Department of Electrical, Computer and Software Engineering

Part IV Research Project

Literature Review

Seismic preparedness for the general public using virtual reality

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Project Number: 36

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Declaration of Originality

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1st May 2019

Seismic preparedness for the general public using virtual reality

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Abstract

New Zealand experiences a wide range of earthquakes on a regular basis. Despite precautionary drills and documentation on the potential hazards during an earthquake, avoidable casualties still occur. Causes may include bad furniture placement, or the inability to identify the safest refuge spot during an earthquake [1]. Learning drills, reading documents and brochures may not be enough to teach and raise awareness of the hazardous items in ones enviroment. This project will therefore investigate the potential benefits of using new and future virtual reality technology as a learning tool. This report outlines, in detail, why and how using virtual reality will aid learning, past work that has used virtual reality as a learning tool and other past work that has tried to teach and raise awareness of the potential hazards during an earthquake.

1 Introduction

Earthquakes are a natural disaster that, depending on the strength, can cause severe structural damage and cause severe injuries to those who are unaware or uneducated in the procedures of an earthquake[2, 3, 4]. Earthquake preparedness and safety knowledge is essential for everyone to know, especially for counties that experience a large range of earthquakes, such as New Zealand. New Zealand sits in the middle of two tectonic plates called the Australian plate and the Pacific plate, because of this, New Zealand has a lot of small fault lines, one of the major ones being the Alpine fault[4] which runs through the majority of New Zealand's South Island and can be seen from space due to its size. New Zealand is also known for being placed in the southwestern reigon of the Ring of Fire or also known as the circum-Pacific belt. Around 80% of earthquakes occur in this region[5]. This fact further emphasises the need for earthquake preparation lessons that are both retained and immersive to ensure public safety in cases where a high magnitude earthquake was to happen.

Taking past earthquakes such as the 2011 magnitude 6.2 Christchurch earthquake[2] as an example we witness that aside from all the structural damage there are a lot of injuries that could have been avoided if proper anchoring to furniture was put in place. It was researched that around 63% of people overall have not prepared their furniture for anchoring[6]. These results gathered shows that teaching through the use of lectures, reports and videos are not sufficient enough to get the message through. It was also found that people have learnt to value the importance of safety precautions, for example, structural integrity and safety precautions when in the middle of an earthquake[2]. Because of this, most people learn better through experience rather than reading precautionary steps through a guide[7, 8]. Experiencing an earthquake is a very dangerous and daunting experience so it would be very beneficial for people to experience the potential outcomes of an earthquake without the drawback of experiencing the mental trauma and physical wounds associated with it[1].

With new powerful hardware being released constantly developers have been making use of these new hardware to develop tools such as the Oculus Rift, HTC Vive and many other head sets to virtually simulate a scenario that can be simulated to mimic a real life scene such as an office or a room[9]. The use of virtual reality has been rising in popularity due to the everlasting opportunity that it has contributed to the gaming community. However, as well as gaming, virtual reality can be used as a learning tool. As of now, using virtual reality as a learning medium is not common in current schooling settings, but in the cases where it is used as a learning medium it has shown good results, mainly in memory retention and ability to perform tasks taught by the tool[10, 11]. This increase in results can be shown through virtual reality's ability to completely immerse users in a detailed and vivid simulated world that interacts with the user giving them a sense of real experience. Virtual Reality is especially useful in this project due to its ability to simulate the Earthquake environment but also making sure that the user is completely safe and away from the dangers of a real Earthquake.

Earthquakes end up resulting in structural damage, physical injuries and sometimes mental injuries. To help minimise these injuries, this project will primarily be targeting proactive safety which includes aspects like furniture anchoring and potential hazard identification during an earthquake. We try to focus this project on pro activeness rather than re activeness. This is to limit the amount of movement and motion sickness that is associated with Virtual Reality to give the best possible experience attainable. The result of this project will aim to illustrate the potential of Virtual Reality as a learning tool by recording data on these perspectives:

- Effectiveness: the training result from people who trained to identify hazards through our virtual reality tool will be compared to those who trained through a traditional way of identifying hazards such as reading through hazard instructions.

- Confidence: a comparison of people's confidence level of identifying hazard before and after training through our Virtual Reality educational tool.

This literature review will mainly talk about why it is necessary for people to be educated properly when it comes to earthquake preparedness and the benefits that we will see if people are educated in earthquake safety. This report will also talk about the advantages and disadvantages of using Virtual Reality as a medium for learning and previous attempts at using Virtual Reality as a learning tool. This literature review will conclude with an overall discussion of Virtual Reality and its current use as an education tool as well as future work that could be explored.

2 Background

2.1 Earthquakes

Earthquakes are natural phenomena that cause death and destruction, ranging from physiological tremors to structural damage, earthquakes are a significant topic not to be taken lightly. Earthquakes are caused by a sudden slip on a fault line. These fault line slips occur kilometres beneath the Earths surface and the amount of friction and tension prior to this slip determines the intensity of earthquake felt on the surface. The cirum pacific belt also known as the ring of fire is a major area known for housing over 80% of all recorded earthquakes. The cirum Pacific belt lies primarily in the border of the Pacific plate and covers the many countries such as New Zealand, Indonesia and Japan. Most of all the strongest earthquakes are recorded within or near the cirum Pacific belt, all these concerning information emphasises the importance of earthquake preparedness for everyone especially to those living in an area of a high probability of earthquakes. One way of recording the strength of an earthquake sis through the Richter scale. The scale itself is easy to understand but what people fail to realise is that the difference in devastation and strength in between each point of the Richter scale is logarithmic, which denotes that each one-point increase in the scale represents a 10-fold increase in strength of an earthquake.

Disaster preparedness is a constant challenge filled with many hindrances and aversion, this can be further explained with the help of the protection motivation theory. The protection motivation theory states that an individual will adopt protective behaviours and actively attempt to reduce perceived threats based on four factors. These factors include the probability of occurrence, the perceived severity of the threatening attack, the efficacy of the recommended preventive behaviour and the individual's belief in their innate ability to avoid threatening events. This theory has the common theme of the motivation of preparedness comes from experiencing the severity of natural disasters. Such an increase in motivation can be shown in several studies and reports of previous major earthquake disasters.

2.2 Virtual Reality

Virtual Reality is described as a means to simulate a person's physical presence in an immersion and convincing environment [12]. Over the years virtual reality has been evolving in terms in a plethora of ways, some of which include an increase of immersiveness which is a result from technological advances such as headsets like the Oculus Rift or the HTC Vive which project virtual reality in a more in-depth and detailed way which continues to narrow the gap between computer-generated graphics and reality. Virtual reality has also shown a more immersive feel through recent technologies such as the Leap Motion controllers and the Virtual Reality treadmills which introduces a hands-free virtual reality environment. Virtual reality technologies are now more readily available due to the option of using mobile devices as a means of interacting with a virtual environment.

Loftin describes that the main differences seen in visualisations between virtual reality and conventional display technologies can be categorised between immersion, presence, multimodal displays and interaction [13]. Loftin primarily focuses on the idea that virtual reality has the added benefit of further confining the senses to the computer-generated images which causes the user to be more immersed with the virtual environment. This immersion implies "freedom of distractions" which is achievable through confining the user's senses, which in most cases is sight. Presence is defined by Loftin as the quality of the virtualised environment which can be measured by the display fidelity, sensory richness and real-time behaviour. Real-time behaviour can also be related back to the interaction seen in a virtual environment. Interaction refers to the systems ability to respond to interactions with the environment in a realistic and smooth way to keep that sense of immersion. Finally, multimodal displays can be seen as the use of various senses to create a sense of the perceived environment around them. Presently, virtual reality focuses primarily on the visual sense as that is arguably the most depended sense we use but with future hardware developments, the use of other senses may also be available for the use of solidifying the sense of a simulated reality. Similar to Loftin's view of virtual reality Steur defines virtual reality as a means of distorting a user's senses through the aid of a simulated environment [14].

In both cases, virtual reality is collectively defined as the use of a computer-generated imaging to create an immersive and interactive environment in which an individual feels that they have their senses altered to create this simulated environment.

3 Related work

3.1 Earthquake simulations

There have been many implementations on earthquake simulations, an example being Yamashita et al's earthquake simulator which was designed to simulate how certain furniture fell in an earthquake [15]. Yamashita used unique Augmented Reality markers to create an augmented display on the mobile phone to demonstrate how certain objects will react in the case of an earthquake. At the end of Yamashita's experiment, it was observed that the participants made a better improvement in identifying hazardous areas, in addition to the success we also witness little to no progress in the participant's confidence during an earthquake. Such confidence can be applied through feedback through the tool or using serious game concepts to enforce their ability to confidently judge dangerous areas [16].

Yamamoto et al's follows a similar implementation, the major differences being they used a virtual reality environment instead of an augmented reality version. Another major difference is that to activate the earthquake simulation an external physical stimulus is required to calculate the strength of the earthquake [9]. Yamamoto took advantage virtual reality's ability to immerse the user in the earthquake environment, however, one criticism that can be said is that the use of an external stimulus could be preventing the user from learning the behaviour of the environment as they are too distracted from the external stimulus.

Old fashioned earthquake simulations also include earthquake drills that people undertake to practice proper procedures to take during an Earthquake. Ramirez, Simpson and Vásquez all conducted studies to show the effect of these drills [17, 18, 19]. The common findings include the overall effects of the drills prove less than effective for reasons such as individuals already have their own procedures developed by their own families, participants treated the drills as a compulsory exercise with little meaning and that the drills were found to be less cost-efficient. Although drills are necessary to have to know what procedures to take in case of a disaster they provide minimal knowledge of the potential dangers of the environment. In addition to the fact that they are non-immersive adds the lack of focus during these drills.

3.2 Virtual reality as a learning tool

An experiment conducted by White et al focused on determining the effectiveness of using a virtual reality simulator for performing surgery [10]. To evaluate the effectiveness of virtual reality training the patients the participants performed with were asked to fill out a form which lists the number of time they felt levels of pain which was separated to mild, moderate, severe and extreme. It was shown that the patients experienced less discomfort with the virtual reality trained participants, the study also describes the usefulness of simulations which included aspects such as cost efficiency effective training.

Another study revolving around virtual reality is the study done by Huang et al. The study involved participants interacting with two virtual reality applications for the human anatomy and answering a questionnaire that contains their evaluation on the applications [20]. Overall, interaction and imagination were found to be the highlighting feature of virtual reality learning. Having access to a 3 dimensional and interactable view of the human anatomy helped the participants visualise key elements of the body and where they lie relative to the rest of the body rather than using a flat monitor or page to describe the placement of key body parts.

4 Discussion

From all the research papers reviewed in previous sections, it is proven that the use of virtual reality can improve users cognitive abilities. This is mainly done by providing an interactive and immersive environment in which the user is not disturbed by the outside environment and can focus solely on the simulated environment generated. Examples of earthquake simulations have been made before to aid and reduce the number of accidents caused, some of which included drills which simulated the emergency escape. This method does not immerse users enough to treat the drill as an actual threat, this is why realistic simulations are made to prepare users in case of an earthquake.

Previous tools have been developed to aid in earthquake preparedness, however, they did not provide a learning framework which aids and develops the users learning. Previous tools that were gone over focused on the simulating earthquakes, this lead to the simulation focusing on reactivness rather than preparing for earthquakes. This research aims to study the effectiveness of virtual reality in conjunction with serious gaming concepts against ordinary earthquake preparedness tools in terms of identification of hazardous places to be during an earthquake and confidence identifying safe places to be during an earthquake.

5 Conclusion

This literature review identifies the physical damages and emotional distraught caused by earthquakes. Damages caused by earthquakes can be easily averted by having a well-defined learning program that will ultimately reduce the risk of injuries during an earthquake. Procedural memory and retention are both prominent aspects when aiming to improve earthquake preparedness, a perfect learning tool that will help this is virtual reality as it offers an immersive environment that captures the user's attention and utilising their senses to let them witness the effects of an earthquake without any risk of physical harm. A major problem with earthquake drills and simulations was that the users did not have that sense of attentiveness, virtual reality helps break this.

Multiple earthquake simulation tools have been developed to aid in reducing the earthquake disaster toll, many of them have also used virtual reality. The next step to focus on now is to develop a learning framework that will focus on preemptive preparations rather than creating procedures on what to do during an earthquake. And so with this planned research, we aim to help users be better prepared and have the proper confidence if there ever happen to be an earthquake occurring.

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