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Enhancing Lifeguard Training through Virtual Reality

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Abstract

According to the CDC, over three thousand people die every year from drowning in the United States. Many of these fatalities are preventable with properly trained lifeguards. Traditional lifeguard training relies on videos and mock rescues. While these methods are important, they have their shortcomings. Videos are static and do not build muscle memory. Mock rescues are labor-intensive and potentially put others in danger. Virtual reality (VR) can be used as an alternative training tool, building muscle memory in a fully controlled and safe environment. With full control over variables such as weather, population, and other distractions, lifeguards can be better equipped to respond to any situation. The single most important aspect of life guarding is finding the victim. This head rotation skill can be practiced and perfected in VR before guards ever get onto the stand. It also allows guards to practice in uncommon but nevertheless dangerous conditions such as fog and large crowds. VR also allows the user to get immediate feedback about performance and where they can improve.

Introduction

In the United States drowning is a major problem, with more than three thousand reported cases, lifeguards hold a high importance for the safety of people in swimming pools and beaches. Training needs to be effective and as a lifeguard, important tasks that require mastery include scanning the waters, identifying someone in distress, and being able to adequately respond to emergency situations. Currently, for the purpose of training, lifeguards use a classroom-based learning style which includes lectures, test, some hands-on practice, and various cheat sheets and reference material to increase their understanding [1].

They are presented with terminology, lectures, and when applicable videos. There is, in some cases, the availability of demonstrations to assist with learning and visualizing a search and rescue. When a lifeguard training decides if a person lives or dies, it is important that the lifeguard receives the most effective training possible.

Knowing the skills needed to be a productive lifeguard is only half the battle, these skills need to be applied training method to improve the training's effectiveness. Effective training would include actual hands on rescues so that the lifeguard can gain a better understanding of the tasks, which means that someone would need to be drowning. Due to the fact that it is dangerous and extremely unethical to purposely drown a person for training purposes, using rescue mannequins for dummies could be possible. However, although dummies are useful, they only provide training to a certain extent. The only way to gain hands on rescue experience would be working a shift, however that is also dangerous and unethical due to the fact that a poorly trained lifeguard is responsible for the lives of the people in the water. If an emergency were to arise, there is no way to know if the lifeguard would know what to do in the situation seeing as though they had never done it before. Some could argue that a mix between trained and new lifeguards would solve this problem, but having an expert watch over a novice lifeguard would only cause more distractions.

This research is meant to enhance the current training practices by creating opportunity for muscle memory and allowing for training in various conditions. For one, the task allows for complete control of the training environment, the user can train in various weather conditions, different times of day, or different types of waters. The ability to manipulate certain conditions allows for directed and effective training. Secondly, the process of completing the task in a repetitive manner allows the trainee to gain muscle memory. The user is able to do the task an infinite amount of times with many different conditions until the user is effectively trained. Aside from the repeatability, the task also utilizes a metaphor for swimming. The metaphor is translated through a grab and pull motion that is synonymous swimming.

In other words, lifeguards hold a high importance to society, and because of that should receive the best training possible. Current practices are not negligent but hinder the lifeguard from reaching his or her maximum potential. This research intends to add to current resources and techniques and increase the total effectiveness to lifeguard training. With the ability to manipulate everything in the task, its repeatability, and the fact that it breaks no ethics, this task can largely impact current training methods.

Background

The background will cover current lifeguard training procedures, how virtual reality (VR) can augment current procedures, and navigational techniques in VR to simulate real navigation.

Lifeguard training

Lifeguarding is the act of overseeing others with the purpose to ensure the safety of those who swim in the water and are around the water. In order to become a lifeguard, one must attend classes and get certified. The American Red Cross offers classes and lifeguard certification [1]. Even before one can participate in lifeguarding classes for certification, students must be at least 15 years old and be able to complete a rigorous swimming test. Although lifeguards must attend classes and get certified before beginning to work, in 2018, 23 drowning fatalities occurred with a lifeguard present by statistics from the United States Lifesaving Association (USLA) [2]. Since this only accounts for USLA affiliated lifeguards, this number may be larger. Lifeguards are also needed at neighborhood pools, water parks, and other swimming locations.

Multiple studies have been conducted to determine the quality of the training lifeguards receive. In a study conducted by Jeff Ellis & Associates using a submerged mannequin to test lifeguard response times, results found that it typically took one minute and 14 seconds for lifeguards to recognize the submerged mannequin. Recognizing a submerged mannequin within 10 seconds only occurred 9% of the time [3]. Based on the 10/20 Second Protection Rule, also known as the 10/20 lifeguarding rule, this data is not promising. The 10/20 rule states it should take 10 seconds for a lifeguard to recognize a victim in need and 20 seconds to retrieve and recover the victim for resuscitation [4]. A study by Lanagan-Leitzel L. and Moore C. examined the differences between lifeguards and non-lifeguards in the quality of surveillance. Surveillance quality between lifeguards and non-lifeguards was almost equal [5]. The study results indicate that surveillance and recognition of drowning training is not fully comprehensive. More work should be done to improve the recognition of important to monitor events. Another study, conducted by the International Life Saving Federation, also concluded that lifeguards have trouble recognizing a submerged victim [6].

The research conducted on lifeguards conveys a need to improve lifeguard training. Placing lifeguards on duty who are unprepared to notice and react quickly to signs of distress does not bode well for guests at any pool or beach.

Virtual Reality Training

While the most common way to teach a group is in a classroom, individualized training is hard to achieve. Learners who cannot keep up with the pace of the class or fail to grasp minute details of a lecture may result in poor lifeguarding later on. Virtual Reality (VR) has the ability to teach at a pace and in a way that adapts to the learner's abilities. In a review of VR in education and training, the review determined multiple situations which could benefit from utilizing head mounted displays (HMDs) to learn various skills. The various skills mentioned in the review include remembering and understanding visual information, visual scanning, and emotional response handling [7]. For example, VR has been used in CPR training. VR has augmented CPR training compared to using a physical mannequin, because the VR tool increased presence with effective feedback regarding a user's performance. Users from the study responded positively to the use of VR for CPR training [8]. With respect to firefighting training, VR has been implemented to better prepare firefighters for real life scenarios. When combining haptics with VR, jet reaction forces can be recreated without having to utilize real water. To ensure presence in the VR training, physics modeling was implemented to realistically create water dispersion and accurate interactions with fire and smoke particles [9]. Another reason VR can be utilized is due to its ability to simulate uncommon, dangerous, or expensive scenarios. As seen through a VR simulated emergency evacuation of a nightclub disaster. In the real world, to test the performance of evacuations, people and practiced disasters must be created. This is costly with possible liabilities which could result in legal repercussions. This challenge is solved through VR which can model a real disaster without harm to any current infrastructure, people, or bystanders. The VR simulation was used to further comprehend human behavior in response to disasters [10]. This also reduces cost and time, since the simulation can simply be reset rather than having to physically recreate an entire situation.

As presented through various studies, VR has the time and patience to dedicate to the learner. Real and uncommon scenarios can be simulated, and the learner can retry the exercise until muscle memory has been ingrained.

Navigation Techniques

Swimming is a key aspect to be a lifeguard. One must be able to demonstrate their strong swimming abilities before they can begin learning. In training to become a lifeguard, learners get a few opportunities to apply their training in carefully contrived scenarios. This enables them to get an idea of what a real-life rescue would feel like. VR does not require users to maneuver in the same way swimming navigation works. However, in order to simulate a real scenario, VR should expect the user to act and move the same way a real-life response would look like. To navigate through a virtual environment (VE), physical bounds of a room usually restrict a user from physically moving through an entire virtual environment. Therefore, physically moving within an environment is impractical. Research into ways to increase presence while navigating in a VE has led to the development of various modes of navigation.

One study compared physically walking to physically rotating and translating within a VE. Participants were tasked with navigating through the VE until eight targets were located. While physically walking is the ideal mode of transportation in a VE, participants engaging in full body rotations paired with translation to a desired location performed almost equally as well [11]. Another study compared gaze-directed translation to a pointing method. The pointing method consisted of users standing still while using a virtual cursor to point and rotate before translating to their desired location. Given the starting and ending locations, participants had to navigate to the end location. The results of the study found that participants performed better with the pointing method. Participants using the pointing method navigated to the end location faster with greater accuracy [12]. Based on the differing results of these studies, both methods for land navigation are being used discretionarily.

Multiple studies have attempted to combine various technologies to create immersive VR swimming. For example, one study created a suspended harness apparatus which users could strap into to experience virtual swimming [13]. Another studied proposed a motion platform for the user to lay on. This apparatus was used to simulate a SCUBA diving experience [14]. Both examples require complex machinery and only allow for swimming applications. In lifeguarding, lifeguards work on both the land and water. An example where users are not harnessed in was through a creation of a virtual aquarium. Sensors located on the head and hands were used in conjunction with a motion tracker to determine movement in the aquarium. Different movements were then calculated using physics to replicate the motions completed in real life swimming [15]. These examples prove the complexity of navigation in VR. With respect to VR swimming, a cheap, nonrestrictive method has not been created.

Methodology

The methodology section describes work required to build the lifeguarding VR application, as well as the hardware and software tools used. A VR simulation application was developed to teach multiple facets of lifeguarding in varying conditions. The training simulation focuses on head rotation mechanics and rescue strategy. The first task objective of the simulation is finding the victim in distress among other non-drowning patrons. Once found, the participant highlights the victim with a ray-like pointer. Once tagged, the participant must navigate to the victim using two types of locomotion (running and swimming). When the participant tags the victim, the simulation is complete and a text box with appears containing feedback about path and search efficiency.

Figure 1: Ray-like pointer used for tagging victim in distress

Implementation

The lifeguarding application was built using the Unity game engine. Various elements were implemented to make the simulation as realistic and effective as possible. The simulation was run on a HTC Vive, a computer driven HMD. This platform was used due to its low cost and relatively high resolution. This HMD is capable of 1080x1200 resolution and a 110-degree field of view. This device uses a lighthouse tracking system in conjunction with other sensors to update the displays relative to the user's head orientation and location.

Figure 2: Various distractions on the beach and in the water

Figure 3: The weather can be changed to make conditions more difficult

Lifeguards must have experience in all conditions. Before the simulation is run, the user sets two environment variables, the population and the weather. The application automatically spawns avatars in the water and on land in random locations around the beach. Virtual patrons are complete with animations based on their location in the environment. Before each patron is created, the location is checked to make sure it is clear and the patron will not overlap with another object or person. After a random time interval, one of the patrons in the water will begin a drowning animation. Guided by transparent instructions, the participant must find the victim as fast and possible and tag them with a ray-like pointer. A telescope feature was also implemented to help locate victims that are farther away. Once tagged, a yellow beam will appear above the victim until they are saved.

Figure 4: The participant must swim to the tagged victim

Once the victim has been located, the participant must navigate to the victim's location. Locomotion over land is done using the touchpad on the Vive controller. To simulate swimming the application uses a climbing mechanic as a metaphor for swimming. If the players controller is under the water and the trigger is pulled, then the location of the player in the game moves in the opposite direction of the controller. This allows the player to pull themselves through the water and simulated the front crawl or freestyle stroke, used by all lifeguards. This mechanism is also relatively slower than the land navigation, so players move faster over land that through water. The simulation ends when the participant gets to the victim. The participant is then provided feedback about their path efficiency. A common error for new guards is entering the water too early and swimming a diagonal path to the victim. The fastest way to the victim is always swimming the shortest distance, that means making a right angle turn into the water. The feedback feature will tell the participant if they need to improve their navigation path.

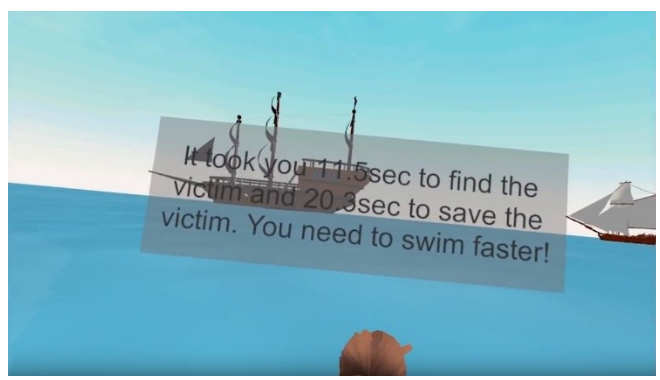

Figure 5: Feedback presented when the simulation is complete

Discussion

Under the current simulation's constraints, the method of evaluating a participant's efficiency of the search and approach tasks were based on the time taken to complete them. The evaluation metrics consisted of three thresholds: too slow, acceptable/average, and fast. Each tasks' completion time, determined which of three thresholds the performance fell in. Each task was evaluated independently, and at the end of the simulation, there was one final evaluation which took into account the completion times of both tasks and gauged the overall performance.

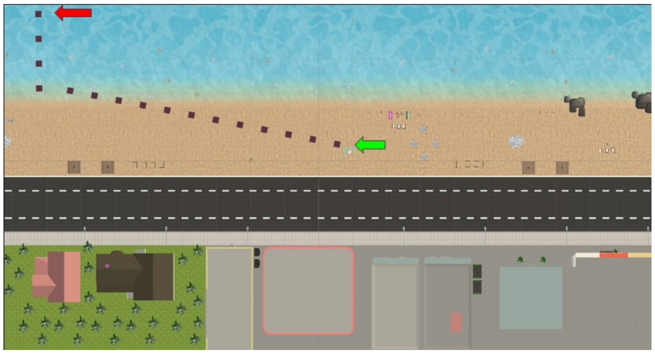

Figure 6: The optimum path to a victim

The visual search task's purpose was to practice head rotation and victim-identifying skills. Since the time and location in which a patron began the drowning animation was random, the participant could not grow accustomed to the animation's timing, regardless of the number of attempts they took, thus, reinforcing the practice of constantly keeping watch over their assigned area. Another aspect of the visual search task was that the population of patrons and their locations varied in each iteration of the experiment, giving the ability to change the difficulty of the simulation. Because every lifeguarding watch is different, this unpredictability of real-life scenarios was one facet emulated in this project.

Table 1: Comparison of training modes

Comparison of Effectiveness in Various Training Methods

Training Capabilities	Textbook/ Lecture Learning	Demonstrations and Videos	Mock rescue	Virtual Reality Task
Learn formal terminology and etiquette	✔	✔	✔	✔
Visualize a rescue		✔	✔	✔
Gain muscle memory through action			✔	✔
Receive personalized and targeted feedback			✔	✔
Fully repeatable training scenarios				✔
Control over the environment and distractors				✔

The approach task measured the lifeguard's approach to reaching the victim. Since it is faster to navigate on land than in water, navigating the most amount of time navigating on land and then swimming the shortest distance possible to the victim results in maximum efficiency and lowest navigation time. As a result, the evaluation of the Approach Task was divided into two subtasks: land navigation and water navigation. Each subtask's evaluation was also subjected to a three-threshold gauge. Considering that the navigation speeds in water and on land differ, the thresholds for each subtask were established in accordance with times estimated believed to be acceptable. As a result, the times taken to complete each subtask gave a rough estimate of the navigation route taken and in which form of navigation the participant could improve in.

Conclusion

According to the CDC, over three thousand people die every year from drowning in the United States, many of which are preventable with properly trained lifeguards. However, because traditional lifeguard training relies on videos and mock rescues, the numerous shortcomings and limitations limit the lifeguard from being as trained as possible. This VR Lifeguarding Simulation helps overcome some of these limitations. By having full control over weather, population, and drowning transformation time, lifeguards receive the opportunity to practice their head rotation, scanning, and approach skills before guards get onto the stand. Our VR lifeguard Simulation even includes an evaluation system which also allows the user to get immediate feedback about performance and where they can improve.

In the end, this project opens up a new frontier in lifeguard training. After conducting considerable background research, there is not much work on the use of virtual reality for lifeguard training. However, the results of research done on using VR to train specific skills as well as research on navigation techniques is clear: it is effective to use VR for training. Therefore, it is effective to use VR in training lifeguards, see Table 1.

However, it is clear that the results of research done on using VR to train specific skills and on navigation techniques show that it is effective to use VR for training. Therefore, it should be effective to use VR to train lifeguards.

Future Work

There are upgrades that can be made to improve the simulation project. For example, such as establishing a counter to keep track of the number of times the participant missed spotting the victim while they were in their field of view. Currently, while measuring the time it took for the participant to identify the victim, there is no way of tracking if they overlooked the victim in the process. A big part of watching process in lifeguarding is being able to identify from first glance if someone is in need of help. Therefore, there is a need to track the number of times a lifeguard overlook the victim in order to heighten their sense of awareness, while naturally reducing scanning time.

Another task to improve is to increase the variety of animations for the victim. It is imperative that we have a wider set of animations in order to cover the most common gestures people do when they are drowning. It is by developing an awareness of these gestures that lifeguards become better more familiarized with what to look for when they get on the stand. Any increase in simulation fidelity would be beneficial to the training outcomes.

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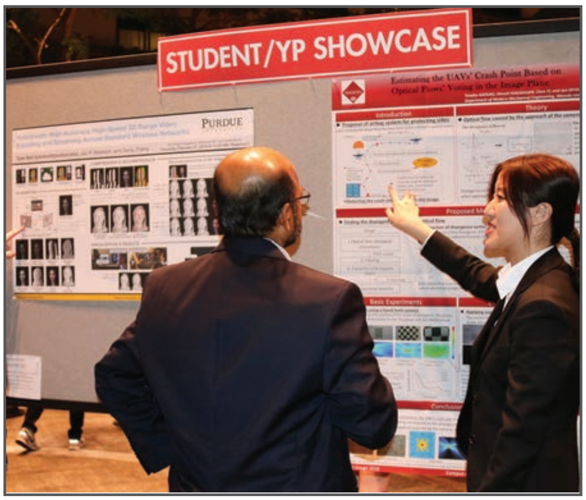
STUDENT/YP SHOWCASE
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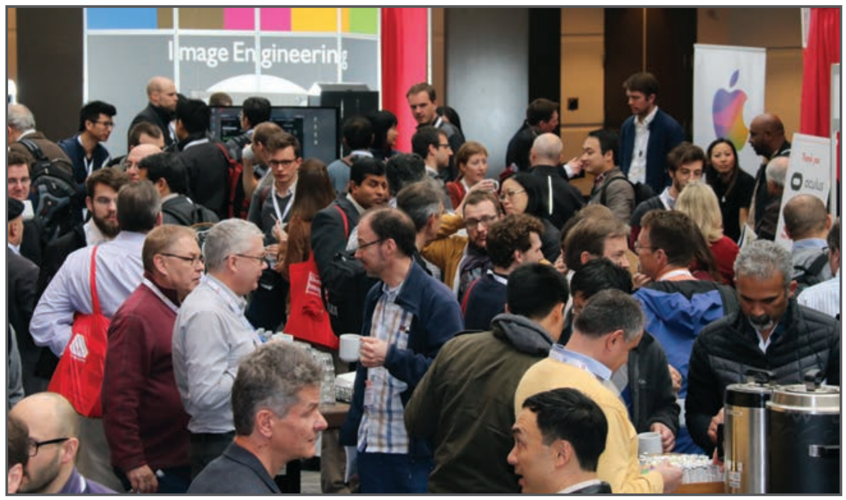


AR is a fundamental and transformative interface and platform.
20+ years from my initial working demo to today's AR displays
Optimistic that it won't take another 20 to reach ubiquitous consumer AR!
My first working AR prototype
Today's platforms
Ubiquitous consumer AR