- Prototype implementation - The prototype will be the main method of testing the work done through the dissertation and evaluate the quality of the meta-model. This prototype will allow the requirements to be tested as well as the gathering of some extra data to improve the project itself. As it is expected, the prototype should be able to dynamically generate the level of the game as the researcher chooses the parameters which should be defined by the meta-model.

However some changes needed to be done along the way. For instance, the generation of the game level would not be done in a procedural way. Instead, it was given the opportunity to the investigator to create his own level. As explained in chapter 5, this tool was even more helpful because it gives the investigator full control over the experiment. This way he is capable of choosing the scenario and environment, and even forcing a determined path to the player using the rooms and obstacles available. This choice brought another good result with it. As the level generation is made by reading a xml file, it is possible to generate a level without the use of the

level creator. Since the structure for the xml is defined, it is really easy to create or import another xml file. This makes the integration easier for this platform.

As the prototype does not have any furniture, and the environment is not very immersive, the motivation to play the game can not be supported by fun. This has some clear disadvantages. Usually for a serious game to be useful they need to have a component of fun, as this represents one of their most important advantages. As said by *José Fernando et al*., the benefits of combining serious games with other simulations include the usually higher motivation [SAP+13]. However, the prototype is really just a base for a much larger scheme. Although it lacks components of fun, it has other really important features for the validation of the experiment. The level can be easily created giving the investigator an easy and fast way to create an experiment. The decision points are easy to add and a lot can be learned from the answers provided by them. The abstraction of the room makes it possible for the investigator to recreate the experiment several times, without representing any specific building or blueprint.

The prototype can be used to collect a significant amount of data, which means it has the elicitation component intended. The data collection can be done by observing the path that each player takes as well as using the answers provided by the decision points. As the decision points can also provide information or warnings to the player, they can be used as signs. So this allows the investigator to understand all the different behaviors that the player produces depending on the different scenario or obstacles, or even on the different information that he receives.

Finally the meta-model was a lot harder to theorize than expected. The different scenarios and its perks change the way the experiment is conducted and therefore the creation of the platform. As said by *Atkinson et al*., a meta-model is often referred as a model of a model [AK03]. In this case the meta-model is a model that generalizes the creation of an experiment intended to behavioral elicitation. As these experiments can be abstracted into models, we can say that the definition fits. However there is a lot missing in this meta-model. The more this subject was studied the more it was possible to realize that it is an ambitious goal to summarize all the different scenarios for the simulations in one model. The bigger the abstraction more are the details that will be missed, and many of them are really important for some individual experiments. It is possible to say then, that this one objective that was not fully accomplished.

Chapter 7

Conclusions

7.1 Final Remarks

The objective of this dissertation is to help the psychologists and other type of investigators and institutions that use serious games and simulations to help behavior modeling and elicitation. The main motivation was to make their life easy, by creating a meta-model that can represent a great set of parameters that lead to certain user stories. This would make both, elicitation and behavior modeling even more valuable.

Most serious games aim to achieve one goal or a small set of goals. We intended to create a way to transform the creation of a serious game or simulation in a set of parameters that can easily be chosen by the researcher in order to achieve the specific goal wanted at the time.

After most of the work was done, it was possible to realize that the initial intended prototype was too ambitious to be accomplished. However it fulfills one of its primary objectives. It is able to replicated the experience conducted by *João Emílio et al.* [ARF+14], without the furniture components however.

The meta-model was also too ambitious but for different reasons. It was found that it is very difficult to find a model that can effectively cover all the parameters needed for the intended types of simulations. The abstraction is the main difficulty, because it is an obstacle to a good generalization. The fact is that if the meta-model is intended to cover all the parameters from the different simulations, it needs to me as much abstract as possible. The problem is that some important and specific use cases can be lost in the generalization. However if we want to specify these needed parameters, the generalization becomes very hard to accomplish. That is the main reason to the half success of this point of the dissertation.

7.2 Future Work

First of all the data collection can be improved. As it is right now, the investigator can use the information provided by the experience, however he has to do the collection manually. An useful feature would be to create a tool that collects all kinds of data during the game and saves it in a file.

Another possibility even more ambitious would be to create automatic reports with self generating graphics and statistics. That may be useful but not essential.

As it is possible to see in chapter 5, the prototype is very basic. Does not have furniture, the walls have no textures and there are only four types of rooms. These are easily improved features. Both the furniture and textures are easily added although they did not seem that necessary at the end of the development of the prototype. The four types of rooms were chosen to be as generalized as possible to improve the amount of buildings that can be represented by them. However another type can be added, should be to improve the range of possibilities covered by the level creator.

As said in chapter 6 the meta-model is a really ambitious objective and can always be improved. It can be more abstract and seek to accommodate as many different scenarios and simulations as possible. Or it can be more specific, lowering the level of its abstraction, seeking to define more individual experiments.

7.3 Lessons learned

From the writing of this dissertation it was possible to realize that there are a lot of applications and benefits from serious games but it is also hard to make them a valuable asset. The meta-model was a really ambitious objective and the initial intention of the prototype was too. However the prototype serves one of the main objectives that was accomplished.

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