VR for Landslides

B.Tech Major Technical Project Report

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Chapter 1

Introduction

Serious natural disasters like landslides have the potential to seriously harm both infrastructure and human life. It's critical to comprehend human behavior in the aftermath of landslides in order to create mitigation and response strategies that work. The study uses the C# programming language, Gaia Environment, Easy Roads, and Unity 3D software to produce lifelike 3D landslide simulations. These models were employed to investigate the cognitive processes involved in landslide incidents. The study discovered that during landslide events, cognitive behavior can influence decision-making, risk assessment, and evacuation techniques. Landslip phenomena can be fully understood by combining cognitive psychology and geographic information technology. With this knowledge, more effective risk-reduction strategies that may save lives can be developed. Understanding the intricate relationships that occur during natural disasters between geological forces and human consciousness has advanced significantly as a result of this work. People will be more robust in the face of such tragedies thanks to the study's findings. This research makes a significant contribution to the fields of disaster management, psychology, and geology.

This study investigates historical records of landslides in India, with a focus on those of socio-economic relevance. It is written by Surya Parkash, who is associated with the World Centre of Excellence on Landslide Disaster Reduction, National Institute of Disaster Management, New Delhi, India. It seeks to give a thorough rundown of these incidents, their causes, and their effects. The research contributes insights to enhance risk assessment and disaster management in a region susceptible to landslide hazards by studying past landslides [1].Debris flow landslides, known for their destructive nature, pose challenges for prediction and disaster management. Prior research mainly used static models. This paper pioneers VR simulations to bridge the gap between theory and practical insights into these events. It could revolutionize landslide research and enhance risk assessment and mitigation strategies by providing immersive, real-time experiences [2].The paper explores how virtual reality (VR) technology can enhance the visualization and assessment of geohazards, such as landslides and earthquakes. Its goal is to improve risk assessment and understanding within geohazard research and mitigation [3].

Chapter 2

System Model

- **The Problem Statement**

  Though advances have been made in understanding the impact of landslides, there are still drawbacks like disaster management strategies due to limited exploration of interaction between human cognition and external geological forces, during landslide events. VR simulations are starting to show promise in minimizing the drawbacks and the study can help investigate their potential and minimize the risk to human operators.

- **Virtual Reality environment for landslide using Unity 3D**

  Construct a landslide virtual reality simulation: Building a digital environment that mimics actual landslide scenarios is the first step in creating a virtual reality (VR) simulation. This virtual reality simulation can be used for landslide-related research, education, or awareness-raising. Integrating geospatial data to create a realistic landscape, incorporating dynamic weather and environmental factors, allowing user interaction for exploration and decision-making, simulating human reactions during landslides, producing educational content, developing different landslide scenarios, and putting real-time monitoring and risk assessment tools into place are some of the steps in the process. By fully immersing themselves in these scenarios, users can experience various landslides and learn about landslides and disaster preparedness. An efficient virtual reality experience that aims to raise awareness and educate people about landslides requires careful planning, testing, and improvement.

- **Human data collection using virtual reality simulations for landslides**

  Using immersive technology, human data (EEG, HRV, Demographic, Unity) is collected through virtual reality (VR) simulations in order to examine and record people's reactions to landslide scenarios. Participants interact with virtual reality environments that imitate various landslide scenarios, and their behavioral and cognitive responses—such as risk assessment, evacuation plans, and decision-making—are captured. This data adds to our understanding of landslides and helps to improve methods for disaster prevention and mitigation by providing insightful information about human behavior during these events. It is a powerful way to look into human reactions in a safe, regulated, and morally sound environment.

- **Analyze the collected human data (EEG, HRV) using statistical modeling**

  Analyzing the human data collected through statistical modeling requires a methodical examination of data gathered from various sources. Applying statistical techniques to the data gathered from people's reactions during landslide simulations is what it means in this context. Using statistical models, researchers can find links, patterns, and trends within the data. This procedure enables a deeper understanding of how people react to landslides, assesses the influence of different elements, and develops insightful conclusions. By using this analytical technique, researchers can glean insightful information from the collected data, allowing for well-informed suggestions or conclusions based on statistical findings.

- **Build Reinforcement/Imitation Learning models based on data collected using VR simulations**

  Developing reinforcement learning models using data from VR simulations entails the creation of algorithms that leverage information collected in virtual reality settings to build and enhance intelligent decision-making systems. In this context, the data originating from human interactions within VR simulations is the foundation for constructing and optimizing reinforcement learning models. These models can learn and adapt by receiving feedback in the form of rewards or penalties based on their actions to make more informed decisions within simulated landslide scenarios. This method could enhance the training of AI agents to respond effectively in real landslide situations, thereby contributing to improved disaster preparedness and mitigation strategies.

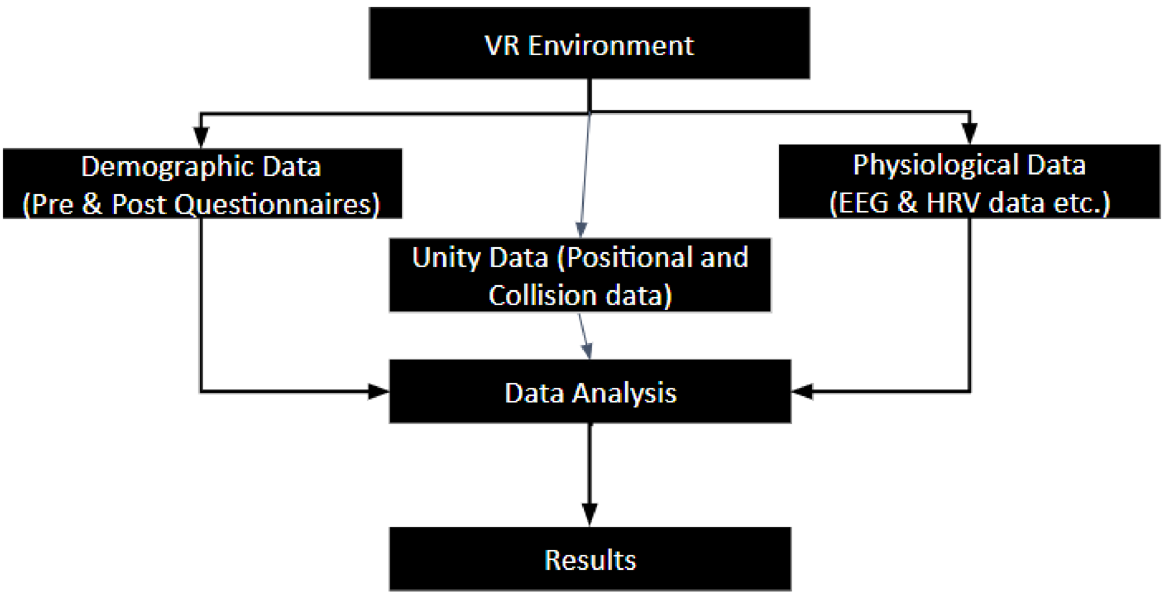

Fig. 2.1: Flowchart

Chapter 3

Results

- **A Glance at VR Created specifically for a landslide environment.**

Fig. 3.1: Screenshot of simulation

Our Unity 3D VR environment seamlessly integrates Oculus VR and Logitech G29, offering an unparalleled driving simulation. A single track meanders through diverse terrains, presenting challenging landscapes for a realistic driving experience. The Logitech G29 steering wheel enhances precision and responsiveness, elevating user control.The environment includes three landslide-prone zones. Utilizing the Oculus VR headset and Logitech G29 steering wheel, participants navigate a single track through diverse terrains, encountering three strategically placed landslide-prone zones.

- **Driving Simulation Scenarios: Exploring Varied Probabilities of Landslides**

  We implemented 4 scenarios:

  - Day Mode, with high probabilities of landslides
  - Night Mode, with high probabilities of landslides
  - Day Mode, with low probabilities of landslides
  - Night mode, with low probabilities of landslides

Fig. 3.2: Day Driving Mode

Fig. 3.3: Night Driving Mode

- **Landslide Trigger Mechanism Description: Enhancing Realism in Virtual Driving Simulations**

  In our virtual driving simulation scenarios, an innovative Landslide Trigger Mechanism has been implemented using a C# script in Unity. Positioned just before the designated landslide-prone areas, an imperceptible collider serves as the trigger point for landslide events. This collider is strategically placed to activate the simulated landslide based on a predetermined probability when the virtual car traverses through it. The probability factor, easily adjustable within the script, introduces an element of unpredictability, adding realism to the driving experience. Upon triggering, a designated landslide object is activated, simulating the dynamic and challenging conditions associated with landslide-prone environments. This mechanism contributes to a more immersive and authentic virtual driving encounter, allowing for a nuanced exploration of participant responses in diverse driving scenarios.

- **Data Collection in Virtual Driving Experiments**

  During the human data collection phase, we collected data from a total of 20 participants, with five individuals allocated to each specific driving mode within the VR simulation. The collected data includes demographic details, such as age and gender, and physiological metrics such as Heart Rate Variability (HRV) and Electroencephalogram (EEG) readings. These physiological measurements were taken both before and during each participant's virtual driving experience, providing insights into their physiological responses. Furthermore, we recorded car positional data and collision events during the simulations, utilizing VR headsets and Logitech G29 steering wheels to replicate a realistic driving scenario. This comprehensive approach aims to explore the complex relationships between demographic factors, physiological reactions, and driving behaviors, offering valuable insights into human responses in landslide-prone environments.

Fig. 3.4: Participants Data Collection

- **Statistical Analysis of Collected Participants Data**

  During the data analysis phase, we examined the average number of collisions across different driving modes, presenting the findings in a bar plot. Notably, the mode with the highest average collisions was associated with a high probability of landslides, particularly in night mode. This outcome indicates that participants encountered greater difficulty driving in nighttime conditions, especially in areas prone to landslides. The heightened collision rate in this specific mode underscores the challenges participants faced when navigating through simulated landscapes, mirroring real-world complexities. This observation provides valuable insights into the perceived difficulties of driving at night in landslide-prone environments, highlighting considerations for enhancing safety measures and driver training in such contexts.

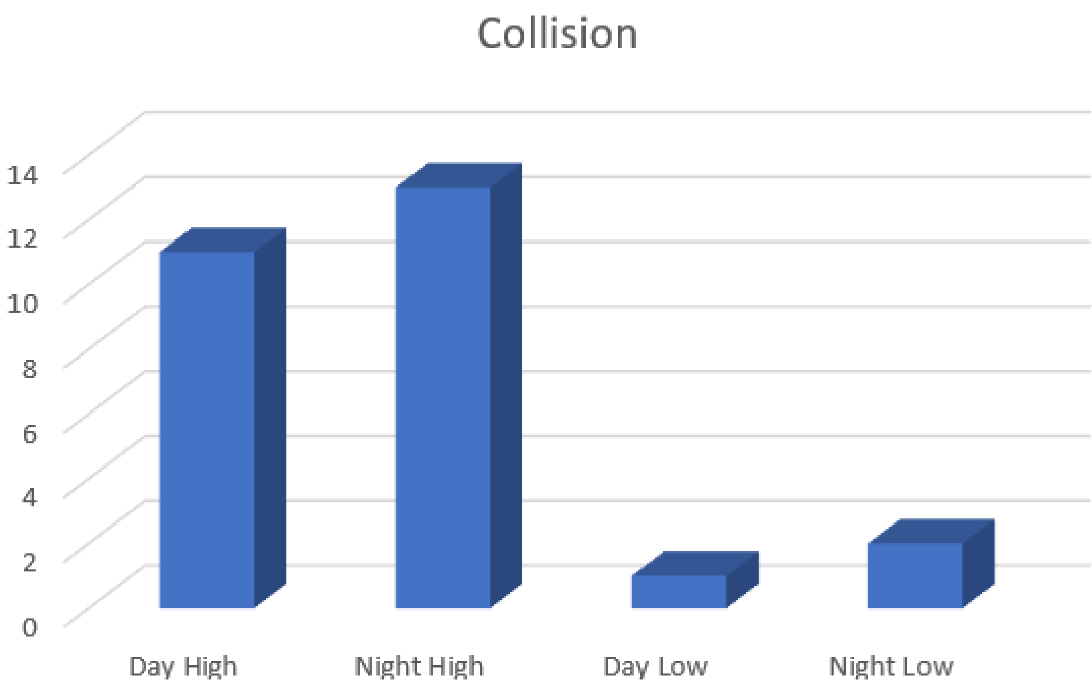

Fig. 3.5: Bar chart for Average collision Number

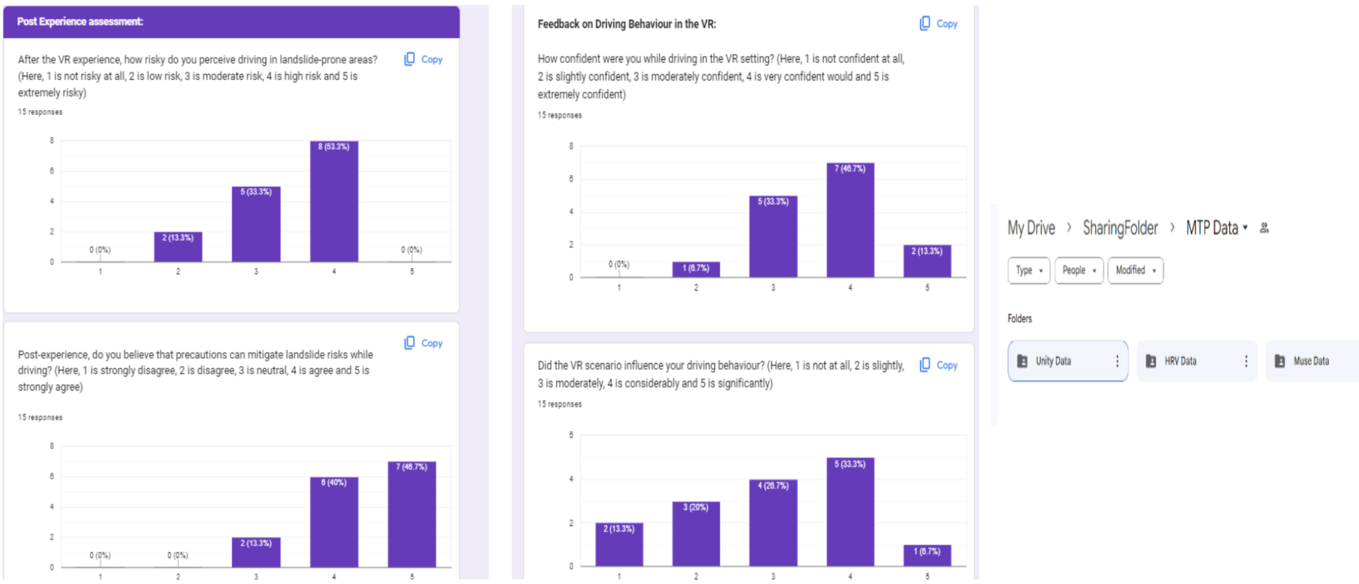

Fig. 3.6: A brief overview of data collected

Chapter 4

Future Work

- **In-Depth Analysis of Demographic and Physiological Data**
  - Explore correlations and patterns within the collected demographic and physiological data to gain deeper insights into how individual characteristics may influence human behavior during virtual driving simulations.
- **Implementing Reinforcement Learning (RL) and Imitation Learning (IL) for Automated Driving**
  - Utilize the gathered positional and collision data to train an automated driving system using state-of-the-art techniques such as RL and IL. This avenue of research aims to develop intelligent systems capable of autonomously navigating through simulated environments, contributing to advancements in autonomous vehicle technology.
- **Enhancing Virtual Reality Environment**
  - Introduce additional complexity to the VR environment by incorporating simulated traffic on the roads. This expansion will provide a more realistic and dynamic driving experience, allowing for a comprehensive study of human behavior and responses in the presence of other virtual vehicles.

- **Conduct Longitudinal Studies**
  - Extend the research by implementing longitudinal studies to observe how participants' responses evolve over time. This approach can provide valuable insights into the adaptability and learning curves associated with driving in challenging conditions.

Bibliography

[1] S. Parkash, "Historical records of socio-economically significant landslides in india," *Journal of South Asia Disaster Studies*, 12 2011.

[2] G. Alene, H. Vicari, S. Irshad, A. Perkis, O. Bruland, and V. Thakur, "Realistic visualization of debris flow type landslides through virtual reality," *Landslides*, vol. 20, 09 2022.

[3] H.-B. Havenith, P. Cerfontaine, and A.-S. Mreyen, "How virtual reality can help visualise and assess geohazards," *International Journal of Digital Earth*, vol. 12, 08 2017.