APPLICATION OF VIRTUAL REALITY IN DISASTER RESPONSE TRAINING

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Abstract—The coming of the Virtual Reality technology opens doors to not only more immersive entertainment, but also possibilities of better training for Disaster Management strategies. The immersive experience the VR brings offers a realistic experience to the wearer, and thus can be used to better prepare a disaster response team, or any individual, and acclimatize them to the situational hazards as compared to other conventional techniques like classroom or instructional learning. Projecting a digital world, VR can be used to simulate any kind of scenario conveniently, and thus cuts down on the costs, monetary and otherwise, of preparations of a mock drill for disaster management training, which are mostly not possible or feasible to recreate either due to being inherently unsafe, regulations-wise disallowed, or incur significant people and assets. Depending on how realistic a simulation is, it also helps bring down the trauma for the responder, thus enabling clearer thought at critical moments for safety of self. VR is already being used in a wide range of practice applications, including flight simulation for pilots, medical preparedness through virtual surgeries and for military training purposes. This project thus reviews this method of training against other conventional methods, and finding the advantages, disadvantages and challenges associated with it. The initial proof of concept is being shown through a fire emergency scenario, and depicting its hazards and mitigation strategies.

Keywords—Virtual Reality; Disaster Management; Real Time; Simulation; Android;

I. INTRODUCTION

In many parts of our increasingly globalized world, phenomena such as poorly designed and handled urban development, ecological deterioration, and inappropriate administration are continuously increasing the levels of disaster risks. Considering the recent trend of both private and private investments tending to not keep in mind the disaster risks, the chances for future losses are tremendous. These include the investment done towards increasing the awareness about disasters as well their mitigation strategies at a micro level. This poses a critical threat to economic development and social welfare, to which a solution lies in making the people more self-reliant and prepared for times of calamities [5].

Educational Institutions have the responsibility of properly conveying strategies one must follow in case of disasters in the most effective manner. Traditionally, safety is taught to trainees through conventional methods of meetings, presentations such as PPT slides, procedure safety books and pamphlets, or online modules that trainees are required to read and answer simple questions to. All of these methods are acceptable for conveying facts, but one has to question their effectiveness. According to Dales research[1] on audio-visual methods in teaching, there are degrees and classifications of learning. Dale presented this to show that learning through audio, visual, and written examples is only a small part of learning. As seen in Figure 1, the greater support is based on direct experiences and use of the learning.

Fig 1. Comparison of Learning Retention Rates of different learning modes (as per National Training Labs, USA)

Virtual reality technology opens doors to multiple opportunities in the field of innovative training and education. A few examples of the technological possibilities include experiencing a virtual surrounding in real time, permitting the learners to interact with and envisage a 3-D representation virtually, boost their understanding of concepts by making or changing the digital simulation, visualizing arbitrary ideas, visualizing correlations between multiple variables in a virtual system dynamically, have the freedom of 3 0 degrees of viewpoints, as well as interact with and visit events or places that are not possible or inaccessible due to time, distance, safety issues, or cost. With such capabilities, in which some are unique to this particular technology, virtual reality offers many educational benefits that if appropriately implemented will bring a positive impact to its application to education.

II. RELATED WORK

A meeting on Challenges of Disaster Management Education was hosted by the Fritz Institute and the Institute for the Study of International Migration of Georgetown University, which was attended by professionals, trainers, MNC delegates, and several non-profit organizations. This meeting gave a chance for experts to study the demand and supply problems in humanitarian training and education. Stating that procedural training for humanitarian organization's agents is a necessity and not a luxury, the practitioners tried to find out the most effective method for training, and the role of these methods in actual practice on field . Similarly, acknowledging the need of training the new era of response agents, the members evaluated the methods by which theoretical teaching could be improved for the benefit of both
individuals and response teams.

Through the discussions, participants recognized primary problems faced by organizations involving in disaster response and management. The issues ranged from inefficient educating and learning systems to raising funds. Within the domain of skill learning, training itself proves to be a major problem because of language barriers, staff handling at larger numbers and members leaving for more lucrative jobs. These problems are even further intensified due to resource deficiency and lack of funding. Most investors in these organizations are found to be hard to be convinced that skill improving programs and organized training are necessary steps for impactful disaster management and response teams. Moreover, there is an increasing lack of both adequate academic material required for disaster education, and enough tutors with a balance of theoretical knowledge and field experience.

In a joint interdepartmental paper[2] by the University of New Mexico, a study was done on 25 students about the Effect of degree of immersion upon learning performance in Virtual Reality simulations. From the test population, volunteers were arbitrarily divided into two sub-groups: one where volunteers wore a Virtual Reality head-mounted screen, and the other where volunteers played the Virtual Reality simulation, that was being displayed to the other group on the head set, on a computer monitor. Both the sub-groups navigated using a game-pad, having control of movement and interacting with objects with buttons. The results implied that from the simulation, both the sub-groups had increased skill and knowledge about the simulation subject given to them, as it was measured by the considerable resemblance to that of experts in the same subject. But among the two, the first sub-group with head mounted displays for the simulation showed a substantially better learning than the second sub-group. This experiment proved that a Virtual Reality simulation has a greatly positive effect in the learning curve of a trainee and an even greater effect when used with a head mounted VR screen as opposed to a monitor screen.

III. PROPOSED DESIGN

The process of gamification has been utilized in this project due to a variety of reasons. Compared to other methods, the elements of a game scenario have been proven to be found more interesting and immersive than other means of simply reading or tutoring. This leads to greater memorization and also adds a factor of intuition learning, thus giving the trainee the closest possible realistic experience, which would greatly help in countering situational trauma at the time of the disaster.

The project is created in form of a game in which the player (referred to hereby on as trainee), wearing the virtual reality device, would assume the role of a person encountering a specific disaster (referred to as character). Upon start, the character would be placed in a generic environment (for this example, an office building), which has been hit by or is going to be hit by an emergency (e.g. fire in office building). The trainee would then be given the freedom to perform certain actions, depending on which it would be determined whether the trainee survives the disaster or not, and if yes, if he/she manages to help any of the other virtual co-victims of the disaster. For instance, in a fire, if the trainee takes an elevator, that can result in a catastrophe.

The scenario also contains some realistically placed interactive objects that the character can use in order to increase chances of survival, while also warning the trainee of some of the common hazards that can be caused due to misinformation. In the fire scenario, this includes various types of fire extinguishers, with instructions on how to operate them and the hazard warning would caution against using water based extinguishers on electrically started fires. Of all the objects visible to the simulation player in the layout, some are interactive to the player, directly affecting or adding to the outcome of the scenario, while most are non-interactive, only adding to the experience of the disaster. While more interactive objects create more variables for the disaster, thus adding realism, it also increases the scope of the simulation by increasing its control difficulty and reducing the intended tutorial to be imparted. The game is based upon actual Safety norms and protocols, so as to increase awareness of the safety procedures through an interactive way. As the current implementation is planned, the scenario will give the player multiple choice of actions at every step, some being based on the safety protocols, and others being common mistakes someone might take either because of trauma or lack of information of the protocols. The trainee virtual character will then face either consequences or fruits of their series of decisions. This imbues a learning into the trainees mind not only about the things they are supposed to do in case of any such disaster, but also about the thingsthey should be careful not to do.
IV. PROCEDURES AND METHODS

The simulation has been developed through Unreal Engine 4, which is an open source game engine allowing for integrated gameplay design, programming as well as modelling and texturing. The engine allows C++ based programming, which makes it convenient to make class based object in-game and design an environment that have different properties but can still inherit some common ones. For instance, in the scenario, a variety of objects in the world can dynamically catch fire if close to a flame, but can be completely different, from being a table to a cloth.

A. Layout Design

For the first scenario, a generic office building is depicted. The architectural layout plan of several office spaces was reviewed to identify the key elements present in most of them, for instance elevators, meeting rooms with furniture, lobbies, fire exits etc. in order to replicate a relatable layout. Universal signs and symbols are used in the simulation as guiding references, including symbolic instructions like those of fire exits and on fire extinguishers. This helps in symbol acquaintance and helps cross the language barrier.

The office floor is designed using Unreal Editor itself, which allows transforming static meshes into desirable structures with materials. To make the layout more identifiable from its basic structure, items like lamps, furniture etc are added to the rooms. Some of these items are interactive in multiple ways. This includes potentially flammable furniture to fire extinguisher canisters used to douse specific spots of fire to escape.

B. Character Controller

Inside the simulation, the trainee can view in a first person mode, i.e. projection through the characters sights. The character movement is carried out by a controller connected to the android device via Bluetooth. The movement includes forward, backward, left and right, with one action button to crouch and another to interact with surrounding intractable objects like fire extinguisher. The simulation also implements head tracking, i.e. the view visible to the trainee would change depending on where he/she turns the head, based on the android devices in-built gyro sensor.

C. Interactive Elements

1) Flammable Objects: In order to make the simulation more realistic, the environment changes over time of the simulation, and the trainee has to either adapt to it or avoid it. In the first case, the environment catches fire over a period. All flammable objects are managed under a common class with similar properties. For every object, the properties include the range of catching fire, its flammability and its visual asset. The visual asset determines the appearance of the asset, and could be assigned anything from a chair to curtains. The range tells the maximum distance another object can be at in order to catch fire from this object's flames, while the flammability determines the rate at which an object catches fire when in range of another object. The propagation of fire is governed by the following algorithm:

```c
void Burn()
{
    this.onFire = true;
    fireIntensity = 0;
    Object _array[] = getAllObjectsInRangeOf(this);
    for each (Object obj in _array)
    {
        obj.Burn();
    }
    do
    {
        fireIntensity<- fireIntensity + Flammability;
        Flammability--;
    }while(this.fireIntensity!= 0)
}
```
2) **Extinguisher:** Due to the safety protocol, most buildings have various kinds of fire extinguishers, namely Type A, B, C, D, and E, installed within them. The simulation tries to include most of them while communicating their application by showing each one's use. The extinguishers types are made within a singular class from which the types derive from. The common properties include type-tag and visual asset in order to physically distinguish between them. The other functions are type based, to be able to get different results from using different extinguishers in the same condition.

3) **Elevators:** Even if it is common knowledge that elevators are not to be used in case of fire, the simulation implements these to reinforce the point. The elevator in the simulation is part of the interactive environment. The elevator can be called on floor and be boarded, but its danger is depicted along with the visual cues of the smoke in the elevator shaft, thus showing possibilities of suffocation. The sequence proceeds to halt the lift and increase smoke in the shaft if the lift is boarded, after which the trainee has to replay the simulation from a previous checkpoint.

V. CONCLUSION

Virtual reality is a new field that is being actively explored and researched with. In many fields, there has been experimentation and implementation with training using virtual reality. Training in safety is only growing as humans continue to interact and evolve with the world. Similarly, while virtual reality is new, it is not a passing technology and it is here to stay. It has been used in a variety of fields and its role and importance in safety training cannot be denied. Safety training using virtual reality software proposes an entire new field of study where humans can be trained using an inexpensive and effective method. The possibilities are endless when it comes to safety training using virtual reality software.

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**REFERENCES**


