Campus Fire Evacuation Drill

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***Abstract*—The goal of this project is to create a virtual simulation of a campus fire evacuation scenario to educate and train individuals on proper evacuation procedures. The simulation includes a realistic virtual environment of the University of North Texas engineering campus building(s), Discovery Park, and surrounding areas, interactive elements to guide users through the evacuation process, and AI-controlled characters to simulate various behaviors and responses. The simulation provides feedback and evaluation mechanisms to assess users' performance and understanding of evacuation procedures. Implemented using Unity 3D, the simulation incorporates detailed modeling, sound effects, animations, interactivity, and AI functionality. Targeted at students, faculty, staff, emergency responders, and anyone interested in fire safety, the project is managed through designated roles including project management, development, 3D modeling, sound design, and quality assurance.**

***Index Terms*—XR, VR, Simulation, Evacuation Drill, Safety**

I. Introduction

Our VR application's main objective is to instruct and teach people on safe fire evacuation techniques in a realistic and engaging way. The ultimate goal of our project is making a realistic simulation of a campus fire evacuation scenario. VR allows for safe, risk free simulation of a fire emergency situation and also can provide a quality, immersive experience for a low cost. The project's objectives include developing an interactive evacuation procedure guide, an accurate virtual environment of a campus building and its surrounding areas, and AI-controlled characters who can replicate a range of behaviors and reactions. Users can acquire and practice crucial skills including locating ways to evacuate, utilizing emergency equipment, and helping others during evacuations by simulating a campus fire evacuation scenario.The target audience for the VR application includes:

- Members of the faculty, staff, and students of educational institutions. Due to their frequent occupancy of university buildings, these people are major users and should be well prepared for emergencies such as fires.
- Security staff and rescue workers may practice cooperation during evacuations and get acquainted with campus layouts by using this program, which is a useful training tool.
- Visitors and Guests: It is also beneficial for guests attending events or activities on campus to be aware of the evacuation protocols in case of emergency.

The application is useful for:

- Enhanced Preparation: The program helps users become more prepared for crises in real life by putting them in realistic fire evacuation exercises that might endanger lives in life-threatening situations.
- Risk Mitigation: The project lowers the chance of confusion and fear during genuine crises by acquainting users with campus layouts and evacuation protocols. This results in more effective evacuations and lesser injuries or deaths.
- Flexibility in Training: The VR application presents a scalable and adaptable training platform that lets users practicing evacuation procedures whenever it's most useful to them, without requiring real-world exercises or physical assets.
- Feedback and Evaluation: The application's feedback and evaluation tools evaluate users' performance and knowledge of evacuation protocols, allowing emergency preparation plans to be continuously improved and strengthened.

Our project uses Unity 3D and AI-controlled characters to create a virtual simulation of a campus fire evacuation scenario. A realistic campus environment, complete with buildings, green spaces, and emergency assembling locations, will be included in the simulation. Users will be instructed through the evacuation process via interactive features, and characters controlled by artificial intelligence will replicate different reactions and behaviors. Feedback systems will evaluate how well people execute and recognize evacuation instructions.

II. Modeling

The virtual environment of our simulation includes textured models of the engineering campus layout with customized,

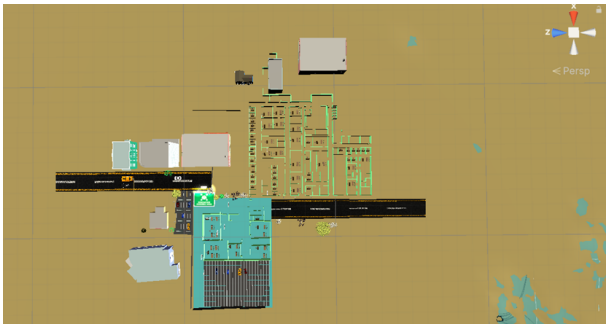


Fig. 1. Full scene model.

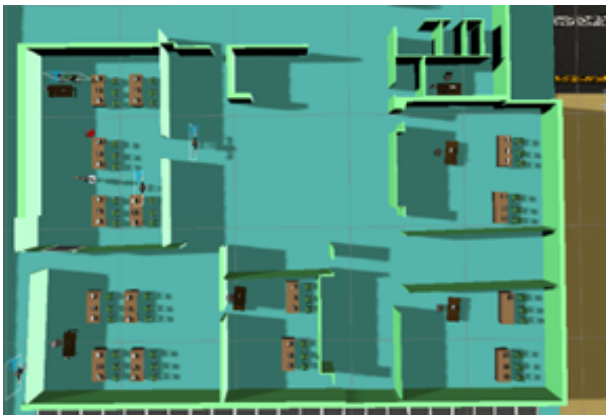


Fig. 2. Virtual Campus Building 1.

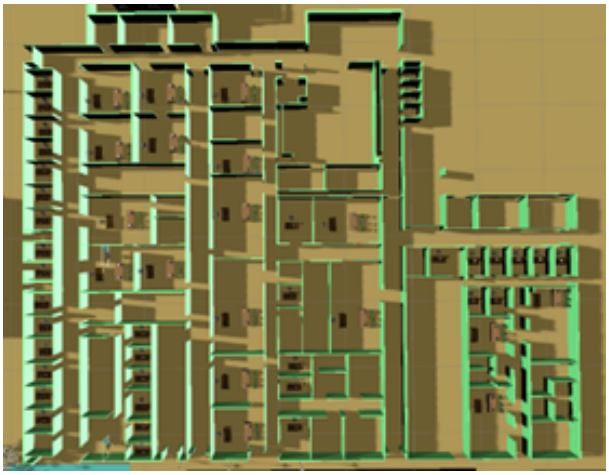


Fig. 3. Virtual Campus Building 2.

furnished building interiors, terrain and treas, surrounding areas, evacuation routes and fire hazards. We modified a 3D model of the Discovery Park building that included classrooms, offices, walkways and more. To increase the sense of realism and immersion, we furnished the campus layout environment with a variety of models for different types of items such as desks, chairs, computers, briefcases and more. In addition to the modeling of campus buildings, our virtual environment modeling also includes surrounding areas such as parking lots, other buildings and transportation roads.

The designed virtual environment involves designing and realistic parking lots, pathways, buildings, and surrounding scenery. Ensure that the building structure is accurately replicated to provide the VR simulation a genuine atmosphere. By including furniture, obstructions, and moving parts, the simulated setting becomes more complicated and replicates the difficulties of a real-world evacuation. SketchUp was used to create the building's classroom and walls, then Unity 3D was used to add the textures. SketchUp was used for modeling, while Unity 3D was utilized for applying textures. People in need of emergency evacuation, as well as textures and animations for emergency signs, alarm systems, smoke, and fire.

III. Implementation

1. Introduction: The evacuation drill simulation starts by pressing either the enter key on the keyboard or a start button in our application GUI. The evacuation drill starts from the main classroom, the classroom we attend this class in. Once the drill starts, the player must navigate through the environment to exit the classroom safely with the NPCs before losing full health.

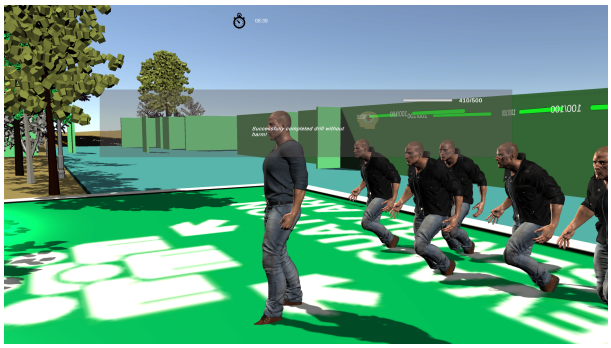
2. Evacuation Starts: The simulator should show exit doors for evacuating from the classroom to a safe environment for the evacuation assembly area looking out for the fire that is spreading through the classroom.

3. Evacuation Plan: The simulation provides an overview of the classroom evacuation drill, including the route way, exits, and assembly points. Users will be able to visualize the evacuation drill and understand the importance of following it in case of an emergency situation.

4. Evacuation Procedures: The simulator helps the user to gather all the remaining persons from the fire situation spreading overall the classroom helps him/her to take out of the classroom from evacuation drill.

5. Safety Equipment: The simulation will cover the safety measurements like sound alarm when the fire starts it will stop when the drill is finished. Guiding participants through the simulated emergency situation.

6. Drill Test: This project makes the successful drill test from the students and staff will get knowledge of understanding, the fire evacuation drill that was caused fire in the classroom that was successfully completed without any harm.



Overall, using virtual reality technology to conduct a campus fire evacuation drill is a major step in improving the university community's awareness for fire safety. It intended to deliver to students and visitors with the expertise and knowledge essential to react adequately in a critical situation and to protect their own safety as well as the safety of people.

IV. Functionality

Explain how the following were implemented:

1) Vision: To accurately represent the classroom environment, textures and 3D models were carefully created and applied to represent the buildings, pathways, rooms, exits, outdoor walkways, and emergency assembly locations. safety features, evacuation routes, and fire emergencies were created using high-resolution textures to convey highly accurate visual information.
2) Sound: Fire alarm sound is triggered when the user initiates the evacuation drill, creating a sense of urgency. Door opening sounds are played when the user approaches a door, Success sound is played when the user successfully completes the drill without any injuries to themselves or NPCs, providing positive reinforcement.
3) Animation: Fires are depicted using particle effects, simulating the dynamic movement, and spread of flames. NPCs exhibit running animations as they navigate the environment during evacuation. Player animations include walking, running, and jumping, enhancing immersion and control responsiveness.

4) Interactivity: User-triggered events include starting the evacuation drill, ending the drill by reaching the target area, opening doors when in proximity, and calling for help in case of emergencies.
5) Characters/Avatars: Multiple AI-controlled NPCs are implemented with path-following behavior, simulating realistic evacuation scenarios where characters follow predetermined routes to safety.
6) Sensors: Proximity sensors are utilized for doors, triggering their opening when the user approaches. A timer sensor tracks the time taken to complete the evacuation drill. Touch sensors detect when the user enters a fire, triggering appropriate responses.
7) Player: A third-person controller is added to the scene, allowing users to navigate the virtual environment and interact with objects.
8) AI Implementation: AI functionality is employed for NPCs to follow the player's movements and avoid collisions with each other, enhancing realism and simulating crowd behavior during evacuation.
9) Interface elements: User interface elements include start buttons, call buttons, a drill stopwatch to track time, and health bars to monitor the user's condition during the evacuation.
10) Multi-User Environment: The application may support multiple users in the same environment, enabling collaboration and teamwork during evacuation simulations. Hardware such as VR headsets can be integrated for immersive user experiences, enhancing realism and engagement.

V. Conclusion

The Campus Fire Evacuation Simulation stands as a pivotal tool in safety training, providing a controlled environment where users can rehearse evacuation procedures without facing real-life risks. Its immersive nature ensures that users experience scenarios closely mirroring actual emergencies, thereby sharpening their preparedness and ability to make critical decisions under pressure.

Its significance lies in offering a risk-free environment where users, including students, faculty, staff, and emergency responders, can immerse themselves in realistic scenarios without endangering lives. Users can interact realistically with the environment, including opening doors and navigating spaces, enhancing the training's effectiveness.

Dynamic scenarios can be created and adjusted in real-time, offering a wide range of training experiences. The virtual environment ensures a safe learning environment, allowing users to make and learn from mistakes without real-world consequences.

Overall, VR technology provides the perfect platform for developing a campus fire evacuation simulation, offering a blend of realism, interactivity, and safety.

The Campus Fire Evacuation Simulation project faces several challenges and potential areas for future improvement. First and foremost is the delicate balance between realism and performance in virtual reality environments. While striving for immersive realism, developers must ensure the application maintains smooth performance to prevent user discomfort. Additionally, advancing the complexity of AI behaviors poses a significant challenge. While current implementations cover basic pathfinding and NPC following, future iterations may require more sophisticated AI, such as crowd dynamics and adaptive responses, necessitating careful optimization to avoid computational bottlenecks.

Accessibility remains a key concern, with efforts to integrate features for users with disabilities ongoing but still potentially incomplete. Scalability and customization present another hurdle, as adapting the simulation to various campus layouts and scenarios demands streamlined tools and frameworks. Enhancing user feedback and evaluation mechanisms could further improve the learning experience, requiring the implementation of more robust metrics and detailed feedback systems.

Lastly, hardware limitations may hinder the simulation's effectiveness, calling for optimization efforts to ensure compatibility across a broader range of devices. Tackling these challenges will require ongoing research and collaboration to refine the simulation into a more comprehensive and impactful educational tool for fire safety training.

VI. Acknowledgements

We would like to acknowledge and thank the professor for teaching us the concepts and providing us beneficial resources and support for this work.

VII. References

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