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# Virtual Reality for training the public towards unexpected emergency situations

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***Abstract*— Nowadays, unexpected situations in public spaces are quite frequent; for this reason, there is the need to provide valid decision-making tools to support people's behavior in emergency situations. The aim of these support tools is to provide a "training" for the public on how to behave when something unexpected happens, in order to make them aware of how to manage and control their own emotions. Thanks to the introduction of new technologies, trainings are also feasible in Virtual Reality (VR), exploiting the chance to create virtual environments and situations that reflect real ones and test different scenarios on a sample of people in order to verify and validate training procedures. Virtual simulations in this context are paramount, because they offer the possibility to analyse reactions and behaviors in a safe, "not real", so without health concern, environment. Three scenarios (fire, heart attack of a person in the environment and terrorist attack) have been reproduced in VR, analyzing how to define the context for emergency situations. Users approaching the training only know they are going to face a situation without having details on what is happening; this is fundamental to test the training efficiency on people's reaction.**

***Keywords*— *Virtual Reality, Training, InfraBIM, Emergency situations, Human behavior***

## I. INTRODUCTION

Generally, VR training is used to teach technicians to perform specific operations, for instance maintenance activities, without being physically on the working site. This procedure is useful because technicians, for instance, will know exactly how to perform repair procedures on machines when breakdown occurs. Anyway, further investigations and researches are implementing the field of applications, for instance related to increase security in strategic city locations or public space, in order to make citizens aware of what could happen and drive them towards the best reactions and operations in specific emergencies. Thanks to the combination of automation and innovative technology systems such as Virtual Reality (VR), emergency situations can be directly controlled to evaluate possible optimal solutions related to the users' security [1] .

These tools are developing in a considerable way because they enable to reproduce in a virtual environment several factors and parameters that can influence real unusual events, testing scenarios on a sample of people in order to verify and validate training procedures. It is possible to monitor people's reaction in order to define the causes of specific behaviors, that can be influenced by various aspects, for instance eventual anxiety disorders or pathologies. VR enables the user to interact, manipulate and monitor information affecting complex situations both in a static and dynamic manner. For this reason, training using VR enables a faster learning of new configurations and a step-by-step evaluation of users' reactions in dangerous situations. By developing an accurate and detailed simulation model, it is possible to *a priori* evaluate different evacuation solutions and strategies to prevent damages [2].

When performing simulations, it is paramount to correctly input human behaviors. In doing so behaviors are abstracted, but testing real movements with virtual ones defines the accuracy of both model and attitudes, improving the effectiveness of simulations [2]. These tools are believed to be impactful because VR training involves a "learning by doing" method; in fact, instructions for a specific activity are not just seen in a video, but users can experience in the first person the situation, getting more involved in it.

The present research was carried out with the aim to provide "generic" users with specific instructions on how to approach an unexpected situation. For this reason, three different virtual scenarios were developed.

## II. METHODOLOGY

### A. Case study

The case study chosen to test the applications is an underground station under construction in Paris, entitled Sevran-Beaudottes and located along the line 16 of Gran Paris Express. This infrastructure was the preferred choice for this research because of the fragility of such structures in case of emergencies. The structure is divided in several levels underground and is composed of several stairs and other elements of space subdivision that enrich the overall architectural composition, creating a dynamic interior.

The choice of the case study itself gave inspiration to the development of scenarios in situations specifically critical for such a space, for instance the crowdedness at peak times on the quay could be an issue in case of fire, or the chance that a person has a heart attack and needs someone with Basic Life Support (BLS) knowledge. Three scenarios have been developed on the basis of previous considerations and namely: evacuation in case of fire, offering assistance to a person with BLS techniques, facing a dangerous situation involving shootings.

In the first case, training is useful to make users test their abilities in understanding the best exit routes on the basis of indications given within the applications, in order to remember those indications in case of need. The same happens with both the other two scenarios. The idea of living an emergency situation, but in a safe environment because part of a virtual simulation, is helpful to act rationally and to absorb movements and ways of thinking that could help in a real dangerous situation.

Each scenario was built with the aim to make people realize what are the actions they have to perform, simulating the experience through a gamification approach, which refers

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to the use of game design elements into a non-game context to increase engagement while learning [4]. Each scenario was set in order to ask users to "level up", reaching given instructions on how to carry the task out.

*B. Workflow*

The methodology workflow for each scenario was the same and was based on four main phases: Data collection, Data processing, Data visualization and Data output (Fig. 1).

First of all, a data collection was performed in order to understand the available data to perform such simulations. After having identified the topic, the next step was to define the three scenarios, getting information on such situations. For instance, in the first case the data collection gathered necessary information on how to simulate the fire and available timing to escape. Such data is retrieved from previous works developed on the case study. As far as the event of a firearms or weapons attack is concerned, the UK National Counter Terrorism Security Office offers a lot of materials, such as videos and leaflets with instructions to follow. The second scenario, instead, is referred to the use of BLS techniques to offer assistance to a person in danger. This phase was considerably time consuming, because it involved the setting of three virtual environments instead of just one and the definition of "training instructions" for each scenario.

Data processing involved the transformation of collected instructions into a VR environment; at this step the model was developed towards the aim of defining a realistic environment, which could make feel the user at ease. For this reason, the model of the underground station, developed within a digital parametric platform, was exported in Autodesk 3ds Max to apply textures and to correct possible graphical mistakes. Once this operation was finished, lights and adjustments have been performed in the cross-platform game engine Unity. At this point, four different scenes were defined:

- The starting phase, a scene in which users can navigate the model in order to become familiar with the VR environment, spaces and moving tools. After about three minutes the user is automatically redirected to another scene in which three objects are flashing; by approaching one of this objects one of the three scenarios described below is activated;

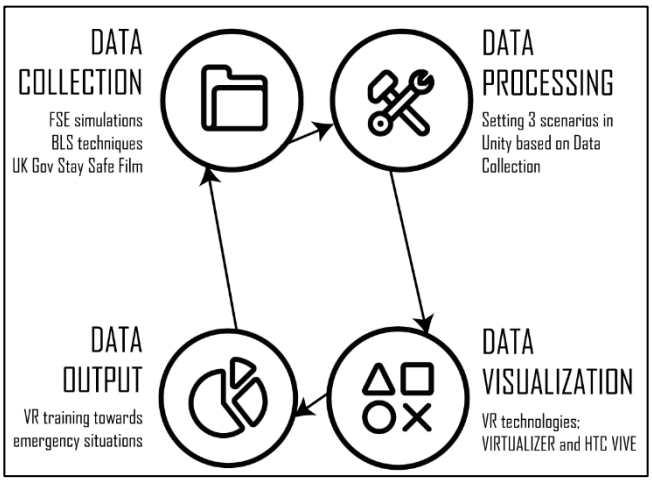


*Fig. 1: Methodology workflow*

- The first scenario, in which the user, thanks to the instructions that appear within the display device, has to escape from the fire; in this case a countdown timer appears, so the user can check the time left to escape;
- The second scenario in which there is a person who needs help because of a heart attack, so the user is given a list of actions to do before rescues arrive. In this case a real tutorial in steps is visualized within the display device;
- The third scenario in which a suspicious person suddenly starts shooting, so the user has to follow the instructions that appear in order to stay safe and escape from the situation.

Data visualization is related to the choice of technologies to implement in order to better experience the VR scenarios. In this case, the Virtualizer technology was tested together with HTC VIVE. The Cyberith Virtualizer is a locomotion platform for virtual reality that enables full movement in virtual environments; it is used mainly for professional training and VR simulations because of its precise motion tracking system [5]. Using the Virtualizer it was possible to track users' physical walking movements, by calibrating settings of the platform itself. HTC VIVE have been combined in order to give users the chance to be part of the VR environments, adding a level of interaction; using HTC VIVE controllers in the second scenario it is paramount to complete the tasks.

Data output is related to the results of the whole process; training scenarios are implemented on the basis of the data collection and processing. Once the training is completed, it can be tested on a sample of people in order to assess the effectiveness of such application; the results are the output of the research carried out, which can be developed in further activities, comparing scenarios and different technologies.

## III. RESULTS

*A. Scenario 1*

In the first scenario, it is possible to compare results from Fire Safety Engineering (FSE) simulations with the virtual experience. For instance, in FSE the most important parameters to take into account in order to perform simulations are the Available Safe Escape Time (ASET) and the Required Safe Escape Time (RSET). ASET is the time in which it is possible to escape, so it refers to the time between the starting of the phenomenon and the moment in which the attendance of the environment is no longer sustainable for people. The RSET is the time necessary for escape and it is strictly related to the conditions in which the escape takes place. Of course, there is a safety margin, because of uncertainty in defining parameters used for the evaluation. Knowing these parameters, it is paramount that ASET < RSET. The same parameters valid for FSE simulations have been set for the simulation in VR, so within the environment, the countdown (Fig. 3) showing the seconds left to escape is realized on the basis of the RSET, which was previously calculated using specific simulation software. The instructions in this case are related to the escape route to follow; the user have to achieve the safe point as soon as possible considering possible given obstacles.

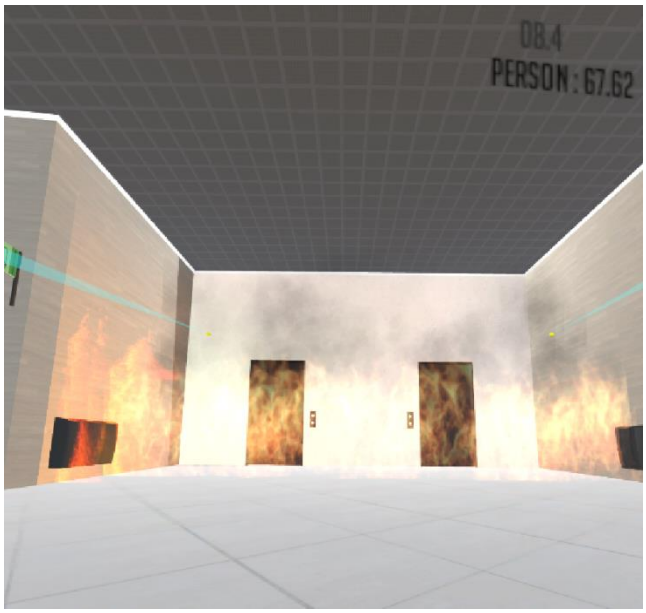


*Fig. 3: Scenario 1 - Fire simulation*

In particular, in this scenario, anomalous behaviors have been observed from testers; for example, going backwards and changing direction several times with respect to the initial phase showed indecision in which route to follow. This highlighted users' need to correct the path from time to time, defining step-by-step the most effective escape route.

### B. *Scenario 2*

The second scenario is more static and requires the use of controllers to perform specific activities appearing on the screen close to the scene. The instructions are divided in four main steps and namely: *Check for danger*, which means that all objects close to the person have to be removed; *Ask for response*, to check if the person is breathing or not; *Call for help*, on the right of the person there is a phone, by calling the first aid number a tutorial on how to give cardiac massage appears; *Start Cardiopulmonary resuscitation (CPR)*, after having read instructions on how to perform it. Each step has to be performed in order to "level up", in fact each button have to be green in order to confirm the success in performing that specific action (Fig. 4).

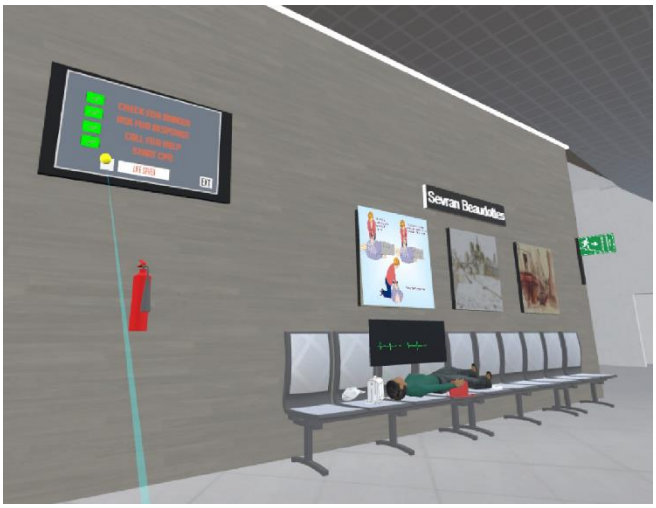

*Fig. 4: Scenario 2 - First Aid techniques*

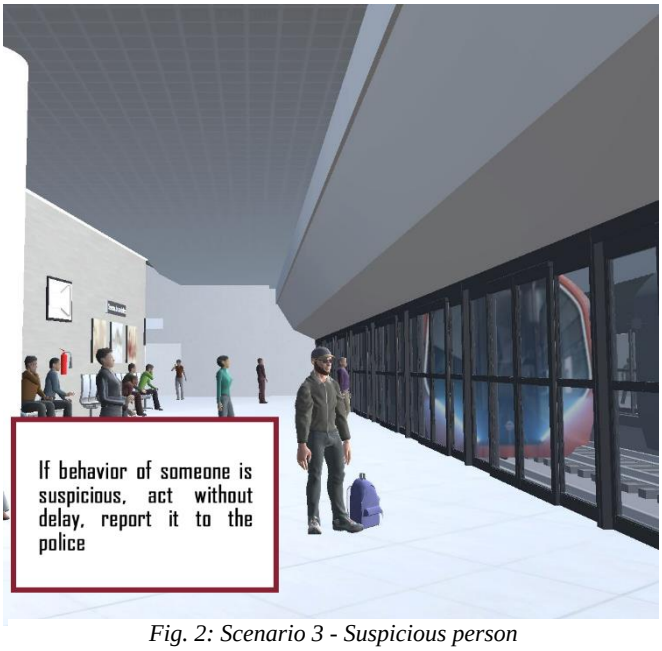


*Fig. 2: Scenario 3 - Suspicious person*

### C. *Scenario 3*

The last scenario obtained involves the simulation of a firearms or weapons attack; at first a suspicious person is identified, so the first message is related to the observation of this person who is loitering in the underground station; at this point the message "If behavior of someone is suspicious, act without delay, report it to the police", so the user is recommended to call the police. The second message is related to the advice to go away from that place; after a while bangs and people shouting suggest something happened. The next steps, which appear as instructions within the display device, are the following: *Escape if you can*, by considering the safest options if there is a safe route then run, trying to insist others leave with you and leaving your belongings behind; *If you cannot run, then Hide*, try to find a place, a room where to hide with reinforced walls to protect from bullets and lock yourself in, be quite, silence the phone and turn off vibrate; the last step is *Tell*, when reached the point suggested by instructions it is time to call the police and report the police location, direction, descriptions etc. Every time a task is completed the user has to check the related button, so it is possible to check which tasks are finished correctly.

## IV. CONCLUSIONS AND FURTHER DEVELOPMENT

The output of the current research shows that developing VR applications is useful not only for professional training, but also to study and analyse human behaviors in particular unexpected situations. Thanks to VR it is possible to test human behavior through simulation scenarios that can provide a reliable representation of generic dangerous situations. In fact, several testers reported the effectiveness of such training in the different scenarios that involved a stress condition, because the proposal of an emergency situation through VR is recognized by users as a real emergency, that makes strongly feel the danger to which it is connected.

In fact, once immersed in the virtual environment through the HTC Vive viewers and the platform, the user can modify the walking speed and the interactions that different scenarios offer using virtual buttons. Using these two technologies combined (HTC Vive and Cyberith Virtualizer) makes it possible to realistically simulate the movements during an

emergency situation. By carrying out preliminary tests, the authors chose to insert an initial scene of "familiarization" with the VR environment, which allowed to refine the actions and to control in detail the psycho-physical behavior of the user. In order to test the efficiency of the system, it would be interesting to install within strategic premises, some stations? where the user can explore the place in the different emergency situations. Currently the viewers for the VR produce motion sickness, especially for the less experienced. For this reason, the choice to create a scene of settings in which the user can familiarize himself with the tools and communicate any problems in a short time is very useful to test the best training solutions. In future developments, a questionnaire can be used to evaluate the motion sickness during the virtual experience and to better set the walking and focusing parameters of the buttons.

By connecting different users with multiple viewers and platforms, it is possible to control at the same time the reactions that can be generated during the three scenarios. It is also possible to define which of the three moments of danger is the most critical, to the point of not reaching the goal through the wizard. It is possible to collect the number of times the user makes the same mistakes, in order to generate a database useful to modify the procedures and simplify the paths to reach a safe place.

The limits of the research are related to test scenarios on a sample of miscellaneous people, which will be further developed. In general, such training could be interesting to study the approach of different kind of people, with different ages, anxious or not, to unexpected situations that could make people uneasy. In further studies, the psychological processes that emerge during a dangerous situation will be evaluated: for example, the reaction to the situation and the unexpected, the general evaluation of the virtual experience, the behavioral expectations and the reactions influenced by the crowd. The main for this focus was on the overall scenarios, so less attention was payed to the setting of each scene; by testing applications on users further development to improve the efficiency of given instruction will be implemented. Thanks to the opinion of users also technologies involved within this experience are going to be analysed and compared with others, in order to reach the best result in terms of performing.

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