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# A Simulation of a Fire Accident in Second Life

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**Abstract**

*Simulating the evacuation of an office building can be helpful to better prepare the potential occupants in the event of fire. Virtual environments are the ideal candidates for this type of simulations because they allow testing of numerous scenarios with minimal costs. We also needed a multiplayer collaborative environment for our experiment and for this reason, our choice fell on Second Life. In our study numerous tests were conducted on various groups of users to analyze their behavior and reactions and experienced through a virtual environment during a dangerous situation. In this paper we describe how our experiment was enacted and the results and observations made after the tests.*

## 1. Introduction

Following the numerous accidents that often occur on the workplace, the importance of safety standards and prevention measures has gained a great deal of attention. The behavior of people in case of danger is mostly unpredictable. Even a minimum emergency situation can become a full fledged tragedy if those responsible for the safety of the potential victims of the accident are not sufficiently prepared to respond to the problem or do not act promptly. This can be avoided by adopting the appropriate safety regulations and measures. To achieve these results, it is essential to comply with all safety parameters for a structural environment building and to prepare people to deal with emergency situations. This can be obtained by teaching them how to handle the situation in a passive way, through the knowledge of laws, and in an active way through real exercises on the field: the simulations.

Our work consisted of two phases: a modeling phase. and a simulation phase. In the former, a real office environment, an INAIL building (Istituto Nazionale per l'Assicurazione contro gli Infortuni sul Lavoro – National Institute for Insurance against Work Injuries), was modeled. A great deal of attention was given to all the structural parameters which safety regulations require. The latter was necessary in order to assimilate all those practices which may not be innate and spontaneous in emergency situations, through the "Learning-by-doing". This is a concept that refers to the capability of users to improve and prepare their behavior by regularly repeating the same type of action, especially in dangerous situations where their skills are limited by fear. We carried out this experiment in the virtual environment of Second Life.

### 1.1. Why Second Life?

Among all of the possible platforms available we have chosen to work with the Second Life environment because it is an excellent collaborative tool that allows many people to interact with each other and exchange views, ideas and feelings in real time. This makes the simulation experience more realistic and engaging because Second Life recreates many different types of interaction through the use of text chat, vocal chat and gestures, depending on the situation. All these features can become very useful in case of need, like an evacuation due to a fire accident, because it allows avatars to establish a closer relationship between them and take prompt decisions.

In addition, to make the evacuation simulation easy and usable for each type of user, all avatars' actions and interactions with the environment can be achieved through the use of directional arrows and mouse clicks. During the simulation, then, users only have to focus their attention on interacting with the environment rather than thinking about how to actually do it. Moreover, to ease the movement of the avatars and avoid visual and perception difficulties, the building and each element's dimensions have been increased by 50%. This increase also mitigates the "sense of oppression" [1] that some casual users experience during the exploration of virtual environments, thus easing their interaction.

An evacuation simulation is useful: to prepare users to face a potential danger situation in the real world; to verify how users are able to orient themselves inside a building; to test visibility and positioning correctness of emergency lights and signals; to check the evacuation plan efficiency. For this purposes the Second Life engine, tough it isn't graphically realistic and does not implement a physics engine able to elaborate complex fluid-dynamic equations, has proved to be the best compromise between ease of use and usefulness for our final purposes and evaluations.

Finally, another important factor that persuaded us to choice Second Life is its widespread diffusion in the world, with its 7 million residents, which increases the chance that users are already aware of the potential of this platform where they can feel "at home".

## 2. Related Work

Research in the field of disaster simulation has been widely explored in literature. In fact, learning how to analyze and possibly prevent various disasters, either natural or man-made, is of the utmost importance. The results obtained from such studies and simulations can then be used to further our knowledge about how to best respond and plan accordingly to such occurrences.

G. Andrienko, N. Andrienko, Bartling [2] describe the design of an automatic scheduling algorithm generator tool that can produce evacuation plans: a human supervisor can then analyze the output to verify the feasibility of the plan and identify any problems that might occur. Johnson, in his paper argues that HCI will need to play a significant role in the future development of evacuation simulations [3]. In fact, it can affect and possibly alter the outcome of the rescue attempt, so it is of critical importance that the insights gained from conducting such experiments can then be applied in an effective way, should such a situation arise.

Many researchers developed various simulations that make use of virtual reality environments for either training or evacuation purposes. Obviously, it isn't always possible to conduct real life fire evacuation drills because of cost and time involved. In some circumstances it is better to analyze such events in a virtual environment because many more what-if scenarios can be tested [4]. Bukowski, Séquin [5] developed a simulation software that used the National Institute of Standards and Technology's CFAST fire simulator. In this environment, fire safety system can be analyzed and subsequently evaluated. Julien, Shaw [6] developed a virtual environment application to use for the training of firefighter trainees where 3D models of the firefighters team try to extinguish a house fire. Trainees can then issue various commands that will then be performed by the virtual characters. Backlund, Engstrom, Hammar, Johannesson, Lebram [7] developed a firefighter training simulation using the Half-Life 2 [8] engine in which users have to wear equipment (to simulate the physical stress one would experience) and use it while physically moving into an immersive CAVE system. Experiments showed that users reported of having gained valuable knowledge from their experience with the system. Differently from our implementation, these system are aimed towards persons from the firefighter domain, whereas our system doesn't have this kind of requirement and doesn't require any prior knowledge.

In this paper we present the experience we did in simulating a building fire and the consequent evacuation of the people working inside the building. We were interested in observing the reactions of the people working in the building during the evacuation. We needed a multiplayer environment, one that the users already knew. Differently from the systems reported above we used Second Life [9] as the virtual environment in which we conducted our simulations. The choice of Second Life was due to several reasons. It is cheap to use for a casual user, because only an entry-level computer is needed, together with an internet connection. Since many people use Second Life, it is easy to find people that would be willing to participate to the simulation.

Second Life has been the focus of many studies on education and public awareness topics. Examples are the use of virtual environments for health education [10], and the description of the advantages and disadvantages of using virtual environments, such as Second Life, for learning purposes [11]. In the field of learning within Second Life, the literature is very prolific [12]. On the other hand, the use of Second Life for the purpose of evacuation simulation has not been explored thorough to the best of our knowledge. Thus, another reason for our study.

Next Section presents a technical introduction of the paper. In Section 4 the simulation is illustrated, then, in Section 5 we discuss the results and eventual future work. Finally our conclusions are stated.

## 3. Design and development of the experiment

In order to perform our tests, we built the virtual representation of a real building of National Institute for Insurance against Work Injuries. The work was divided into two parallel and complementary phases: in the first phase (the "modelling" phase), we designed the actual building which hosted the simulation. In the second phase, we added interaction features to the virtual world by using the LSL (the Second Life Linden Scripting Language) in order to make sure that users could interact with the surrounding environment in a familiar way. Here follows a detailed description of these two phases, which focus on the most relevant points.

### 3.1. Modelling phase

In the "modelling" phase, we constructed the building from the architectural and structural points of view. At this step, we ran a detailed analysis of the limits and of the level of interaction of the avatars within the virtual world of Second Life so that we could assess the proper size of the building and of the pertinent objects in order to make them as similar as possible to their real world equivalent. The primary structure of the building closely follows the plans of its real life equivalent, using the same sizes, proportions and organization of the inner spaces. Furthermore doors, windows, balconies, staircases, elevators and furniture were modelled so that avatars could interact with the building as realistically as was possible, even in dangerous situations and during the evacuation, where the orientation is fundamental.

In the simulation, a key role is played by emergency exit signs (

Figure 10). In fact, in order to comply with the current Italian rules about security, signs indicating the emergency exits were positioned in the whole building, along the hallways and on the anti-panic doors to indicate to the avatars a possible way to escape. In addition, plans of the building are displayed along the hallways so that an avatar is able to find his/her own position within the building should he/she need to, especially in the event of a participant who does not know the building. All the signs were displayed at the average height of the face so that they could easily and rapidly be identified by avatars. They were drawn with reflective materials, green coloured for the emergency signals and red coloured for the fire signals, so that they can be easily seen also in the event of poor visibility. After having observed the avatar’s behaviours during the simulation of the evacuation, we added transversal signs because in that position, the identification of the emergency exits, staircases and elevators was considerably easier during the fire when the smoke greatly reduces the visibility. Besides these signals, we also placed bright and loud signals, which revealed to be very effective in the actual evacuation simulation because they are very easy to see and hear. Furthermore, such signals may promptly alert an avatar when needed.


**Figure 10 The emergency signs and plans**

We observed that if the avatar is made aware of the situation or is able to orient him/herself, it will be more likely that he/she will remain calm and retain clearness of mind. This simulation is therefore useful to make the avatar more able to behave in situations of danger. Flashing signals of anti-fire danger were positioned in the corridors and flushing signals of emergency exit on the anti-panic door, with a loud anti-fire signal. Some signs showing how to behave in case of fire were displayed in the corridors and in the rooms in order to educate the avatars about the proper procedures to apply. The extinguishers were placed in the corridors. A rallying point, very important when the simulation was over, was arranged outside the building so that avatars would have a common place where to meet with the others who managed to escape. In this rallying place, operators would make sure that each one of them is fine and shares comments and suggestions.

## 3.2. Scripting phase

The scripting phase allowed us to make the objects in the surrounding environment react to user interaction and events that happen in the case of a fire accident and the immediate evacuation of a real building. Here follows a description of the more relevant scripted elements. Since the focus of our study was the simulation of the evacuation of a building after a fire accident, we reproduced it for the purposes of our experiment. Fire is one of the most unpredictable natural phenomena and therefore it is very difficult to simulate, especially in the Second Life virtual world because of a series of technical limitations. For these reasons, we made an effort in order to make it as realistic as possible in the light of the above-mentioned limits but also of the function and the purpose that fire has in this simulation.

Firstly we tried a way to manage and control fire depending on requirements of each virtual evacuation simulation, in order to guide avatars to escape from particularly dangerous situations, such as the impossibility to reach the nearest emergency exit due to fire, or situations where there is a violent and fast blaze or a fire that spreads by two different fronts, etc.

Secondly, we attempted to grant more freedom of action to the evacuation expert that conducted the simulation by allowing s/he to manage the activation and propagation of fire and its intensity and speed during the progress of the whole simulation. For these two reasons we built a “spreading zone system” to simulate the propagation of the fire. The building floor in which blaze occurs is divided into three zones, in which fire can spread autonomously. This system allows to set fire to one or more positions simultaneously or to start the fire in a fixed position and activate the propagation of the fire in the rest of the floor.

To perform the fire effect we opted to use a particle-system implemented through ad-hoc code instead of using simple prims with animated textures, in order to make it more graphically realistic. We also generated a red light effect that lights walls and objects. This effect simulates the light emanated by flames. This is a key factor to guide the avatars’ behaviour during the simulation. Obviously, smoke is also simulated: another important factor to recreate the condition of a real blaze. Similar to the fire, the smoke is obtained through particle effects, but its propagation is faster than fire, swiftly reaching surrounding areas and reducing the overall visibility.

Another object connected to the fire is the fire extinguisher. In the simulations the fire extinguishers are used by a particular group of avatars having experience on how to operate it. By using this object the avatar is able, proportionally to its duration, to extinguish an hotbed by pointing and clicking with the mouse. An on-screen message will notify the fire extinguisher exhaustion when it becomes unusable. We implemented this behaviour for the fire extinguisher in order to allow avatars to get the feeling of really using it. Since they have a fixed lifetime, they will have to quickly decide what is the best choice between using it to put out the fire (taking into account its scarce duration in case of a fast propagating blaze) or immediately leave the building.

Another relevant element is the door. In the building there are various types of doors: simple ones that can be opened (and closed) by mouse clicking, revolving doors, and fire (emergency) doors. The last kind of door closely reproduces the behaviour of real modern emergency doors, as dictated by enacted laws. This doors works in a centralized way, remaining open in a normal situation (to facilitate people transit) and closing automatically when the fire alarm is activated, allowing the evacuation of the building occupants (made easier by the anti-panic door-handle and the automatic locking up) but blocking the fire propagation because of the particular material they are made of.

Another object we customized is the elevator. In Second Life elevators are realized in a counterintuitive way: typically the avatar needs to be linked to an object attached in the elevator, like a chair or a label, then the avatar can chose the floor. We built more intuitive elevators that work exactly like real elevators, through the use of a collision detection system. In the point of view of our evacuation simulation, elevators act in a realistic way and also allow, for instance, handicapped users to safety leave the building.

In every room of the floor there is also a phone from which it is possible to perform an emergency call to the evacuation expert who will receive a message that will inform him about the fire and will allow him to promptly alert rescue services and activate the fire alarm.

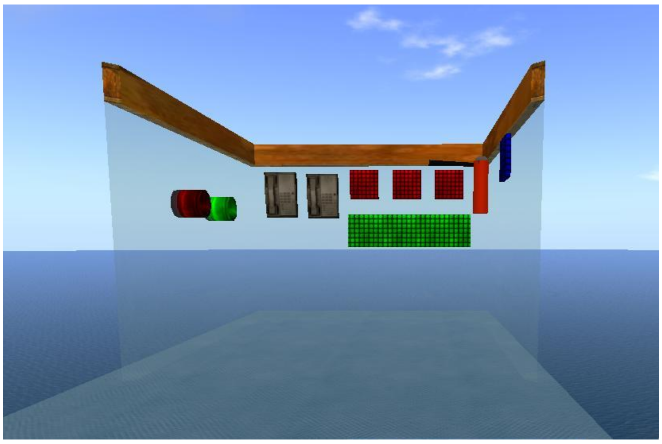

**Figure 11 The evacuation expert cabin**

All those activities (activating and deactivating a fire alarm, starting and stopping the fire propagation, etc.) are managed in a particular command deck (

Figure 11) positioned on the top of the building that allows the evacuation expert to manage the whole simulation from a good vantage position. We also made the ceiling of the building transparent only from one side. The evacuation expert, from outside of the building can see what's happening inside the building, but from inside it is not possible to see outside. In addition, in the evacuation expert cabin, there is a button that allows the expert to send a feedback note at the end of the simulation.

## 4. The evacuation simulation

### 4.1. Roles and tasks

In this section we briefly describe the roles that users can play during the evacuation simulation. There are mainly two kind of roles: playing characters (PC) and non-playing characters (NPC). PCs are the real users of the virtual building and, in a number usually between 5 and 10, are the participants of the evacuation simulation. The NPCs group was formed by a team of eight people that in turn assisted each simulation we ran. The PCs were casual people who were visiting our stand in a trade fair event (Forum PA held in Rome in 2008) and spontaneously decided to participate to the experiment. Each PC performed the simulation only once. The PCs seldom were experts of virtual worlds and in particular of Second Life. For this reason we designed and developed the whole project so that it could easily be accessible for users that don't have familiarity with new technologies.


**Figure 12 The avatar with a disability and the person responsible for her safety**

Among PCs, besides the building employees, there are specific characters that will perform particular tasks, soto set up a more realistic situation, similar to what would happen in a real evacuation in the event of fire. One of this characters is represented by an avatar with a disability (

Figure 12) on a wheelchair, and her/his role assumes primary importance to simulate discomfort and eventual movement difficulties, because of obvious factors such as fire, smoke, scarce visibility, other avatars' behaviour, etc. According to the law, at least a person responsible for the evacuation of disabled people must be present on the floor at all times, when the fire alarm starts, this person reaches the avatar on the wheelchair and brings her/him out in a safe place such as the external balcony, where they can wait together for rescue. Another safe place is the gathering place situated outside the building if the elevators are safe.


**Figure 13 The fire extinguisher operator in action**

Another PC is the fire extinguisher operator (Figure 13). This operator is the only user that, in the event of fire, can use the fire extinguisher to douse the flames. The introduction of this role makes possible to simulate the behaviour of a user struggling with the flames in various situations. The user actions can be more or less correct, depending on the extension of the fire and action timeliness. An important factor is the duration of the fire extinguisher, that forces the operator to evaluate the fire situation and act accordingly. Another task for this character is to act as a reference for other users during the whole process of the evacuation simulation.

An important role in the simulation is done by the panicked user. Often, in a real situation, a panicked character causes a lot of accidents, because of her/his irrational behaviour, obstructing the other users' escape or risking her/his own life. The purpose of this avatar is to simulate the unpredictable reaction provoked by the danger situation thereby forcing the fire extinguisher operator is whether or not to take care of her/his rescue (because in the simulation, the operator is supposed to be the most qualified person). The panicked user tries to annoy other PCs, asking them for assistance or to be escorted to safety; s/he could even be comforted and be told that "everything is going to be all right"! NPCs aren't meant to be understood as AI controlled characters but, instead, avatars interpreted by specialized staff or evacuation (simulation) experts attending the Land. Their principal task is to lead and coordinate the progress of the simulation test, without interacting with PCs playing their roles. Their number can vary depending on the number of PCs. A NPC is the coordinator, and her/his task is to lead the progress of the evacuation simulation using the command desk situated in a overlooking position. The coordinator's task is to activate the three steps of the simulated blaze and to disable them at the end of simulation. Moreover s/he has to manage the fire alarm when an user uses the phone to call rescue. If nobody calls rescue, fire sensors can still detect the fire and activate the alarm, consenting to other users to proceed with the evacuation simulation. Another coordinator's task consists in sending to PCs a final feedback note, describing the correct behaviour to follow during the escape in event of fire. At the end of the evacuation simulation each character can confront his behaviour with the most appropriate described into the note and discuss it with other characters.

Another NPC is the cameraman: s/he has the task of recording a video of the progress of the simulation. This is an important task because it allows staff and PCs to watch again the actions performed in order to evaluate their correctness and document the evacuation simulation for future analysis.

### 4.2. Description of the experiment

In this section we are going to analyze the phases of a typical evacuation simulation in the event of fire. The tests were conducted during the Forum PA 2008 trade fair, held in Rome, into an IBM stand by using several isolated working stations (only visual isolation, by means of panels among the working stations). Several PCs were contacted and were asked to meet in the SL land from working station outside the trade fair. Since we showed the experiment in a trade fair we put a big screen that showed the simulation to people passing near the stand. Future participants would arrange telephonically or via IM to meet at an agreed time on the particular Second Life area where the simulation would have taken place. Before the simulation all the participants met outside the building. The NPCs briefly explain how the simulation is going to unfold. In this phase the coordinator assigns roles to PCs. Soon after, all the PCs go into the building and reach the third floor, the place of the actual evacuation simulation. Everyone then takes her/his place in their typical workspace, like in a common working day. At the same time the cameraman user places himself inside the building waiting for the beginning of the simulation. In the meanwhile the coordinator user reaches the command deck positioned on the top of the building and waits a few minutes before starting off the simulated blaze. Once the fire starts the real simulation will begin.

The coordinator will wait for a PC that notices the presence of fire and calls for rescue using one of the emergency phones situated in every room. As soon as s/he receives the message, the coordinator will activate the fire alarm, consisting in a siren and flashing light signals, in order to warn all playing characters. The coordinator will also contact the fire extinguisher operator, that will evaluate the situation and will independently decide whether to try to extinguish the fire or leave the building sooner with the other users. In addition, another task of the fire extinguisher operator is to help other users in difficulty, should it be necessary.

While other users reach the emergency exits, the person responsible of disabled users will reach her/him and will guide her/him to the nearest emergency exit, as previously described. The evacuation simulation ends when all the PCs reach the rallying place situated outside the building. At this point the coordinator sends a feedback note to all users that contains the correct behaviour to follow in case of evacuation in event of fire and resets the whole system. While the users who escaped wait in the rallying place (

Figure 14), they can discuss about the evacuation simulation just completed.

**Figure 14 The rallying place, at the end of the experiment**

## 5. Discussion and future work

### 5.1. Results of the tests

We performed 12 simulations, with 8-12 avatars each, at scheduled times during a week period. Various typologies of users took part in our experiment. Among those we can list fire fighters, workers of various regional and local agencies and junior high school students. At the end of every simulation, participants were asked to express their own personal opinion about the ease of use or interaction quality with the virtual world that we have recreated, giving their opinion regarding simulation usefulness. The results are presented in Table 1. We noticed that users that didn't have familiarity with new technologies were able to easily reach a good degree of familiarity with the environment interaction features. Also, all the participants learned notions clearly. We also observed that users' behaviour changes depending on their awareness. Avatars performed rational actions proportionally to information that they could acquire during the tests.

| | | | | | Fire extinguisher operator | | Panicked Avatar behavior | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Simulation Nr. | PC Avatars | NPC Avatars | Total Avatars | Was the disabled avatar assisted? | Did he try to douse the flames? | Did he succeed? | Did he panic? | Consequences | Did he influence other avatars? | Was the fire signaled by phone? | Did all avatars escape? |
| **1** | 9 | 3 | 12 | Yes | Yes | No | Yes | Confusion<br>Non cooperation | Yes, two avatars tried to help him, postponing their own escape | Yes | Yes |
| **2** | 7 | 3 | 10 | Yes | Yes | Yes | Yes | Confusion<br>Hindered others<br>Avatar goes towards opposite escape direction | Yes, one avatar tried to help him, postponing his escape | No | Yes |
| **3** | 8 | 3 | 11 | Yes | Yes | No | Yes | Confusion<br>Non cooperation<br>Hindered others | No, panicked avatar didn't influence others | Yes | Yes |
| **4** | 8 | 4 | 12 | Yes | Yes | No | Yes | Confusion<br>Shock<br>Needed to be saved from the flames | Yes, three avatars tried to help him, postponing their own escape. One avatar saved him from the flames | Yes | Yes |
| **5** | 4 | 4 | 8 | No | No | No | Yes | Confusion<br>Shock<br>Avatar hides in bathroom | No, panicked avatar didn't influence others | Yes | Yes |
| **6** | 7 | 3 | 10 | Yes | Yes | Yes | Yes | Confusion<br>Shock<br>Avatar hides in bathroom | No, panicked avatar didn't influence others | Yes | Yes |
| **7** | 7 | 4 | 11 | Yes | Yes | No | Yes | Confusion<br>Avatar goes towards the flames | Yes, one avatar tried to help him, postponing his escape | Yes | Yes |
| **8** | 9 | 3 | 12 | No | No | No | Yes | Confusion<br>Non cooperation<br>Hindered others | Yes, one avatar tried to help him, postponing his escape | Yes | Yes |
| **9** | 8 | 4 | 12 | Yes | No | No | Yes | Confusion<br>Avatar goes towards the elevator to escape | No, panicked avatar didn't influence others | Yes | Yes |
| **10** | 9 | 3 | 12 | Yes | Yes | Yes | Yes | Confusion<br>Shock<br>Avatar hides in bathroom | Yes, two avatars emulated his behavior | No | Yes |
| **11** | 9 | 4 | 13 | Yes | Yes | No | Yes | Confusion<br>Shock<br>Avatar did not move | No, panicked avatar didn't influence others | Yes | No |
| **12** | 9 | 3 | 12 | Yes | Yes | No | Yes | Confusion<br>Shock<br>Avatar hides in a office | No, panicked avatar didn't influence others | Yes | Yes |

**Table 3 Results of the simulation tests**

We observed the behaviour of the panicked user in order to see whether his actions could influence the actions of the other. We noticed that in half cases (6 out of 12) other avatars take notice of her/his actions only if s/he acts in a visibly irrational manner. In fact when s/he remained immobile in her/his office or hid into another room, the others tried to escape normally. This is most probably due to the fact that the feeling of presence experienced through the devices used for the test (a normal PC and a LCD monitor) didn't contribute to the spatial and locational awareness that a real person should have. Cries of help, the sound of doors being blocked or other similar sound clues could help to increase this kind of result. Whenever avatars didn't take notice of the panicked one, they didn't bother to search for her/him. We can assume this is probably a lack of a personal bond attachment between them. In fact few of them knew each other and therefore were not motivated to search for the panicked avatar and for other avatars who may have been left behind.

Another observed factor was whether or not the fire extinguisher operator managed to douse the flames. We observed that every time he tried, he succeeded. Other observed parameters included how the fire was actually signalled. In most cases some avatar managed to call the rescue services. Perhaps, as a future work, we might try to simulate a malfunction of the phone lines to see how this influences (or not) the behaviour of the avatars. In the other two cases, the “evacuation expert” avatar had to start the alarm, simulating a fire sensor that was not implemented.

Finally we tracked down how many of the participants managed to escape to the rallying point. In only one case someone was left behind, because (as we later came to know) the user left his computer due to real life reasons. The use of emergency signals and their position resulted in a key factor during the evacuation simulation, because they helped to find the way for those users who weren’t accustomed to the floor layout. It also contributed to enhance the level of realism in the virtual environment. In this way, avatars are able to put in practice in the real world, all the notions learned in Second Life, in a direct way.

In addition, the final debriefing gives the participants the chance of reviewing the results of their actions in the simulation through the recordings made by the cameraman avatar and evaluate their correctness with the simulation experts.

### 5.2. Future work

This work shows the simulation of the evacuation of a building not having a basic plan structure (with numerous rooms, at least two emergency exit and escape hatches, etc).
This virtual simulation of a real event can be interpreted from two points of view: educational and evaluative. In the first case the simulation is seen like a way to prepare and practice personnel to the actual rules to follow in event of fire. In this case it is possible to foresee the future progress of the project as a further gradual improvement of the virtual simulation, in which all the participants involved have to correctly respect their own role and the specific actions that his role allows in the virtual world, while the virtual simulation has the purpose to let users to become familiar with their tasks in event of fire. In this case we will follow the current work line. In the second case the virtual simulation has an evaluation purpose and can become a tool capable of verifying that users learned the rules and their assigned tasks in event of fire. In this case the follow up of the project development can experience two distinct directions.

The first direction requires the creation of a further user role: the supervisor-tester, that examines the users’ behaviour and, at the end of the virtual simulation judges the users and gives them an evaluation. The second, more difficult, direction leads to an automatic evaluation system, that autonomously “observes” users’ behaviour and send hints and corrections during the progress of the virtual simulation. At the end it gives a final feedback containing the list of the user’s mistakes, the correct behaviour to follow and an evaluation of the particular user’s behaviour. This direction is however difficult to explore, especially using the Second Life virtual world, because of its intrinsic technical limitations in particular of the scripting capabilities required to implement the expert systems needed for this task.

Another possible future follow up consists in the modelling of other buildings having a more complex plan (such as a building with more floors and more than one hallway) using the virtual simulation as a tool that aids the evacuation expert to tweak and perfect the most appropriate escape plan by observing the various users’ behaviours followed in the set of evacuation simulation tests.

Furthermore, it becomes necessary an improvement of the users’ visual feedback part of the interface, by introducing visual indicators that inform the user about her/his health state, and about its immediate environment (fire proximity or asphyxiation due to smoke), maybe with the introduction of ad hoc animations that make immediately recognizable an avatar’s health condition. Another possible direction consists in porting the whole project into a more sophisticated virtual environment that can take advantage of a better graphical presentation and of a more realistic physics engine, without losing the peculiar characteristics of Second Life: collaboration, experience sharing, multiplayer, environmental interaction, etc. The simulation, would certainly benefit from a more immersive and realistic simulation [13][14], because improved graphics and accurate physical reactions would certainly help users maintain a strong “suspension of disbelief” [15] which in turn could force the users to act in a more accurate way.

## Conclusions

This paper presents an experiment conducted within the virtual environment of Second Life in which participants assumed the role of the building occupants where a fire accident would take place. The adoption of Second Life has shown to be interesting because of the collaboration aspects intrinsic to its nature. It facilitated would-be participants to assume their role and served as a valid tool to make them experience a dangerous situation such as the one described in this paper. This experiment gives us the confidence to further pursue this direction with an increased effort on the immersion aspect of the simulation because of the implication and effects that it could have on future users.

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