Virtual Reality Firearm Safety Field Day: Training Experience

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ABSTRACT

Virtual Reality (VR) in recent years has progressed extensively to include educational and training applications where it has proved to be a valuable mode of conveyance of information in the respective field. Some of these fields often include safety training in hazardous environments which require the participants to go through risky experiences where there can be no accommodation for a margin of error. Virtual Reality (VR) eliminates this issue by providing the participants with a virtual environment free from the repercussions of errors. It also allows the user to redo the whole training upon failure which might be close to impossible in a real-world scenario. In this paper, we choose a field of non-military cadet safety training to establish the effectiveness of such VR implementation in place of an actual in-person Firearm Safety Field Day. We mainly explore the handling of firearms in VR during a training scenario using VR controllers and Hand Tracking in VR. This mainly involves the user being able to learn to control firearm handling through controller input-based hand tracking as well as be guided through the dos and don't of the experience. The program also includes an instructor that guides the user throughout the training duration along with periodic responses to errors and final feedback on the user's performance.

CCS CONCEPTS

• Human-Computer Interaction (HCI) → Virtual Reality • User Studies • Interaction Techniques

KEYWORDS

Training, Interactive Virtual Environments, Firearm Safety, VR Education, Virtual Reality

1 INTRODUCTION

With advancements in technology, certification courses have been made more accessible today through online options, alongside this, Virtual Reality training simulations have been more widely deployed and accepted. In some online options for these certification courses, the student is deprived of an immersive/in-field experience which can lead to accidents in the field when the time comes to perform what they have learned. One such example of this is accidents related to firearm misuse, particularly during recreational hunting. [5] A study conducted at a trauma center located in the Rural Midwestern United States captured a proportion of firearm-related injuries that occur in the U.S. The study found that of the three main causes of firearm injuries, the majority were accidental (36%). The study also found that hunting incidents made up 26% of these accidents.

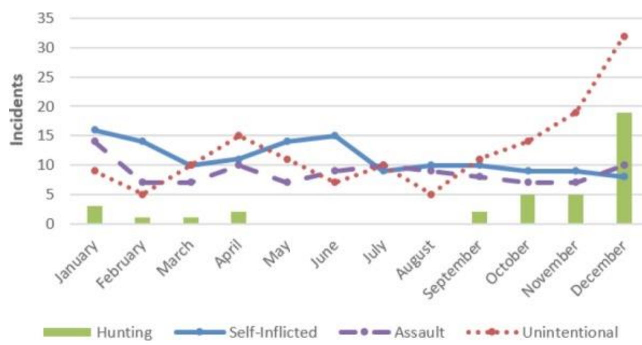

Figure 1: Seasonal variation based on mechanism of injury. [5]

The result of the study stresses the importance of practicing proper firearm safety and the main way of doing so is by completing a Firearm Safety course. One of the requirements to receive a Firearm Safety certification during the Firearm Safety course is a field day where the students get hands-on practice with an actual firearm. Throughout this experience, students learn and perform proper firearm handling techniques for both stationary use and transportation. In some online options for this course, this experience is shown through one single educational video. Through Virtual Reality (VR) we can restore the interactiveness of the Firearm Safety Field Day experience and put the student in situations that feel like they have consequences to gain a greater level of immersion than one would from a video, all while observing and assessing their performance.

2 RELATED WORK

In order to gain insight into the field of safety training in VR, we analyzed a few related studies which implemented the same in different fields of application and occupations.

Certain studies have initiated such an implementation of virtual reality and tested the effectiveness of such training programs. [3] One such study includes the application of virtual reality in construction safety training. The paper addresses for design and development of VR modules for safety training in the roofing sector. Firstly, the paper introduces a sufficient number of statistics to support the increased amount of work-related injuries and fatalities in the construction industry and expands on the same by looking into similar literature reviews. This study was sponsored by an external organization, whose methodology included the usage of an Oculus Quest 2 to test the design and development of 10 different sections consisting of ladder-related tasks based on the data model that was created. The study consisted of test subjects whose results were based on the implementation and judgment as well as user feedback on the spot for each task at hand. The range of participants' demographics pause between the topmost position of the company as well as up to a regular office engineer it's about 93% male and 7% female individuals. One of the main questions which were asked the participants was to agree or disagree that "virtual reality is highly applicable to the workforce training in the roofing sector". [3] The majority of participants (55% agreement, 37% neutral, and 8% disagreement) showed positive perceptions toward the effectiveness of VR for new-generation training. The study also provided a sufficient amount of analytics and data on the different impacts, factors, and causes of accidents in the sector.

Figure 2: The perceived main cause of accidents. [3]

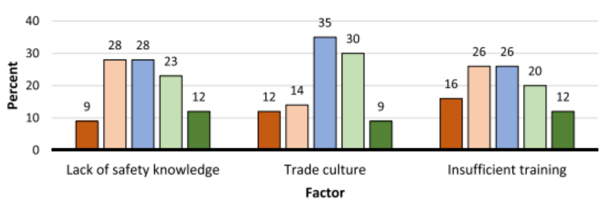

Figure 3: Impact of factors on accidents. [3]

The study also mentions that according to the safety-related section's questions, the data indicated start majority of the companies tend to require at least 16 hours of training for new employees which also indicated the heightened importance of safety training and through this study organizations would be able to fill in the gaps of lack of knowledge and effective training in their respective sectors or fields.

[4] Another similar study looks at the safety training in high-risk engineering industries operating potentially hazardous processes, such as
those found in the petrochemical, construction, and nuclear sectors. This study was basically a literature review of about 45 different articles and studies published in these different engineering-related areas which mainly compared the frequency of usage of VR in two different training evaluations in their respective studies based on *Kirkpatrick's model*. This allowed the authors of the review to establish certain levels of training outcome and the respective method of VR training implementation based on the digital assessment being made on the requirements. Thus, overall the review was able to assess the application of VR-based training applications for various industries in engineering but also proceeded to introduce the fact that various other industries such as the medical and military also use VR-based technologies for safety training purposes.

All in all, since we can see that the application of VR and safety training proves to be a valuable asset in the field of training and education for companies as well as individuals who participate in the program, we tend to shift our focus to the implementation of safety training towards a non-military cadet training program which happens to be a grey area of application of VR safety training.

3 APPLICATION

When planning the main components of our Virtual Reality Firearm Safety Field Day we acknowledged the various factors of a real-life firearm safety field day that could be tracked and recreated in a virtual environment. These factors were mostly physical movements that a real-life instructor would perform for the students and then instruct the students to recreate. We kept these factors in mind while designing an immersive virtual environment and developing an instructor feedback system based on the user's actions collected from their inputs such as hand tracking via the Meta Quest's Touch Controllers or other inputs from the controller. In the aim to develop an immersive and interactive training experience we also placed the user in scenarios to assess the knowledge, they retained throughout the course to use in a final assessment and summary of their performance.

3.1 Virtual Environment

One of the most important factors in creating an immersive experience is the virtual environment that the user will be placed in. While creating our virtual environment we kept in mind the objects and structures that one would find at a real firearm safety field day. While designing the virtual environment to be immersive we also considered the functionality of the map. We planned out appropriate player pathing so the user could smoothly flow through the environment by knowing exactly where to go after completing each component.

Figure 4: Image of the virtual environment

3.2 Virtual Instruction

A firearm field day needs an instructor to teach the students throughout the training experience. In a real-life firearm field day, the instructor would serve the purpose of physically demonstrating proper firearm handling techniques while reiterating the firearm safety knowledge learned in the classroom. To serve both immersion and functionality reasons we inserted an animated virtual instructor into our virtual environment. Although we ran into limitations with the implementation of the virtual instructor. One such limitation was the absence of speech; we chose not to provide any voice acting for the instructor and instead opted to convey the instructor's teachings through the use of "message bubbles" that prompted the user to press the "A" button on their controller after reading to continue. Another limitation we encountered was the provided animations for the free asset we used as our instructor. Since we did not have the animations to use the instructor for physical demonstrations, we chose to insert picture boards of various informative pics of firearm safety that the user could observe while reading the instructor's messages.

Figure 5: Image of message bubble, virtual instructor, and picture board (in order from left to right)

3.3 Applying hand tracking

The most important component of our Virtual Reality Firearm safety field day is user interaction. In our application, we used the tracking information provided to us by the Meta Quest's Touch Controllers to track the user's hand positioning for various lessons in firearm safety. One such lesson in firearm safety that we applied hand tracking to as trigger discipline. Trigger discipline is the practice of keeping your finger off the trigger and out of the trigger guard when you are not shooting. We used the Touch Controller's gesture tracking capabilities to know when the user has their finger on the trigger of the controller and, in our application, the trigger of the gun **(6)**. We recorded the number of times this occurred to report back to the user at the end trial performance assessment. Another lesson in firearm safety that we used hand tracking for was practicing the various firearm carries. In the field, there are certain carries that a hunter performs based on their surroundings. In our application, we created regions at positions relative to the virtual camera rig to detect where the gun was pointing to determine what type of carry the user was performing **(7)**. We used this information to assess if the user was performing the correct carry based on the position of another hunter (the virtual instructor). The last lesson we applied hand tracking to was muzzle control. In firearm safety, it is crucial that you control where the muzzle of the firearm is pointing. The rule to follow is never to point the gun at something you don't intend on shooting. In our virtual environment, we calculated a vector projecting out the muzzle of the gun to detect its collision with another person (the virtual instructor). When a collision occurred, we played an animation on the instructor to cue the user that he is aware of it. We recorded the number of vector collisions with the instructor to report back to the user at the end trial performance assessment.

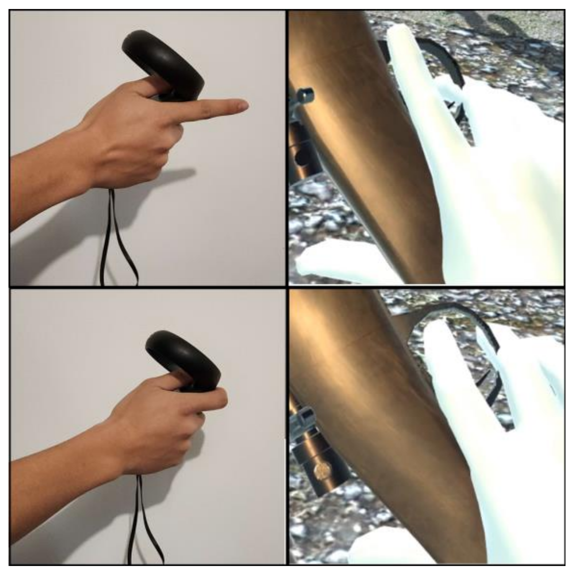

Figure 6: Image of gesture tracking for trigger discipline

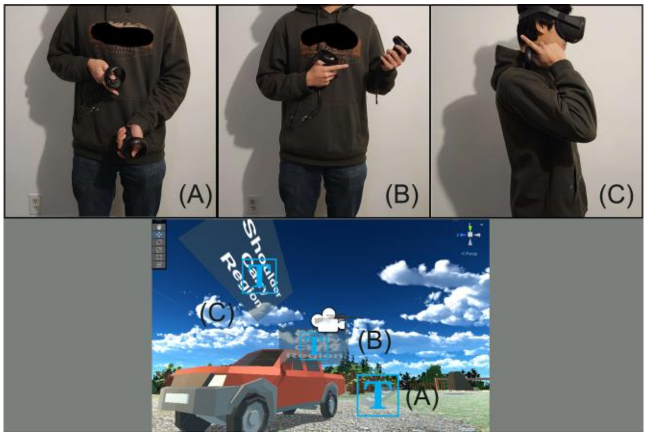

Figure 7: Image of Trail Carry, Ready Carry, and Shoulder Carry controller positioning (in order from left to right) and their regions relative to the camera rig

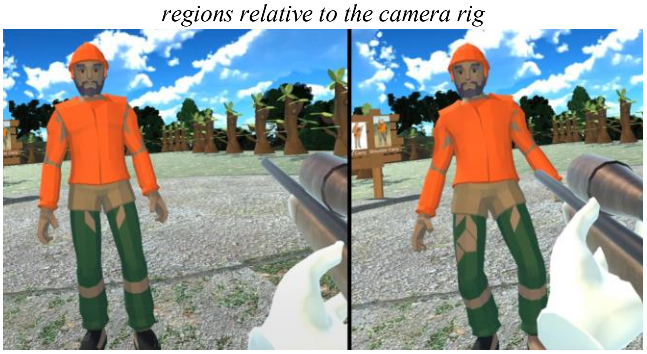

Figure 8: Image of instructor idle animation (left) and animation reacting to a muzzle sweep

3.3 Applying other inputs from the controller

Another way we allowed user interaction was through the other inputs from the controller such as buttons, joysticks, and triggers. The primary use of the joysticks in our application was for navigation through the virtual environment. The joystick on the left Touch Controller was used to move the user around the virtual environment while the right joystick was used for rotation. In our application, we chose to implement smooth turning rather than snap turning for a more immersive experience and to give the user more precision. The primary use of the buttons on the Touch Controller in our application was to progress through the training experience by dismissing message bubbles with the "A" button. The other use of a button in our application was the "X" button. For one of our field day components, the user is instructed to check if their firearm is unloaded before crossing an obstruction in their path. Due to limitations in modeling and animating skillsets we could not implement a more immersive way of checking if the firearm was loaded. We remedied this with a simple press of the "X" button before crossing an obstruction in the path.

Figure 9: Image of obstruction in the path

The most important of the other inputs from the controller that we used was the index trigger on the right Touch Controller. To keep with the immersion of our virtual reality training experience, the right trigger controlled the trigger of our firearm in the virtual environment. Since this is a safety training experience, we did not allow the user to fire the gun at any moment of their choosing throughout the course but keeping with the traditions of in-real-life firearm safety field days there was a point in the course when the user is allowed to shoot.

3.4 Shot scenarios for right index trigger input

The last interactive component of the firearm field day that the user is assessed on is the shoot scenarios component. In real-life firearm safety field days, the students practice firing live ammunition at targets. During this, they are assessed on the firearm safety practices they are performing. Another component of the real-life field day is the review of safe and unsafe shot scenarios where the instructor presents a scenario and describes why it is safe or unsafe to shoot. In our Virtual Reality Firearm Safety Field Day: Training Experience the user is actually put in these safe or unsafe shot scenarios with a firearm in their hand and the choice to shoot or not. In virtual reality, the user can get a better view of their surroundings and can feel the possible consequences of their eventual actions. Our safe or unsafe shot scenarios provide an environment for learning free from the repercussions of the user's actions. The user is placed in four different shooting scenarios that are either safe or unsafe and they must choose to shoot by squeezing the index trigger on the right Touch Controller, mimicking the action of a real gun, or choose to pass by performing a trail carry as they practiced earlier. The results of these safe or unsafe shot scenarios are reported to the user at the end trial performance summary.

Figure 10: Image of the first safe or unsafe shot scenario (unsafe)

Figure 11: Image of the second safe or unsafe shot scenario (safe)

Figure 12: Image of the third safe or unsafe shot scenario (unsafe)

Figure 13: Image of the final safe or unsafe shot scenario (safe)

3.5 Feedback and end performance summary

Throughout the course, the user's actions and practice of safe firearm handling techniques were recorded to determine the feedback the instructor provides in between course components. The feedback is meant to be informative and to correct unsafe practices immediately.

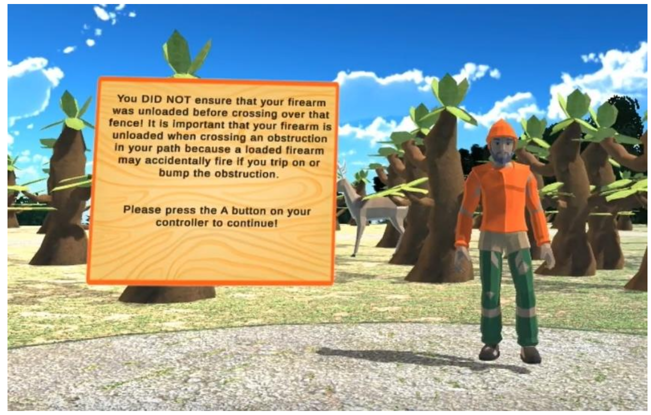

Figure 14: Image of instructor feedback after obstruction in path component of field day course

The same actions are used at the end of the trial when the instructor gives a performance summary and a final assessment of the user based on the user's performance throughout the course. If there are a concerning number of unsafe actions that the user made the instructor recommends retaking the course.

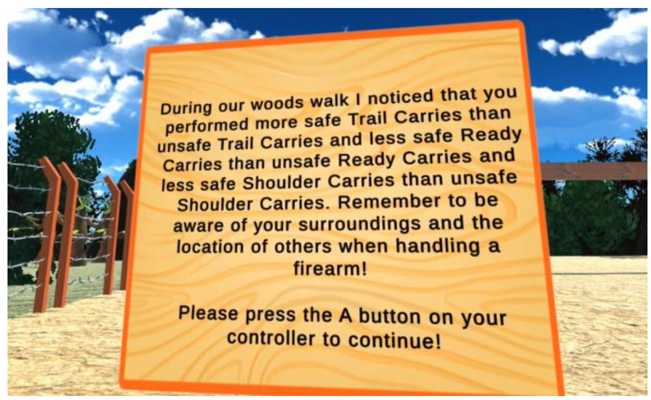

Figure 15: Image of performance summary of woods walk component of field day course

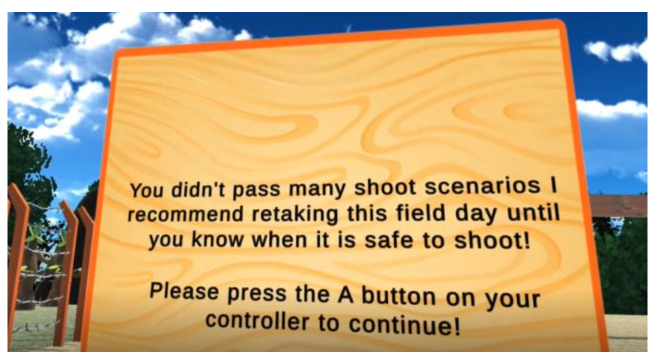

Figure 16: Image of performance summary of shoot scenarios component of field day course; recommendation to retake the course

4 CONCLUSION

In accordance with the user's experience during the Firearms Safety Training Program, the feedback given to the user and indications of marginal errors that were detected by the program during the training were sufficient to prove that the effectiveness of a VR-based safety training program is almost as effective as if not equal to the effectiveness of an in-person training program providing the user with the opportunity to combat marginal error that could only be one-takes if they were done in-person.

The future can hold a wide range of applications of safety training as it proves to be a crucial part of the field of training and with the support of such VR technologies, it will be much more easier and efficient to implement VR-based safety training programs which can offset the risk of injuries and damages that are probable to occur in real-time. Our implementation involves the use of a simple bolt-action rifle as a constant standard firearm. This can be extended to detect multiple similar firearms based on a more active grip system, allowing the program to detect different variations of firearms and alter the logistics of the training program accordingly. Similarly, an inactive firearm can also be analyzed by the program based on whether it is in the user's hands or not and checked for circumstances such as if the firearm is loaded or not, if it is available for pick up by the user based on their rank or not and so on.

One of the major limitations of such an application of safety training in VR would again be the realism that is associated with the experience as even though the user may gain sufficient knowledge to navigate themselves through a certain scenario that may run in real-time, there may be various unintended factors that might arise to be a hazardous externality, hence posing a threat to the user in real life. Another would be the obvious difference between actually holding a firearm with the user's hands as opposed to using controllers to artificially simulate such a haptic situation. Of course, such a limitation can be overcome by using haptic gear but depending on the cost of implementation of such a study or an experience, it might still prove to be a limitation.

Such safety training scenarios experience constant change in logistics and hence may need to be updated periodically to meet the accuracy of the realistic experience for the user and hence the maintainability of such a program may also pose to be a difficult implementation leading to wonder if the costs outweigh the benefits of such an implementation. Nonetheless, we certainly see a plausible benefit of effectiveness in the implementation of safety programs in VR.

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