Application of Virtual and Mixed Reality in Mental Health Care and Rehabilitation

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VR Simulation for Disaster Management

1. Project Overview:

The project aims to develop a Virtual Reality (VR) simulation using Unity, desktop simulators, and the Quest platform to address the challenges in disaster management. By simulating disaster scenarios within the University of Canberra (UC) campus area, the project will focus on improving the effectiveness of emergency response and real-time rescue efforts. This will be achieved through the deployment of multiple drones (soldier drones) to search for survivors and relay information to a central drone (mother drone). The mother drone will analyse the data and present I to human experts, facilitating informed decision-making and coordination of rescue operations.

2. Problem Description:

Traditional methods of disaster management often struggle to cover large areas affected by disasters, leading to delays and inefficiencies in locating and recuing survivors. For instance, the 2019/2020 Australian bushfire season (Black Summer) showcases the limitations of traditional disaster management methods, the fire with their unprecedented scale and intensity, which has resulted in widespread suffering and loss of life, extensive damage to property and natural habitats. Despite the efforts of emergency responders, including firefighters and rescue teams, the magnitude of the disaster overwhelmed traditional approaches to disaster management.

One of the key challenges faced by the team during the crisis was the inability of the traditional methods to effectively cover the vast affected areas. The dynamic of the nature made it difficult to anticipate the intensity of the crisis and the rugged terrain and remote locations has hindered access to certain areas, which resulted in the rescue operations and timely intervention before the loss of life and property. Communication and logistical challenges have also led to critical delays in evacuations and relief operations. As a result, many were trapped in dangerous conditions, highlighting the urgent need for innovative solutions to enhance disaster response capabilities.

In response to these challenges, the project seeks to leverage advanced technologies such as Virtual Reality (VR) simulations to improve the effectiveness of disaster management strategies. By recreating realistic disaster scenarios and providing a platform for training emergency responders, the project aims to address the shortcomings of traditional methods and enhance coordination and real-time rescue efforts in future disasters.

2.1 Systematic Literature Review:

The major objective of the research review was to investigate a recent research trend in the application development of VR technology to support emergency and disaster risk management. The scope of this study spans two large fields: disaster management and XR technology. The papers were searched using specific keywords containing the words related to “disaster” and “XR technology”. For this purpose, one tracking source: Google Scholar (2020) was used to search for relevant papers.

In (Front. Virtual Real., 11 April 2022) states that modelling is the process of creating a computer-based representation of the natural process or phenomena that produces a close input-output

relationship as the original system (de Jong and van Joolingen, 2008). The research trend in this area is directed in the development of an immersive system that can simulate a specific disaster scenario to the user. the wildfire surveillance system uses geo-coordinate information to pinpoint the location of the fire and a smoke simulation to visualize the fire in the AR platform (Stipani et al., 2010). In case of a wildfire, this information is sufficient for the operator to dispatch the responders to the location in a minimum amount of time. Hence, the usage of XR technology has made the surveillance and monitoring network more efficient and effective in the past few years by offering a common operational picture. The literature search resulted in the research works that focused on the development and evaluation of disaster-related dynamic graphics for smoke (Stipani et al., 2010), fire environment (Cimellaro et al., 2019), a tsunami (Jaiswal et al., 2009), radioactive catastrophe (Fischer et al., 2012), debris flow (Zhang et al., 2019), flood (Massaâbi et al., 2018; Wang et al., 2019), earthquake (Sinha et al., 2012) and power failure situations (Chengyun et al., 2018). Underlying dynamics were found to be designed using numerical modeling (Jaiswal et al., 2009; Cimellaro et al., 2019), nonlinear dynamics analysis (Sinha et al., 2012), multilevel visualization (Zhang et al., 2019), and predictive modeling (Wang et al., 2019).

Meng, L. (2020, June) states in Research and development of coal mine disaster prevention and rescue drill platform based on VR virtual reality technology that In order to improve the disaster rescue ability of coal mine rescue teams and enhance the effectiveness of daily training, high-quality modelling technology needs to be established.

In conclusion, the systematic literature review effectively addresses its objective of investigating recent trends in application of VR technology for disaster management. It provides a solid foundation for understanding the current landscape of research in this area while also highlighting opportunities for further exploration and advancement.

3. Project Scope:

3.1 In-Scope:

i. Development of a Virtual Reality (VR) simulation platform using Unity.
ii. Integration of desktop simulators and the Quest platform for accessibility.
iii. Utilization of recent GPU technology for realistic graphics.
iv. Simulation of disaster scenarios within University of Canberra (UC Maps) or Campus areas.
v. Deployment and control of 4 soldier drones for survivor search.
vi. Communication infrastructure for soldier drones to relay survivor locations to the mother drone.
vii. Development of a visualization interface as the project deliverable.
viii. Conduct a systematic literature review to find out critical criteria.

3.2 Out-of-Scope:

i. Physical hardware development for drones or VR devices.
ii. Real-world testings of simulation platform.
iii. Integration with external systems beyond the scope of disaster management simulation.
iv. Customization of the simulation for specific disaster management protocols of individual organizations.
v. Long term maintenance and support beyond the initial deployment phase.
vi. Compliance with regulatory standards for drone operation in real-world scenarios.

vii. Conducting large-scale user studies or surveys to assess the effectiveness of the simulation in training.

4. Requirements Analysis.

For the successful completion of the project, there are some requirements/ deliverables to be met which would ensure the timely delivery of the working project. The requirements of this project are detailed down below.

Objective: Development of VR simulation for disaster management.

4.1 Technical Needs:

- Unity for VR simulation.
- Compatibility with desktop computers and VR headsets.
- Integration of GPU technology for realistic graphics.
- Communication infrastructure for real-time data exchange.

4.2 Functional Needs:

- Creation of realistic disaster scenarios with varying levels of complexity.
- Deployment and control of virtual drones for search and rescue operation.
- Real- time monitoring and visualisation of simulation data.
- User-friendly interface for navigation and interaction within the simulation.

4.3 Operational or Non-functional Needs:

- Smooth performance without significant lag or technical glitches.
- Scalability to accommodate larger simulations or additional features.
- Reliability of communication and data transmission.
- Compliance with ethical and safety standards.

Justification: The development of a Virtual Reality (VR) simulation for disaster management is like creating a training ground where emergency responders can prepare for real-life crisis. Using tools like Unity, the simulation will be accessible on both computers and VR headsets, making it easy for rescue team to train from anywhere. By integrating GPU technology, we ensure that the scenarios look and feel as real as possible, boosting the effectiveness of the training.

Functionally, the VR simulation will offer a variety of realistic disaster scenarios, each challenging the responders in different ways. They will be able to practice using virtual drones for search and rescue, improving their skills without any actual risk. With real-time monitoring and an easy-to-use interface, they can access situations on simulation effortlessly. Operationally, focusing on making sure the simulation runs smoothly and keeps the communication reliable. This will create a safe, effective, and user-friendly tool to help prepare when disaster strikes.

4.4 Deliverables

a. **Literature Review:** A few studies need to be conducted to understand the efficacy of Virtual Reality in the field of disaster management.

- Study the use of Virtual Reality simulations in disaster management: The usage of virtual reality simulations in disaster management should be studied to be able to provide a substantial understanding of how this project could impact search and rescue operations.

- Study the role of Virtual Reality in simulating natural disasters: The role of Virtual Reality simulations should be studied when preparing for a natural disaster. This would prepare the search and rescue teams and other teams involved in the evacuation process without being in a real disaster event.

b. **Develop a Virtual Reality simulation of a natural disaster using Microsoft Unity:**

- A Virtual Reality Simulation needs to be developed with certain criteria as shown below using Microsoft Unity.
- Create a natural disaster environment with survivors scattered throughout the natural disaster area in the simulation suite of Microsoft Unity.
- Establish a working interface between the mother drone and soldier drones, to make the mother drone the point of communication with the soldier drones. The environment should also include the usage of several drones. A central drone is called the mother drone and the other drones are called soldier drones. The mother drone should be interfaced with the soldier drones in such a manner that when the order is passed the mother drone informs the other drones of the required action to be taken.
- The Mother drone is expected to order the soldier drones to investigate a particular area where the disaster has occurred.
- Deploy the soldier drones to the designated area maximally distant from each other. The Soldier drones are expected to be as distant from each other to maximize the area that is being surveyed thereby increasing the chances of finding the survivors from the natural disaster.
- Display the visual feed and location coordinates from the soldier drones to the mother drone. The Video footage or imagery from each soldier drone should be shared with the mother drone to find the survivors and the coordinate information should also be shared with the mother drone on finding survivors. This data would be especially useful to the search and rescue operations and further actions that need to be implemented.
- Allocate localized rescue services based on the information gathered from the soldier drones to the mother drone. Based on the information that is gathered about the number of survivors and coordinates that are generated from the soldier drones, The localized rescue service should be given the information of the greatest number of survivors in a location and their coordinates.

c. **Deploy the Virtual Reality simulation:**

Present a working model of the simulation using the Microsoft Unity SDE (Software Development Environment) where the entire search and rescue operations using several drones interfaced with the mother drone is shown to aid in the natural disaster management and preventive measures.

4.5 Analysis of Preferred Options with Justifications:

A. Simulation Methods:

1. Virtual Reality Simulation: In Virtual Reality Simulations, the simulations that are being run are produced in an artificial environment with emphasis on changes occurring to the environment because of the user or the object in the simulated environment. It also emphasizes creating an environment that is more three-dimensional and immersive.

2. Traditional PC Simulations: In Traditional PC Simulations, the simulations that are produced are made possible on a two-dimensional screen. They produce good and accurate environments for the required simulations. They emphasize a good graphical interface over a surrounding and an immersive feeling.

Virtual Reality Simulation over Traditional PC Simulation:

Virtual Reality Simulations are better than traditional PC simulations for the project as they incorporate the creation of a natural disaster. The focus of this project is the interactive nature of the drones. Where the entire environment needs to be created in a three-dimensional space. Thu using a Virtual Reality Simulation would be a better solution to the project. The virtual reality simulation can be also used to implement a true depth of field that only virtual reality offers over traditional PC simulations.

B. Virtual Reality Simulation Environments:

Many Virtual Reality Simulation Environments are used to simulate VR environments. Some of the environments are shown below.

1. Unity Engine: The Unity Engine is a Virtual Reality Simulation Environment that focuses on the simplicity of creating VR models and simulations that are easy to manipulate. It is also a free-to-use software.

2. Unreal Engine: Unreal engine is a very interesting option as well as it is very useful for creating a graphic-heavy simulation. Unreal engine is also preferred for the two-dimensional SDE.

3. Maya: Maya is another offering of simulation and design software that is primarily used to create animations and elaborate 3D images and moving pictures. It focuses on producing a

true-to-life representation of the simulation environment. The coding and design processes are very tedious in Maya.

4. 3ds Max Design: 3ds Max Design is another product from Autodesk that is used to produce VR simulations. The strength of 3ds Max Design is that it produces good 3d renders and has a very elaborate toolset for the creation of the simulation. However, the process is very tedious as it requires understanding the other tools and programming languages which could make it hard to implement the project on time.

5. Amazon Lumberyard: Amazon Lumberyard is another great alternative to create the simulations. It uses an open-source model that could be used to produce a good set of VR elements in the simulated environment. However, the lack of community support and the lower preference of this SDE to create VR simulations are some reasons for concern

Unity engine over other Virtual Reality Simulation Environments:

The Microsoft Unity engine stands as the best simulation tool for the development of VR applications. The number of developers that prefer to use this for the creation of games and VR applications is a testament to its simplicity in developing VR applications. Another great perk of using Microsoft Unity SDE is that it is a free-to-use application with an extensive community that provides users and developers a community that focuses on the issues while using Unity. This constant support is one of the reasons for choosing Unity for the project. Another important reason for choosing Unity over other SDEs is that Unity has a simple programming requirement over the other VR simulators. Unity also boasts of having many asset stores that could be used to implement the project modules more efficiently and simply to get the proper working output and results in a timelier method.

5. Work Breakdown Structure

GANTT CHART

	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1		**2024-S1-69 Applications of virtual and mixed reality in mental health care and rehabilitation**	**63 days**	**Mon 12/02/24**	**Wed 8/05/24**	
2		**Initiation Phase**	**6 days**	**Mon 12/02/24**	**Mon 19/02/24**	
3		**Project Charter**	**6 days**	**Mon 12/02/24**	**Mon 19/02/24**	
4		Finalize the project team	1 day	Mon 12/02/24	Mon 12/02/24	
5		Initial meeting with the sponsors	1 hr	Mon 19/02/24	Mon 19/02/24	4
6		define the project goals and objectives	1 hr	Mon 19/02/24	Mon 19/02/24	5
7		Project Charter completed	0 days	Mon 19/02/24	Mon 19/02/24	6
8		Initiation phase completed	0 days	Mon 19/02/24	Mon 19/02/24	7
9		**Planning phase**	**5 days**	**Mon 26/02/24**	**Fri 1/03/24**	
10		**Project plan**	**5 days**	**Mon 26/02/24**	**Fri 1/03/24**	
11		Second meeting with the sponsors to gather requirements	1 hr	Mon 26/02/24	Mon 26/02/24	
12		Finalize requirements	0 hrs	Mon 26/02/24	Mon 26/02/24	
13		Assign the project tasks among the team	1 hr	Mon 26/02/24	Mon 26/02/24	
14		Create WBS	5 days	Mon 26/02/24	Fri 1/03/24	11
15		Project Plan Completed	0 days	Fri 1/03/24	Fri 1/03/24	14
16		Planning phase completed	0 days	Fri 1/03/24	Fri 1/03/24	15
17		**Execution Phase**	**42.25 days**	**Mon 4/03/24**	**Wed 1/05/24**	
18		Prototype Development	5 days	Mon 4/03/24	Fri 8/03/24	16
19		Disaster Scene Setup in Unity	5 days	Fri 8/03/24	Fri 15/03/24	18
20		Control Centre and helper drone setup	12 days	Fri 8/03/24	Mon 25/03/24	18
21		Communication setup between drones and control centre	10 days	Mon 11/03/24	Fri 22/03/24	18
22		Third meeting with the sponsors	1 hr	Mon 25/03/24	Mon 25/03/24	21
23		**Disaster Management**	**27.13 days**	**Mon 25/03/24**	**Wed 1/05/24**	**22**
24		Post disaster Response from both helper drones and control center	16 days	Mon 25/03/24	Tue 16/04/24	
25		Disaster response from Control Centre	8 days	Tue 16/04/24	Fri 26/04/24	24
26		Fourth meeting with the sponsors	1 hr	Fri 26/04/24	Fri 26/04/24	25
27		Setting up the system for other disasters	3 days	Fri 26/04/24	Wed 1/05/24	26
28		execution phase completed	0 days	Wed 1/05/24	Wed 1/05/24	27
29		**Monitor and control**	**40.63 days**	**Mon 11/03/24**	**Mon 6/05/24**	
30		**Monitor behaviours of drones during disaster managem**	**38 days**	**Mon 11/03/24**	**Wed 1/05/24**	
83		evaluation report and analysis against the plan and less	3 days	Wed 1/05/24	Mon 6/05/24	28
84		Proof-read final project report	1 hr	Mon 6/05/24	Mon 6/05/24	83
85		Fifth meeting with the sponsors	2 hrs	Mon 6/05/24	Mon 6/05/24	84
86		Get sponsors verification against the project activities	1 hr	Mon 6/05/24	Mon 6/05/24	84
87		Monitor and control phase completed	0 days	Mon 6/05/24	Mon 6/05/24	86
88		**Closing**	**2.5 days**	**Mon 6/05/24**	**Wed 8/05/24**	
89		Handover all the reports	1 day	Mon 6/05/24	Tue 7/05/24	87
90		Poster and presentation	2 hrs	Tue 7/05/24	Tue 7/05/24	89
91		Finalising the closing report	1 day	Tue 7/05/24	Wed 8/05/24	90
92		Sign-off from the sponsors	2 hrs	Wed 8/05/24	Wed 8/05/24	91
93		project Completion	0 days	Wed 8/05/24	Wed 8/05/24	92

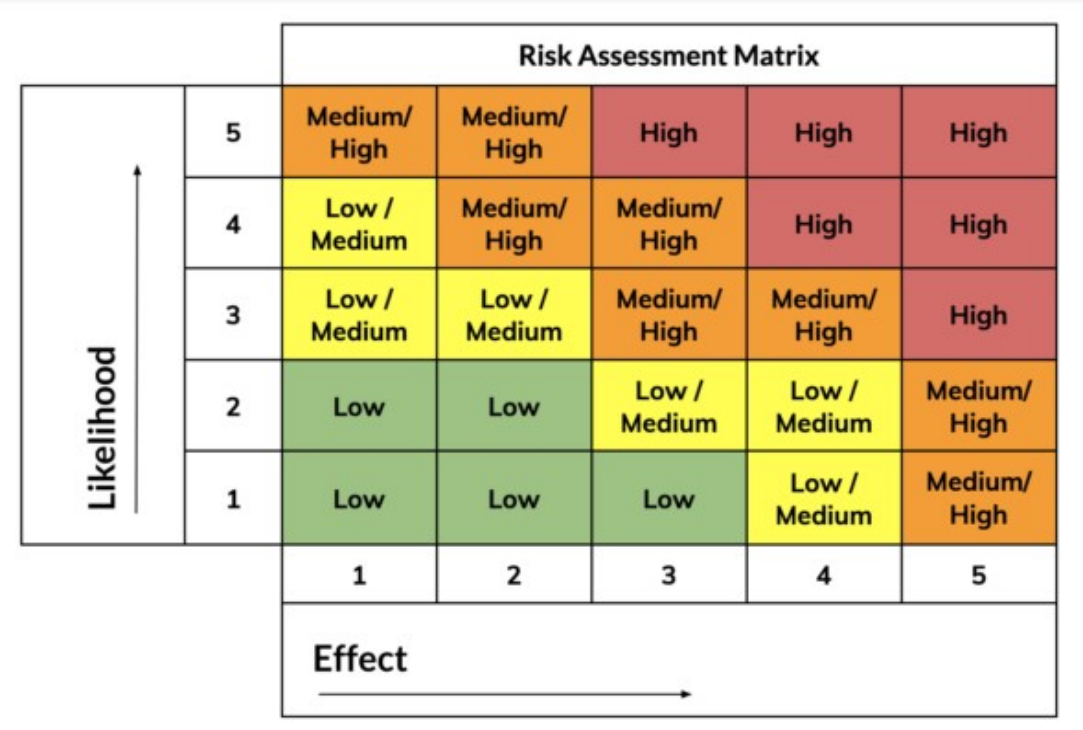
6. Risk Analysis

RISK MATRIX

RISK	PROBABILITY SCORE(1-5)	IMPACT SCORE(1-5)	LIKELIHOOD	CONSEQUENCES	RANKING

Compatibility issues	High – 4	High – 5	Likely	Major	1
Scope creep	High – 4	High – 5	Likely	Major	1
Technical Issues with Unity	Medium – 3	High – 5	Almost Certain	critical	2
Communication failures	Medium – 3	High – 5	possible	Moderate	2
Performance issues	Medium – 3	High – 5	Possible	Major	2
Lack of user adoption	Medium – 3	High – 5	possible	Moderate	2
VR hardware/software failure	High – 3	High – 4	Likely	Major	3
Network connectivity issues	Medium – 3	High – 4	Unlikely	Moderate	3
Unrealistic disaster senarios	Low – 2	High – 5	Unlikely	Major	4
User discomfort	Medium – 3	Medium – 3	Possible	Moderate	5

RISK MATRIX



RISK ANALYSIS AND MITIGATION STRATEGIES

RISK	RISK CATEGORY	RISK DESCRIPTION	ESTIMATED PROBABILITY	MITIGATION	ESTIMATED IMPACT (1-5)	RISK RANKING
Compatibility issues	Technical	Compatibility issues with the VR and the desktop setup	High	Test and ensure that they work seamlessly across the two different hardware	High - 5	1
Scope creep	Project	Expansion of the scope of the project beyond the initial boundaries	High	Have a clear idea on the scope and define the in scope and out scope so that could prevent scope creep and lead to project success	High - 5	1
Technical Issues with Unity	Technical	Issues that could come up at the time of development in unity	Medium	Testing regularly and debugging.	High – 5	2
Communication failures	Technical	Failures in communication channels	Medium	Implement proper communication channels and ensure to communicate everything properly	High – 5	2
Performance issues	Technical	Lag in the performance	Medium	Conduct proper complex testing and optimize the code.	High - 5	2

Lack of user adoption	Project	End-users fails to adopt the simulation	Medium	Involve the end-user in designing and testing phase and provide proper training and support	High - 5	2
VR hardware/software failure	Technical	Malfunction of VR hardware or software during the development or deployment phase	High	Regular tesing and maintenance and have proper backup options	High – 4	3
Network connectivity issues	Technical	Fails to connect to the network and effect the VR and affects the real time monitoring.	Medium	Implement good network connections and fail over mechanism.	High - 4	3
Unrealistic disaster senarios	Project	Scenarios not grounded in reality	Low	Make sure that the scenarios are grounded in reality to actual disaster situations	High - 5	4
User discomfort	Functional	Some user experience discomfort using the VR game	Medium	Provide adjustable settings for proper use of VR	Medium - 3	5

7. Project Governance

ROLES	**RESPONSIBILITIES**	**ASSIGNED TO**
Project sponsor	Provide project requirements and feedback, receives deliverables and reporting	Dr Ram Subramanian Ravi Varman Selvakumaran
Academic Mentor	Provide guidance, receives deliverables and reporting, immediate contact and	Dr Mehdi Hussain

	mediator between project sponsor and the team members	
Project team lead	Primary team member of contact with the sponsor and supervisor via all means of communication. Finalize the report submission.	Kedar Lamichhane
Project Development Team	Develop the VR stimulator from the scratch and in charge of documentation.	Jis Jojet Thomas Kevin David Kedar Lamichhane Kavya Boban

8. Stakeholder Management

The stakeholder analysis is done based on their power, interest, and the importance that they have in the project and that is been prioritized in this framework of stakeholder analysis.

Identify the stakeholders:

1. **Academic Mentor**
   Role: Support provider
   Power: High
   Interest: High
   Importance: Provide support and guidance, mediator between the sponsor and the developers, can shape the project into the success track.
2. **Development Team**
   Role: Development of the project from scratch
   Power: High
   Interest: High
   Importance: Responsible for the complete project from the project planning, implementation/development, and deployment and core team for project success.
3. **Sponsors**
   Role: Requirement providers
   Power: Medium
   Interest: High
   Importance: Provide support and resources, The satisfaction of the sponsor is the crucial part of the project success.

POWER - INTEREST GRID:

STAKEHOLDER	POWER	INTEREST	STRATEGY
Academic Mentor	High	High	**Manage Closely:** Ensure that the project goal is aligned to the work that's been done. Also ensure that there is a

			coordination and unity.
Development Team	High	High	**Manage Closely:** Daily stand-up meetings, weekly technical reviews, provide support and address all the concerns.
Sponsors	Medium	High	**Keep Satisfied:** Weekly updates, Address concerns, ensure that the project is aligned to the objective.

9. Communication Plan

COMMUNICATION ACTIVITY	**METHOD**	**FREQUENCY**	**PARTICIPANTS**	**PURPOSE**
Progress reports	Email	weekly	Academic Mentor, Sponsor, Developers	Update on project progress and milestones
Demos	Virtual meetings/ In-person	Bi- weekly	Sponsor, Developers	Showcase new features and gather feedback
Consultation meetings	Virtual meetings/ In- person	As needed	Academic Mentor or Sponsor	Discuss accuracy and effectiveness
Stand-up meeting	Video calls or WhatsApp	In every two days	Developers	Brief updates on progress and discuss any blockers

10. Quality Management Plan:

10.1 Key Performance Indicator:

- Communication setup between mother drone and soldier drone
- Getting the videos, and the exact location of the soldier drone by the mother drone

10.2 Change Management Plan

This project plan can be changed at any time during the project upon approval with the sponsor. In the first meeting the sponsor, he changed the project requirement regarding disaster management replacing application of virtual and mixed reality in mental health care and rehabilitation.

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