Abstract:

This project focuses on creating a realistic virtual environment using the Unity 3D game engine and virtual reality (VR) technology to simulate and raise awareness about flooding disasters. The goal is to provide an immersive and interactive experience that allows participants to witness the flooding and make informed decisions about preparation and evacuation. The project involves reproducing recorded flood data in the VR environment, allowing users to travel through the simulation and experience the disaster. The development platform used is Unity 3D, with scripting in C#, and the program is deployed on the Oculus Quest 2 VR headset. Performance optimization and user comfort were considered during the development process. The program offers three views: walking, driving, and bird's-eye, each providing a unique perspective on the flood scenario. The VR environment enables participants to observe flood levels, receive warnings, and make evacuation decisions. A participant study was conducted to gather data on participants' evacuation choices and their perceptions of flood risks during different alarm systems. The VR environment shows promise as an effective tool for disaster awareness and preparedness to help policymakers understand the effects without risking their lives. However, improvements are needed to enhance realism, optimize performance, and address technical limitations.

Introduction:

Flooding is a significant and widespread natural disaster that poses substantial risks to communities globally. With climate change and increasing urbanization, the frequency and severity of flooding events have increased, resulting in extensive property damage, loss of lives, and economic disruptions. To mitigate the impact of flooding and enhance disaster preparedness, there is a critical need to raise public awareness and understanding of the risks associated with these events.

Virtual reality (VR) technology has become a powerful tool for simulating and visualizing real-world scenarios. By creating physically realistic environments in a virtual space, VR allows users to experience and interact with various situations, providing an immersive and engaging learning experience. For flooding, VR can simulate flood scenarios and enable users to witness the effects of floods, understand the dynamics of water levels, and make informed decisions about necessary preparations and evacuation measures.

Problem Definition:

The primary problem addressed by this project is the need for more public awareness and preparedness when it comes to flooding disasters. Many individuals and communities need more knowledge of the potential risks and a clearer understanding of the consequences of floods. It often results in delayed responses, inadequate preparations, and increased vulnerability during flood events.

Furthermore, traditional methods of conveying flood-related information, such as news reports and pamphlets, often need to provide an immersive and tangible understanding of the severity and impact of floods. As a result, individuals may need to fully comprehend the urgency of evacuation or the precautions, leading to increased risks to their safety and well-being. By providing an immersive and interactive experience, individuals can witness the effects of floods, observe the dynamic changes in water levels, and better understand the potential risks and necessary preparations for flood events. The project aims to bridge the public awareness and preparedness gap by delivering a realistic and engaging learning experience through VR.

Literature Review:

Virtual reality (VR) has emerged as a powerful tool in various fields, including disaster research, risk communication, and education. In flooding, VR offers a unique opportunity to simulate and study the impacts of flood events, enhance public awareness, and improve disaster preparedness. Several studies have explored the application of VR in disaster research, providing valuable insights into the effectiveness of VR simulations for risk perception and decision-making.

Researchers have found that VR simulations can effectively communicate the potential risks and consequences of flooding to individuals. Wang et al. (2019) highlighted using VR as a risk communication tool, emphasizing its ability to elicit realistic emotional responses and behavioural reactions. They found that participants exhibited similar reactions in both VR and real-world situations, demonstrating the validity of using VR for studying disaster responses.

Kinateder et al. (2013) conducted a VR fire simulation evacuation experiment and found that participants' reactions to virtual accidents were comparable to real-world scenarios. The study showed that VR could effectively simulate emergencies and elicit appropriate behavioural responses, providing valuable insights into evacuation decision-making.

Fujimi and Fujimura (2020) explored using VR to measure evacuation time under different environmental cues in flood scenarios. Their experiment demonstrated that the changing views of the flooding in the virtual environment influenced participants' evacuation decisions. The study highlighted the potential of VR in studying flash flood evacuations and suggested that providing more information cues in the virtual environment could lead to earlier evacuation decisions in real-world scenarios.

Bernardini et al. (2020) conducted experiments to examine the effect of different water levels on the speed of movement during flood evacuation. The study considered various physiological conditions, including height, weight, and gender, to assess their impact on evacuation speed. The findings revealed the importance of water depth in influencing movement during flooding and provided insights into the optimal and safe water levels for successful evacuation.

These studies collectively demonstrate the effectiveness of VR in simulating and studying floods. VR simulations enable researchers to control and manipulate various factors, observe participants' reactions, and study decision-making processes in realistic yet controlled environments. VR's immersive and interactive nature enhances the learning experience, fostering better understanding, risk perception, and preparedness among individuals facing floods.

Methodology:

The methodology employed in this project involves developing and implementing a virtual reality (VR) simulation using the Unity 3D game engine. The VR simulation aims to recreate realistic flood scenarios and provide users with an immersive and interactive experience to enhance their understanding of flooding risks and preparedness.

The development begins by creating a detailed city scene in Unity 3D, utilizing pre-built 3D models from the Unity assets store. The set includes buildings, roads, streetlights, and other elements replicating a real neighbourhood. The goal is to ensure high realism and provide users with a sense of familiarity during the VR experience.

A dynamic and adjustable flood system is implemented within the virtual environment to simulate the flooding process. A flat plane with bump mapping techniques simulates the water surface, giving it a realistic waving effect. The flood depth is controlled by adjusting the controller based on the user's interactions, allowing different flood scenarios to be experienced.

Three different views are implemented within the VR simulation: walking view, driving mode, and bird's-eye view. Each view offers a unique perspective and interaction mode for users. In the walking view, users can move horizontally within the virtual environment, while the driving mode allows users to experience the flood from the perspective of a car. The bird's-eye view provides an overhead perspective, enabling users to freely explore the environment and observe the surge from different angles.

The VR simulation incorporates a user interface (UI) that delivers essential information, warnings, and evacuation instructions. The UI is designed to be visually intuitive and fixed in front of the user's view, ensuring that critical information is easily accessible. Users can interact with the UI using VR controllers to make decisions and respond to the flood scenario.

Data recording was an essential part of the methodology. The VR simulation records the water depth when users express specific responses, such as noticing abnormal water levels, feeling danger, or deciding to escape. Additionally, parameters related to lighting conditions, view perspectives, warning situations, and user height are recorded to analyze their influence on decision-making.

Limitations of the methodology include certain technical constraints and challenges. The stepwise increase in water level may not provide a completely realistic experience. Interactive operations, such as walking and driving, have limitations due to control constraints within the VR environment. Bugs and technical issues arose, such as walking through walls, affecting the overall user experience. The weight of the Oculus Quest 2 headset and the high-performance requirements of the VR simulation lead to computer crashes or device overheating, impacting the experiment's smooth execution.

Despite these limitations, the methodology aims to provide a realistic and engaging VR experience for users to gain insights into flood scenarios. The recorded data will be analyzed to understand the impact of different factors on decision-making during flood events, contributing to the evaluation and improvement of the VR simulation.