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IT CAPSTONE PROJECT – ON CAMPUS – 11522

PROJECT FINAL REPORT OF VR SIMULATION FOR DISASTER MANAGEMENT

SPONSOR: DR. RAM SUBRAMANIAN
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Table of Contents

INTRODUCTION

Disasters happen everywhere, whether it's a natural or man-made it possesses a lot of challenges to the emergency responders and the disaster management teams. There are a lot of significant limitations to the traditional rescue operations like at times we lose time searching wrong area, choosing the wrong methods of rescue operation and at times even taking the long route during all these errors that they make we are losing one life or putting someone in more danger that it should be.

Our project is on the development of Virtual Reality (VR) (Burdea, 2003) simulation for disaster management using Unity. Our objective is to enhance the effectiveness of emergency response team and real- time rescue operations by simulating a realistic disaster scenario within a city environment.

The project arises from the shortcomings of the Australian bushfire season of 2019-2020, also known as the Black Summer (Zander, 2023) and the floods that are happening globally and in various parts of Australia (Service, 2022). This terrible incident demonstrated the shortcomings of traditional methods for handling major emergencies, resulting in great suffering and casualties. Massive, affected areas, challenging terrain, and communication barriers made it difficult to act quickly and conduct rescue operations, which called for innovative approaches.

We studied the latest developments in VR technology application for disaster management through a thorough literature review, demonstrating a promising environment. Virtual reality (VR) technologies have shown promise in enhancing situational awareness and response coordination, ranging from flood simulations to wildfire surveillance systems.

The first challenges in our project's background were resolving problems with team coordination and resource accessibility. Nonetheless, important milestones were accomplished with tenacity and teamwork, such as the start of coding tasks and the completion of all project deliverables. Furthermore, on-time submissions and presentations demonstrated our dedication to fulfilling sponsor specifications and project deadlines.

Looking back, we can see that our project not only achieved its goals, but it also set the stage for future developments in disaster management techniques. Our goal is to revolutionize the way emergency responders prepare for and handle

crises by utilizing virtual reality simulations. This will help save lives and lessen the effects of future crises.

RESTATEMENT OF SCOPE AND REQUIREMENTS

In the initial phase of our project, it aimed to create a fully functional 2D Virtual Reality (VR) simulation, which is accessible using mobile VR devices, particularly Quest platform. This would allow users to immerse themselves in simulated scenarios, potentially incorporating a real-world data from the University of Canberra campus to improve the training environments realism. However, after recognizing the benefits of a 3D environment in upgrading the user immersion and simulation realism, our project scope was updated. This led to creating a 3D Virtual Reality simulation platform using Unity (unity, 2019), shifting the focus towards simulating flood disaster scenarios within a randomly generated realistic city environment. After the approval of our sponsor, Dr. Ram Subramanian, we updated our In-Scope of the project and included the requirements from our sponsor.

It includes the creation of 3D realistic city environment using Microsoft Unity and the deployment and management of soldier drones within the created environment. These drones were tasked with conducting survivor search operations, adding practicality and urgency to the training scenarios. Additionally, the project involved establishing robust communication channels between the soldier drones and the central drone, represented by the mother drone. This communication infrastructure facilitated efficient rely of survivor information, which enhance the coordination and response effectiveness during effectiveness during simulated disaster scenarios.

To ensure the projects methodologies were informed by current research and best practices, a systematic literature review was conducted. This review has gathered information and insights, grounding the project in established principles of disaster preparedness and response. Also, we had initial consideration for mobile VR access via the Quest platform, practical constraints and resource limitations led to its exclusion from the updated scope. Instead, our project was concentrated on the core functionalities of the 3D VR simulation platform and soldier drone operations within the context of flood disaster scenarios in a simulated city environment.

Recapitulating, our project aimed to develop a comprehensive VR simulation platform tailored for disaster preparedness training, incorporating advanced features like 3D environment creation, soldier drone operations for survivor search, and robust communication channel system. Our project focuses on

delivering effective and realistic training experiences for disaster emergency response teams.

IN - SCOPE:

- Development of a Virtual Reality (VR) simulation platform using Unity.
- Simulation of disaster scenarios within an environment
- Deployment and control of 4 soldier drones for survivor search.
- Building communication channel for soldier drones to relay survivor information to the mother drone.
- Conduct a systematic literature review.

OUT-OF-SCOPE:

- Real-world testing of simulation platform.
- Integration with external systems beyond the scope of the disaster management simulation.
- Long term maintenance and support beyond the initial deployment phase.
- Compliance with regulatory standards for drone operation in real-world scenarios.
- Conducting large-scale user studies or surveys to assess the effectiveness of the simulation in training.

PROJECT OUTCOMES

A. DELIVERABLES

a. **Literature Review:** The project conducts a through literature review with the existing research and best practices in disaster preparedness and response. This can provide insights and knowledge to inform the methodologies and approaches, to ensure it aligns with the project.
b. **Environment Creation:** Developing 3D environment models and assets representing a simulated city environment suitable for flood disaster scenarios. This includes creating realistic 3D environments within the VR simulation platform to facilitate effective training and preparedness exercises for disaster response personnel.
c. **Survivor Simulation:** Developing simulation for generating various survivor on different areas within the simulated environment. This involves creating survivors in the scenario, which can improve the realism and effectiveness of training exercises.
d. **Drone Development:** Mother Drone, Soldier Drone: The project designs and develops prototypes or models of both the mother drone (central control) and soldier drones. This includes developing the components

necessary for drone navigation, communication, and control systems within the simulated environment.

e. **Environment Scanning:** The project develops scanning technique using C# for capturing the survivors during line scan, to enhance the realism of the simulated environment. This involves creating methods for scanning and incorporating data, such as terrain features and building layouts, into the VR simulation platform, Unity.
f. **Communication Systems:** The project implements communication systems enabling interaction between the drones and central control. This involves establishing communication channels for the exchange of information from soldier drone to the mother drone and ultimately to human controller, facilitating coordination and collaboration during simulated disaster scenarios.
g. **Survivor Identification:** The project develops code for identifying and locating simulated survivors within the VR environment. This includes detecting and identifying simulated survivors based on various criteria, such as visual, enhancing the realism and effectiveness of training exercises.
h. **Display the Output:** The project designs and implement user interface and visualization tools for displaying simulation outputs and data. This includes creating user interfaces and visualization tools to present simulation outputs, drone activities, survivor information, and other relevant data to users, enhancing their understanding and decision-making during training exercises.
i. **VR Simulation Deployment:** The project deploys the completed VR simulation platform, including all components and functionalities, for use in training and preparedness exercises by disaster response personnel. This involves ensuring that the VR simulation platform is fully operational and accessible to users, facilitating effective training and preparedness activities.

B. ACHIEVEMENTS

a. **The project successfully developed a VR simulation platform for disaster management:** This achievement signifies the successful completion of our primary objective of the project. The team has developed a 3D VR simulation platform capable of simulating disaster scenarios, specifically focusing on flood disaster management within a simulated city environment. This platform provides a valuable tool for training and preparedness exercises for disaster response personnel.
b. **Integration of Drone Technology:** The successful integration of drone technology into the VR simulation realistic platform demonstrates the

project's ability to incorporate advanced technologies to enhance training scenarios. The development and deployment of both the mother drone (central control) and soldier drones enable simulated survivor search operations, adding a practical and dynamic element to the training exercises.

c. **Effective Communication Infrastructure:** The establishment of an effective communication channel between the soldier drones and mother drone is a critical achievement. This infrastructure enables seamless exchange of information between the drones, facilitating coordination and collaboration during simulated disaster scenarios. The robust communication system enhances the realism and effectiveness of the training exercises.
d. **In-Scope Development Completion:** Achieving completion of the in-scope development tasks indicates the project's ability to meet its objectives within the defined scope and timeline. Despite challenges and constraints, our team successfully delivered all planned functionalities and features of the 3D VR simulation platform, including environment creation, survivor creation, drone deployment, and communication channel.
e. **Demonstration of Output:** The successful demonstration of the VR simulation platform's output showcases its capabilities and functionalities. By presenting the simulation outputs, including drone activities, survivor information, and other relevant data, the team validates the effectiveness and usability of the platform for training and preparedness exercises. The demonstration provides stakeholders with tangible evidence of the project's progress and achievements.
f. **Potential for Future Expansion:** The project's completion not only fulfills its immediate objectives but also lays the foundation for future expansion and enhancement. The developed VR simulation platform, with its integrated drone technology and communication infrastructure, has the potential for further expansion. Future iterations of the platform could include additional features, scenarios, and technologies to address evolving needs and challenges in disaster management training and preparedness. This achievement underscores the project's long-term impact and scalability.

C. KEY PROJECT RESULTS OUTPUTS

The key project outputs illustrated the successful development and deployment of virtual reality simulation platform for disaster management. These outputs demonstrate the platform's efficiency in response for a rescue team.

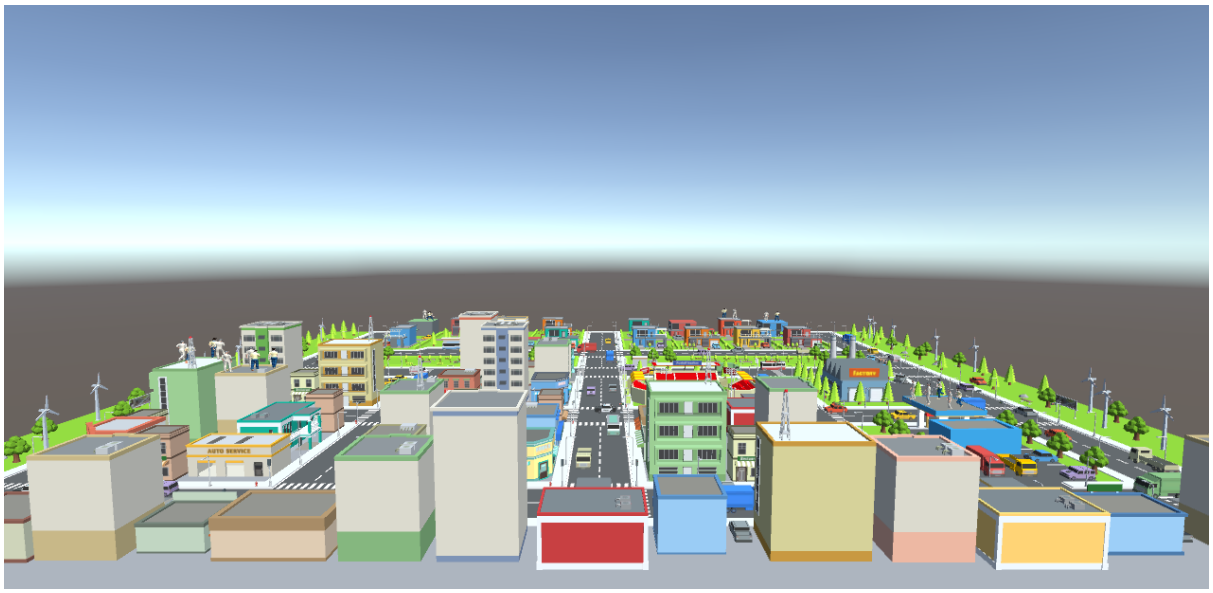


Figure 1 (assetstore.unity.com., n.d.). Initial scene the disaster environment without flood water or no drone deployment.

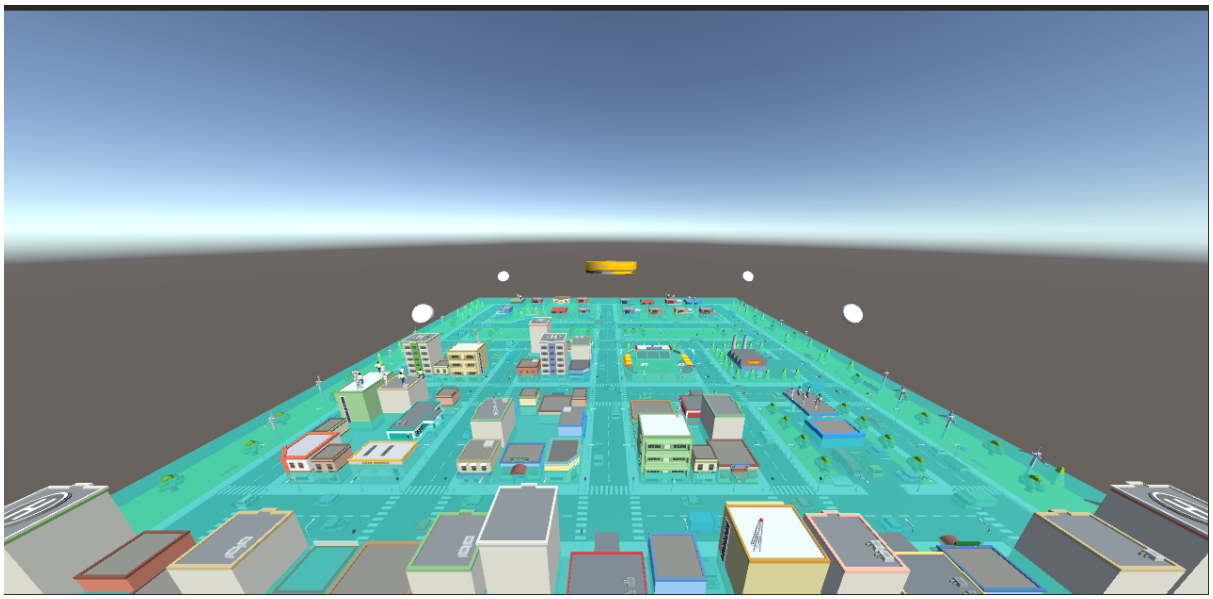


Figure 2. Flood water gradually raised, mother drone and soldier drones deployed into the disaster field.

Figure 3. Top view of the disaster environment. The four soldier drones scan the disaster environment by dividing it into four zones and uses in a line scan method going from one coordinate to the next with in the zone.

Figure 4. Multi camera display integrated to display what all the four soldier drones see.
The Soldier drones find the survivors in area and identify number of survivors in a particular area and report that to the mother drone.

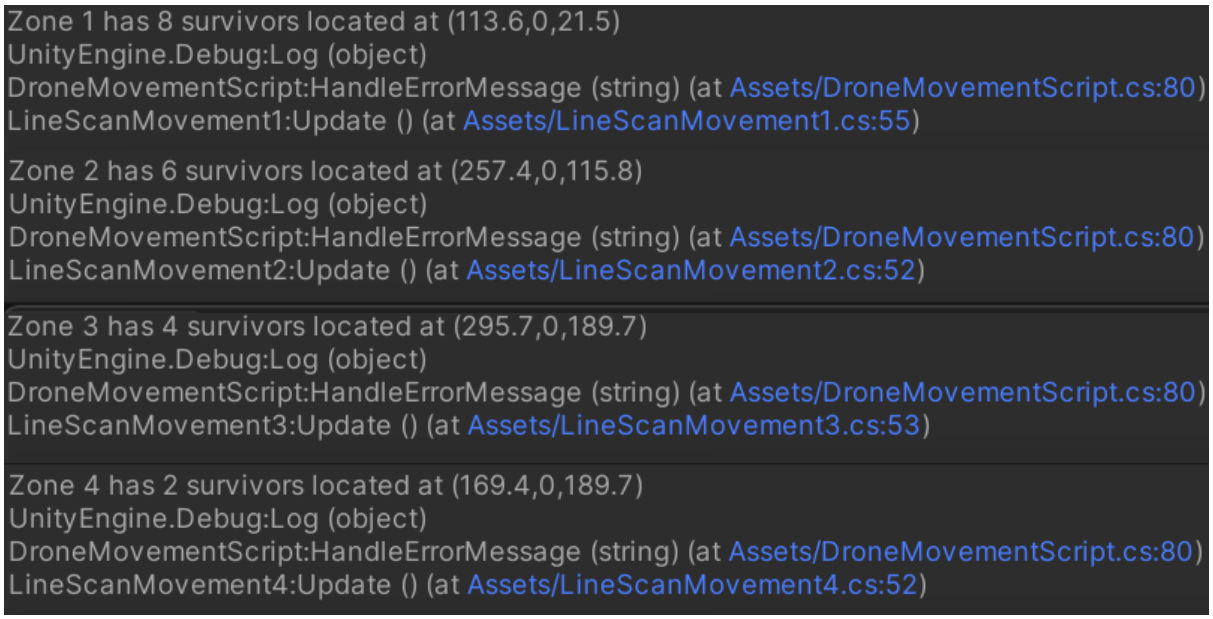


Figure 5,6,7,8. The Four Soldier drones send the information to the mother drone from the four different zone. (the total number of survivors and the location that is the coordinates) and The Mother drone receives the information from the soldier drones.

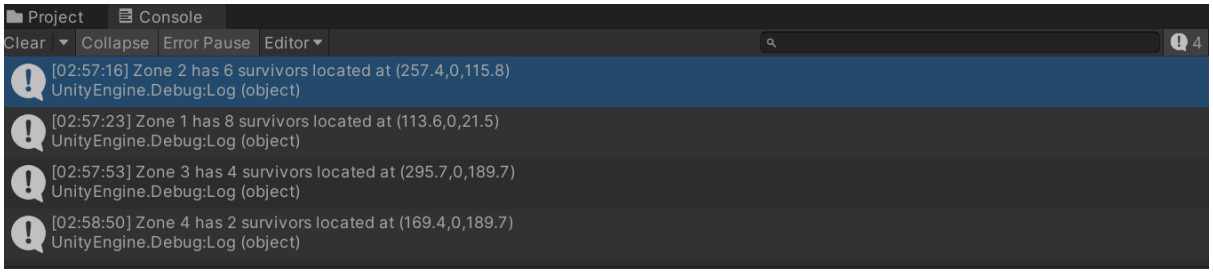


Figure 9. Mother drone displays the number of survivors in each zone via the console to the human controller and Disaster management teams uses this information to allocate more resources for rescue where there are a greater number of survivors.

D. ALIGNMENT WITH KPIs

The success of our project align with our outcomes based on the key performance indicators that reflects on our objective. These are the revised KPIs from the project proposal.

a. **Completion of Deliverables:** measure the status of each deliverable mentioned in the project proposal. This includes the literature review, VR simulation development, and deployment.

b. **Project Timeline:** Evaluate whether the project was completed within the planned timeline.

c. **Technical Performance:** Assess the technical performance of the VR simulation platform. This includes the performance , accuracy , response time and stability.

d. **User Satisfaction:** Gather feedback from project sponsors, mentors, and co- team members , to assess their satisfaction with the VR simulation.

e. **Skills Development:** New skills and knowledge was developed by project team members during the course of the project. that include the coding skills using C# and unity and its working .

f. **Risk Management Effectiveness:** Evaluate the effectiveness of risk mitigation strategies implemented during the project. This could involve comparing identified risks with actual occurrences and assessing the impact of mitigation efforts on project outcomes.

g. **Quality of Documentation:** Assess the quality and completeness of documentation provided in the final report and the deliverables that's provided to the sponsor

h. **Alignment with Stakeholder Expectations:** Measure the extent to which project outcomes align with the expectations and needs of project sponsors and mentors.

E. QUALITY ASSURANCE MEASURES

Throughout the project, the team strived to achieve a product of utmost quality. The context of Quality in this VR simulation project was defined using certain attributes such as proper functionality, seamless performance, usability, and reliability of the simulation. Keeping this in mind the team made it a point to adhere to the best practices in every aspect of the project to achieve a product of good quality.

Quality control measures deployed:

- **Inspections of the current model:** Rigorous inspections of the current model that was used and the results generated due to the usage of the current model were used to ensure that the end product was of better quality.
- **Testing of the model:** By testing the current model we were able to provide a more stable and working solution to the problem. The model testing also helped to show the future issues with using a particular model.
- **Using coding best practices:** Writing code in a more clear and spaced-out format with some comments aids in better readability and troubleshooting when using debugging protocols. This makes it much easier for the identification of potential issues.
- **Defect Identification and Management:** We implemented the code and checked for errors in the functionality of the code and ensured that the simulation made total sense until we progressed into the next part of the project. This ensured that the defects in the project were constantly detected and managed aiding in better quality of the product.
- **Data-based Feedback implementation:** Based on the data from the model we were able to adjust the working of the project and produce better and congruent results this helped to improve the speed and functionality of the project thus contributing to better quality.
- **Continual updating of the project functionality:** We broke down the development phase into smaller parts with multiple testing phases after each iteration. This format allowed us to incorporate the various objectives of the project and create a more robust product thus leading to better quality.

These Quality control measures played a very key role in delivering a superior VR simulation deployment, ultimately fulfilling the project's requirements.

F. IMPACT

This section explores the impact of the project on its intended audience, stakeholders, and the organization it serves. This impact analysis helps us understand the project's overall value proposition. This project uses a VR simulation tool that can significantly improve disaster preparedness and response. Some of the potential impacts include

- **Enhanced Training:** The usage of Virtual reality technology aids in the Immersive training which would allow the emergency responders to practice the scenarios and make better decisions thus providing better response skills during the disaster management scenarios.
- **Improved Coordination:** The various Communication protocols that are developed in the simulation can be extrapolated into other simulation environments thus translating into better coordination between response teams during real disasters.
- **Reduced Risks:** Familiarization with potential hazards by using a simulation instead of a real-world scenario can minimize risks associated with getting injured or facing severe injury. Thus by employing simulations, we can ensure a safer and more better understanding of the disasters.
- **Increased Confidence:** By Training in a safe virtual environment, the emergency responders can get a better boost in confidence during the time of disaster situation this would lead to better and more effective disaster response.
- **Better preparedness:** Employing the VR simulation should make sure that the customer is more inclined to be in a situation where there is a natural disaster. this bolsters a sense of preparedness that helps during these critical times.

REPORT ON RESOURCES

The project required an extended use of resources to be used in order for it to come to light. Some of the resources used are discussed in detail below.

Human Resources:

There was a fair share of human resources that was used for the project.

- **Project team size:** 4 people
- **Total hours spent by the project as a team as of 1/05/2024:** Approximately 900 hours for the overall team

- **Individual hours spent on the project:** Approximately 225 hours per team member.

Tools and Technologies:

- **Simulation Building Environment:** For the simulation, we used Microsoft Unity Engine
- **Programming Languages Used:** we used C# to enable functionality in Microsoft Unity Engine.

Lab Resources:

- Access to the University Of Canberra's Human Machine Interaction AR/VR Laboratory.

REPORT ON OUTSTANDING ISSUES

This report highlights unresolved issues and challenges that may impact post-project operations. Timely resolution of these issues is critical for the continued project success. There are no major outstanding issues as of 01/05/2024 with the project functionality and deployment. However, future development phases will need to address the following issues to manage the project and enable the usage of the project in real-world scenarios.

- **Expansion to a fully immersive 3D VR experience:** The future scope of the project aims to create a fully immersive 3D VR Experience for this application.
- **Integration of the Meta Quest VR platform:** The future scope of the project aims to integrate the simulation into the Meta Quest VR Platform.
- **Incorporation of real-world data from the University of Canberra campus area:** The future scope of the project aims to incorporate real-world locations based on maps.
- **Development of a user interface for user interaction within the simulation:** The future scope of the project aims to develop a user interface that can be used to interact with the simulation which would require more UI components.
- **Deployment of the simulation in real life using drones and human controllers:** The future scope of the project aims to deploy drone technology into the real world in order to enable real-life disaster management

Next Steps To Combat These Issues:

- Assign product owners to each outstanding issue.

- Develop a proper timeline to resolve each issue.
- Communicate the issues that have been identified and pass the resolution plan to all relevant stakeholders.
- Regularly monitor the project's progress while resolving these issues and update the reports as required.

By proactively addressing these outstanding issues, there can be a better successful post-project operation.

REPORT OF RISK MITIGATED

RISK DESCRIPTION	LIKELIHOOD	IMPACT	PROPOSED MITIGATIN STRATEGY	OUTCOME	CURRENT RISK	COMMENTS
Scope Creep	Medium	High	The revised scope is clearly defined and documented	Mitigated	Low	The focus was on the objectives and requirements.
Technical Challenges with unity	High	High	The team members regularly reviewed the code and research.	Mitigated	Low	The team resolved all the challenges efficiently.
Ethical Considerations	Medium	Medium	Create a safe and realistic stimulation environment.	Mitigated	Low	The environment was prioritized as user safe.
Resource Constrains	High	High	Efficient use of available resources by prioritizing task.	Mitigated	Low	Additional resources were secured to overcome the limitations.
Unrealistic Timelines	Medium	High	Adjustment in the project timeline and regular reviews of the work.	Mitigated	Ongoing	The timelines are monitored and maintained based on the project progress.
Communication Breakdown	Medium	High	regular meeting and establish a clear communication medium like	Mitigated	Low	Clear communication channel was established and had a

			email or WhatsApp.			100% team collaboration.
Sponsor and mentor disagreement	Low	Medium	Frequent meeting and updating the progress of the project.	Mitigated	Low	Kept them informed throughout the project.
Presentation date changed	Low	High	Informed unit convenors about the issue and secured another presentation slot as a backup	Mitigated	Low	Mitigating plan effectively by addressing the unexpected change in presentation date.
Resource constraints (laptop)	Low	High	Requested sponsor for suitable laptop for the coding part.	Mitigated	Low	Sponsor supported and resolved the resource constraints.

REPORT OF LESSONS LEARNED

Team Development

	Forming	Storming	Norming	Performing
What Happened?	• Week 2: formed group • Team introduction • Identifying the project lists based on our skills. • Went for second round of project allocation	• Allocated the team leader, and established communication channels. • Normalizing the project matters by developing project management plan • Week 8: Discussions about coding logics and lab usage	• Started having meetings with mentors and sponsors, got clear descriptions of scenarios. • Week 9: coding implementation started making progress	• Working on the project coding till week 12 • Week 11 meeting with the sponsors and got positive feedback with the project progress. • Finalizing the coding and working on the final report- week 13

The above table shows our project team dynamics based on the Tuckman's stages of the group development. At week 2, we formed the group, have introduction with one another and identify the projects lists based on our skills, but unfortunately, we had to go for second round of project allocation.
After finalizing the group project, we started allocating our team tasks and started working on developing project management plan after having the first introductory meeting with the mentor and sponsor. As depicted in the above table, there is a significant time gap between forming and storming phase, the project started making some progress after week 9 and at week 11 and got positive feedback from the sponsors and working towards the project closure. Because of the tight schedule in the project implementation, we come to the following lesson learnt:

- **Team communication:** Since, we had limited lab resources, we all had to work on the same time and had to work on the same schedule. This made us to communicate more, and we could have done much better even with the proper communication with the team and with the sponsors to check our progress within the lab.
- **Leadership and Task division**: Working on the same set of code and on the same computer has significant setbacks specially with the task management. And we could have made much progress if we could have done our task management properly.

HANDOVER MATERIALS

Handover materials	**Description (Deliverables include)**	**Submitted to**	**Submission Date**
Project management plan	Project scope, timeline, budget, resources, milestones, quality management plan, risks	Sponsors and mentor	1 March 2024
Project progress report	Prototypes, literature review, draft project report, progress description till the report creation	Mentor	19 April 2024
Meeting minutes	Meeting date, participants, and agendas	Mentor	6 May 2024 (This includes all the meeting minutes combined)
Literature Review	Research on project problems and solutions	Sponsor	6 May 2024

Working Unity Code (in .Zip files)	Working 3D flood disaster simulation environment built in Unity.	Sponsor	6 May 2024
Peer evaluation report	Individual marks given for each team members for the teamwork.	Unit convenors	26th April 2024
Project presentation and presentation file submission	Presentation Infront of the project panel and explain the complete project including demonstration.	Project panel	26th April 2024
Project poster	Submit a A0 size poster including all information on the poster.	Unit convenor	26th April 2024
Project Report	Updated project management plan, compare against the timelines and critical success factors, and comprehensive description of project deliverables and description	Mentors and sponsors (if they ask)	1 May 2024

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.

Research by (Biao Xie et al.,2021) emphasizes the advantage of 3D VR simulations in improving the training environments and realism. According to Merriam Webster, training is defined either as 1) the act, process, or method of one that trains and 2) the skill, knowledge, or experience acquired by one that trains; or the state of being trained. Conventionally, training happens with physical setups such as classrooms and laboratory spaces through presentations and hands-on practice. However, there are cases in which trainees must travel to specific facilities to receive proper training. To date, VR technology makes it possible to provide real-world training through virtual environments while providing an effective and immersive training experience.
As virtual environments are used to train users to perform real-world tasks and procedures, it is important to compare real-world training with VR-based training. In general, real-world training has the following limitations: 1) it could be time-consuming due to the efforts and time needed to set up the real-world training site and to travel to the site; 2) it could be expensive due to the cost of preparing real-world training materials and hiring human coaches; 3) it could be unappealing and unintuitive due to the lack of visual hints such as 3D animations for illustrating skills and processes; and 4) it could not be possible to train some skills in the real world such as emergency procedures that can be only safely trained in simulators.
Depending on the domain, VR could drastically reduce the cost of training while increasing the number of training scenarios. As VR training scenarios mainly involve computer-generated 3D graphics, VR developers can easily create a variety of scenarios from existing 3D assets, which can be repeatedly applied for training different people. Delivered through the internet, the scenarios are also convenient and inexpensive to access. Although VR training does not guarantee a lower cost, the advantages that those systems bring to the training audience could justify the investment costs. VR training provides a safe environment with

minimal exposure to dangerous situations [e.g., fires Backlund et al., 2007; Conges et al., 2020; explosions, and natural disasters Li et al., 2017]. For example, an instructor can control a virtual fire (position, intensity, and damage caused) in which a firefighter is being trained to evacuate a building. Such scenarios could allow people to easily train in a safe environment that mimics real-world challenges (Xie, 2021).
Research also emphasizes the integration of drone technology into 3D VR simulations. Iqbal, U.; Perez, P.; Li, W.; Barthelemy, J. (2021) emphasis that Floods are one of the most frequent, widespread, and costly natural disasters in the world and the interdisciplinary nature of disaster management (Iqbal, 2021)and technology has hindered the rapid deployment of technological solutions in this domain. However, recently, the trend has been shifted and technology has been widely used to support disaster management activities. Unmanned aerial vehicles (UAVs) are one of the potential technological platforms which can efficiently be used to facilitate the disaster management process. (Iqbal, 2022) (Iqbal, U.; Barthelemy, J.; Perez, P.(2022)). Barber et al.2021 and Redding et al.2021 utilized drone's positions, attitudes, and camera angles to map the pixel locations of target objects to their real-world coordinates with approximately 4–11 m of error.
Simulation is a very important and cost-effective tool, especially if an actual real-life implementation is costly or associated with hazardous conditions. the research presented in the study by Visser et al. showed the importance of developing a simulator, called "AR.Drone," with advanced navigation capability using realistic sensor and motion models. This study has added practical dimension to training exercises, allowing responders to familiarize themselves with drone operations and can practice in a safe and controlled virtual setting.

In conclusion, there has been a significant surge in Virtual Reality (VR) for improving disaster management training. This can provide emergency responders with realistic training in a safe and controlled environment, and which is cost effective compared to other methods. Moreover, the integration of drone can help the responders to familiarize themselves with the drone operations in a virtual controlled setting. The technology holds immense potential to revolutionize disaster management training by providing more interactive experience that improve responder preparedness and effectiveness in real-world emergencies.
The inputs from the conducted literature review have contributed to our project's success, and main points are:

- Drawing from the research on XR technology, especially VR, our project developed a training simulation platform for disaster management. Simulation of realistic disaster scenario in virtual environments, emergency responders were provided with a safe and effective platform to practice essential skills required in the real-world emergencies.

- Then informed by the studies on realistic environment, our project focused on creating 3D virtual environment that closely resembles actual disaster scenario, here we focused on flood simulation. This detail ensured that the responders were exposed to these challenging training situations and thereby improve their decision-making abilities and response effectiveness.
- The research also focused on the importance of drone technology in disaster management made the inclusion of drones to the project for survivor search. Responders could also gain valuable experience in utilizing drones for surveillance, and situational awareness during emergencies.
- Insights on the communication system from the literature has made the communication between the drones within VR simulations. It enabled effective collaboration and coordination during simulated disaster scenarios.
- Research also highlighted the cost-effectiveness and safety benefits of VR based training compared to traditional methods. Our project minimized the need for physical setups and reduced the risk of exposure to dangerous conditions, which ensured a safer and more efficient training experience.

Overall, our project's success can be attributed to the integration of 3D Virtual environment, drone operation for survivor search, and advanced communication infrastructure, all factors relevant were the insights from the literature review on disaster management and Virtual Reality.

Final working Code:

These are important screen short of some of the main parts of the code that demonstrate all the key function of the project.

```
using UnityEngine;

1 reference
public interface InterfaceMessageHandler
{
    5 references
    void HandleErrorMessage(string errorMessage);
}

Unity Script (1 asset reference) | 8 references
public class DroneMovementScript : MonoBehaviour, InterfaceMessageHandler
{
    [SerializeField] private float movementForwardSpeed = 5000.0f;
    [SerializeField] private float rotationSpeed = 2.5f;
    [SerializeField] private float lerpSpeed = 10f; // Adjust for desired smoothness
    [SerializeField] private float tiltAmountForward = 0.0f;
    [SerializeField] private float strafeSpeed = 5000.0f; // Adjust for desired strafe speed

    private Rigidbody ourDrone;
    private float wantedYRotation;

    Unity Message | 0 references
    void Awake()
    {
        ourDrone = GetComponent<Rigidbody>();
    }

    Unity Message | 0 references
    void FixedUpdate()
    {
        MoveUpDown();
        MoveForward();
        Rotate();
        MoveLeftRight();
    }
```

Fig.: 1 Code that will set the drone movement speed: forward movement, rotation, desired smoothness, tilt forward and strafe speed

```
1 reference
void MoveUpDown()
{
    float upForce = 98.1f;
    if (Input.GetKey(KeyCode.I))
    {
        upForce = 8500.0f;
    }
    else if (Input.GetKey(KeyCode.K))
    {
        upForce = -8000.0f;
    }
    ourDrone.velocity = new Vector3(ourDrone.velocity.x, ourDrone.velocity.y, 0.0f);
    ourDrone.AddRelativeForce(Vector3.up * upForce);
}

1 reference
void MoveForward()
{
    float targetSpeed = Input.GetAxis("Vertical") * movementForwardSpeed;
    ourDrone.velocity = Vector3.ClampMagnitude(Vector3.forward * Mathf.Lerp(ourDrone.velocity.z, targetSpeed, lerpSpeed * Time.deltaTime), movementForwardSpeed);
}

1 reference
void Rotate()
{
    float currentYRotation = 0.0f;
    float rotationYVelocity = 0.0f;

    if (Input.GetKey(KeyCode.J))
    {
        wantedYRotation -= rotationSpeed;
    }
    if (Input.GetKey(KeyCode.L))
    {
        wantedYRotation += rotationSpeed;
    }
```

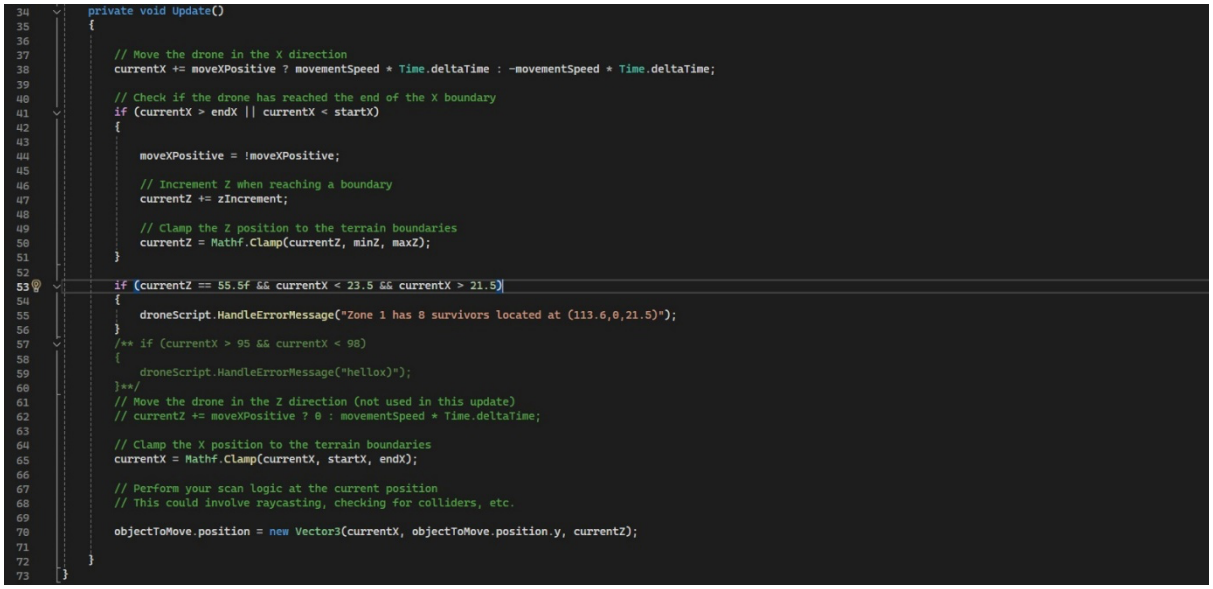
Fig.: set the up force and target speed

```
        currentYRotation = Mathf.SmoothDamp(currentYRotation, wantedYRotation, ref rotationYVelocity, 0.05f);
        ourDrone.rotation = Quaternion.Euler(new Vector3(tiltAmountForward, currentYRotation, ourDrone.rotation.z));
    }

    // New function for left-right movement
    1 reference
    void MoveLeftRight()
    {
        float strafeForce = strafeSpeed * Input.GetAxis("Horizontal");
        ourDrone.AddForce(transform.right * strafeForce);
    }

    5 references
    public void HandleErrorMessage(string errorMessage)
    {
        Debug.Log(errorMessage);
    }
}
```

Fig.: Get the drone movement along the horizontal axis

```
using UnityEditor.UI;
using UnityEngine;
using System.Linq;

Unity Script (1 asset reference) | 0 references
public class LineScanMovement1 : MonoBehaviour
{    // zone 1
    [SerializeField] private Transform objectToMove; // Reference to the object to be moved
    [SerializeField] private float movementSpeed; // Speed of the object's movement
    [SerializeField] private float scanResolution; // Optional: Distance between scan points (not used in this update)

    private float startX = -30.7f; // Minimum X coordinate
    private float endX = 120.4f; // Maximum X coordinate
    private float minZ = 10.5f; // Minimum Z coordinate
    private float maxZ = 110f; // Maximum Z coordinate

    private bool moveXPositive = true; // Flag to indicate positive or negative X movement
    private float currentX;
    private float currentZ;
    private float zIncrement = 15.0f; // Amount to increment Z when reaching a boundary (adjust as needed)

    Unity Message | 0 references
    private void Start()
    {
        currentX = startX;
        currentZ = minZ;
    }

    DroneMovementScript droneScript;

    Unity Message | 0 references
    private void Awake()
    {
        droneScript = FindObjectOfType<DroneMovementScript>();
    }
```

Fig.: Set the maximum moving coordinate in all three dimensions. 'drone Script' will find out the object type assigned to the survivor which will be detected by drone movement.



```
private void Update()
{

    // Move the drone in the X direction
    currentX += moveXPositive ? movementSpeed * Time.deltaTime : -movementSpeed * Time.deltaTime;

    // Check if the drone has reached the end of the X boundary
    if (currentX > endX || currentX < startX)
    {

        moveXPositive = !moveXPositive;

        // Increment Z when reaching a boundary
        currentZ += zIncrement;

        // Clamp the Z position to the terrain boundaries
        currentZ = Mathf.Clamp(currentZ, minZ, maxZ);
    }

    if (currentZ == 55.5f && currentX < 23.5 && currentX > 21.5)
    {
        droneScript.HandleErrorMessage("Zone 1 has 8 survivors located at (113.6,0,21.5)");
    }
    /** if (currentX > 95 && currentX < 98)
    {
        droneScript.HandleErrorMessage("hellox)");
    }**/
    // Move the drone in the Z direction (not used in this update)
    // currentZ += moveXPositive ? 0 : movementSpeed * Time.deltaTime;

    // Clamp the X position to the terrain boundaries
    currentX = Mathf.Clamp(currentX, startX, endX);

    // Perform your scan logic at the current position
    // This could involve raycasting, checking for colliders, etc.

    objectToMove.position = new Vector3(currentX, objectToMove.position.y, currentZ);

}
}
```

Fig.: move the drone in horizontal direction, while moving, push the survivor information to the interface (x number of survivor in x boundary)

RECOMMENDATIONS TO SPONSOR

Project management related:

- Early access to the lab: As we mentioned the gaps in the project progress could have been reduced if we could get the lab resources earlier which was beyond our control. We know that the sponsors were busy, and they made most of our meetings but still, we could have started earlier and completed the project milestones as per the project management plan.
- Communication and lab access: Working on Unity requires good computing power, and we had to ask the sponsors to get the resources. If the sponsors could allocate the resources during the start of progress, the project implementation would be much smoother even for the future projects.
- The project team recommends proceeding with the next phase of development, which could involve transitioning to a full 3D VR environment and incorporating additional disaster scenarios (e.g., earthquakes, wildfires).

Unity and Disaster related:

- Exploring more advanced flood simulation techniques (e.g., water physics, wave propagation): Our project mainly focuses on the communication part of the drones when triggered by the flood. We have only implemented one of the disaster scenes, but the project would be much more interesting if we could implement more disaster scenes.

- The sponsors could add up more human identifying tools and some camera vision tools to get the victims record more explicitly.
- User testing with disaster management professionals would be valuable for refining the simulation's effectiveness and ensuring practical training value.

OPPORTUNITIES FOR FUTURE DEVELOPMENT

a. **Real-world testing of simulation platform:** Opportunity for conducting real-world testing and validation of the VR simulation platform in collaboration with disaster management agencies or organizations. This would involve field trials and exercises to assess the platform's effectiveness in simulating and addressing real-world disaster scenarios, providing valuable feedback for further refinement and improvement.
b. **Integration with external systems beyond the scope of the disaster management simulation:** Opportunity to explore integration with external systems and technologies beyond the scope of disaster management simulation. This could include alongside other emergency response systems, IoT devices, inclusion of Artificial Intelligence or geographic information systems (GIS), enhancing the platform's capabilities and utility for comprehensive disaster preparedness and response.
c. **inclusion of Mobile VR Access via Quest Platform:** In this project we could potentially include mobile VR access via platforms like Quest which can expand the platforms reach and accessibility. The inclusion of Oculus Quest, emergency responders can access training scenarios remotely, enabling more flexible and convenient training options. This can improve the platforms usability which allows the different range of users to benefit from this disaster management training experiences.
d. **Compliance with regulatory standards for drone operation in real-world scenarios:** Opportunity to address regulatory compliance requirements for drone operation in real-world scenarios. This could involve collaborating with regulatory agencies and stakeholders to ensure that the platform meets all necessary standards and regulations for safe and legal drone operation, enabling its use in actual disaster response operations.
e. **Enhanced Scenario Variation:** In this project we can include a wider range of disaster scenarios beyond flood, such as earthquake, wildfires, and pandemics, can provide responders with more diverse training experience. This could help emergency responders to train in different types of emergencies effectively.
f. **Real-time Map, Location and Dynamic Environmental Integration:** In this project we can also potentially incorporate real-time map and location integration alongside dynamic environmental conditions, that provides

realistic training scenarios. Responders can train in areas which resembles to the disaster areas with specific landmarks and geographical features. Different weather patterns and terrain change add unpredictability, which can improve preparedness for real-world disasters.

CONCLUSION

In conclusion, Through the development of Virtual Reality simulation platform with a realistic disaster scenario with a city environment and survivors our project aims to enhance the effectiveness of all the emergency response team and that could potentially help them in the real time rescue operation.

Throughout our project we did come across a lot of challenges from the initial phase of not being familiar with the platform unity and obstacles like the coordination issues with the technical side of the project and many more. However, we did overcome all of that through a good teamwork and communication that in turn made us achieve this milestone.

From literature review to the development phase to the deployment of the project as a desktop simulation our project met all the sponsor requirements and deliverables. Ensured that the project objective and the goals are always aligned to the project requirements. Reflecting on our journey, we understand the significance of continuous improvement and critical thinking and our project demonstrate the same.

In the end, our ultimate goal remains unchanged: “to empower emergency responders, mitigate the effects of future disasters, and ultimately, to save lives. With dedication, collaboration, and a commitment to excellence”, we are confident in the impact of our project on the future of disaster management.

REFERENCES

Al-Mousa, A., Sababha, B.H., Al-Madi, N., Barghouthi, A. and Younisse, R. (2019). UTSim: A framework and simulator for UAV air traffic integration, control, and communication. *International Journal of Advanced Robotic Systems*, 16(5), p.172988141987093. doi:https://doi.org/10.1177/1729881419870937.

assetstore.unity.com., n.d. *SimplePoly City - Low Poly Assets | 3D Environments | Unity Asset Store.*. [Online]
Available at: https://assetstore.unity.com/packages/3d/environments/simplepoly-city-low-poly-assets-58899.

Burdea, G. a. C., 2003. *Virtual Reality Technology.* [Online]
Available at:
https://books.google.com.au/books?hl=en&lr=&id=0xWgPZbcz4AC&oi=fnd&pg=PR13&dq=vr+technology&ots=LFevjU3Jbw&sig=DvsVM2cmQWw9rDvxvsaxaLL-O0Q#v=onepage&q=vr%20technology&f=false

Canberra, U. of. (2019, November 20). UC Home. UC Website. https://www.canberra.edu.au/

Iqbal, U. P. P. L. W. a. B. J., 2021. *How computer vision can facilitate flood management: A systematic review. International Journal of Disaster Risk Reduction, 53, p.102030.*. [Online]
Available at: https://doi.org/10.1016/j.ijdrr.2020.102030.

Iqbal, U. B. J. a. P. P., 2022. *Emerging role of unmanned aerial vehicles (UAVs) for disaster management applications. Elsevier eBooks, pp.281–301.*. [Online]
Available at: https://doi.org/10.1016/b978-0-323-91166-5.00007-0.

Nath, N.D., Cheng, C.-S. and Behzadan, A.H. (2022). Drone mapping of damage information in GPS-Denied disaster sites. *Advanced Engineering Informatics*, 51, p.101450. doi:https://doi.org/10.1016/j.aei.2021.101450.

Project-Management.com. (2018, December 11). The Project Handover Checklist. Project-Management.com. https://project-management.com/the-project-handover-checklist/

Service, A. C., 2022. *floods.* [Online]
Available at: https://www.acs.gov.au/pages/floods

Simulation exercises. (n.d.). Www.who.int. Retrieved May 1, 2024, from https://who.int/emergencies/operations/simulation-exercises

Tutorial Unity3d Flying Drone 2.1 - Levitating/Up/Down Movement. (n.d.). Www.youtube.com. https://www.youtube.com/watch?v=3R_V4gqTs_I&list=PLPAgqhxd1Ib1YYqYnZioGyrSUzOwead17

Tuckman, B. W. (1965). Developmental sequence in small groups. Psychological Bulletin, 63(6), 384-399.

Xie, B. L. H. A. R. Z. Y. J. Y. L. F. L. C. L. W. H. H. A. M. M. C. a. Y. L.-F., 2021. *A Review on Virtual Reality Skill Training Applications. Frontiers in Virtual Reality, [online] 2.* [Online]
Available at: https://doi.org/10.3389/frvir.2021.645153

unity, 2019. *microsoft unity.* [Online]
Available at: https://unity.com/

Zander, K. G. S. O. R. A. M. a. N. D., 2023. *Trends in bushfire related tweets during the Australian 'Black Summer' of 2019/20. Forest Ecology and Management,.* [Online]
Available at: https://www.sciencedirect.com/science/article/pii/S037811272300508X