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College of Computing, Informatics, and Mathematics
Universiti Teknologi MARA Cawangan Melaka, Kampus Jasin
77300, Merlimau, Melaka Bandaraya Bersejarah

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EDITORS

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PREFACE

Welcome to the inaugural volume of the **Progress in Computing and Mathematics Journal (PCMJ)**, a publication proudly presented by the College of Computing, Informatics, and Mathematics at UiTM Cawangan Melaka.

This journal represents a significant step in our commitment to fostering a vibrant research culture, initially providing a crucial platform for our undergraduate students to showcase their intellectual curiosity, dedication to scholarly pursuit, and potential to contribute to the broader academic discourse in the fields of computing and mathematics. However, we envision PCMJ evolving into a beacon for researchers both nationally and internationally. We aspire to cultivate a space where groundbreaking research and innovative ideas converge, fostering collaboration and intellectual exchange among established scholars and emerging talents alike.

The manuscripts featured in this first volume, predominantly authored by our undergraduate students, are a testament to the hard work and dedication of these budding researchers, as well as the guidance and support provided by their faculty mentors. They cover a diverse range of topics, reflecting the breadth and depth of research interests within our college, and set the stage for the high-quality scholarship we aim to attract in future volumes.

As editors, we are honored to have played a role in bringing this journal to fruition. We extend our sincere gratitude to all the authors, reviewers, and members of the editorial board for their invaluable contributions. We also acknowledge the unwavering support of the college administration in making this initiative possible.

We hope that PCMJ will inspire future generations of students and researchers to embrace research and innovation, to push the boundaries of knowledge, and to make their mark on the world of computing and mathematics.

Editors
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TABLE OF CONTENTS

PCMJ

Progress in Computer and Mathematics Journal (PCMJ)
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SIMULATING FLOOD DISASTER USING AUGMENTED REALITY APPLICATION

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Abstract

This study introduces the Flood Survival Augmented Reality (AR) application as a solution for young adults unfamiliar with floods and seeking to learn more about flood preparedness. The application was developed using Agile Methodology and addressed the issues of lack of awareness of flood risks and the lack of preparation necessary to face frequent flood disasters. By creating an immersive AR application, it helps individuals gain a better understanding of how to prepare for flood disaster scenarios, emphasizes the importance of flood preparation, and aids in learning the ideal course of action when flood disasters occur. The objectives of this project are to create 3D models of objects for simulating flood disasters, to develop a flood disaster simulation application, and to evaluate the usability of the flood disaster simulation application. Recent evaluations confirmed its usability score to be 73.5% on the System Usability Scale (SUS), indicating good usability of the application.

Keywords: Flood; Augmented Reality; AR; Disaster Simulation

INTRODUCTION

Many different types of natural disasters occur in Malaysia, with floods being the most prevalent and dangerous hydro-meteorological hazard (Sa Don et al., 2023). Due to several factors, such as unrestricted development, the rise of sea level, recurring rainfall, and torrential monsoonal downpours, Malaysia frequently experiences floods. Floods have a negative impact on society’s way of life by seriously damaging the nation’s infrastructure, socioeconomic stability, and psychological and mental well-being. The increase in development raises the risk of floods by lowering the capacity of the soil to store water.

The most common types of floods in Malaysia are flash floods, monsoon floods, and floods caused by high tides (Sa Don et al., 2023). Floods usually arise from a series of circumstances. Rainfall, for instance, overflows ditches, streams, and rivers (Ahmad Basri et al., 2022). Then, riverbanks and flood defences are overflowed by floodwater. Sometimes, rainfall is so heavy that it cannot soak into the earth or enter sewer systems. The water instead runs across land and down the hills and slopes. Homes and buildings in low-lying areas or at the foot of slopes may be at risk. Domestic sewage may pollute floodwater in towns and cities. Furthermore, when continuous, heavy rain enters the ground, it will result in ground saturation. Due to this occurrence, groundwater levels will rise, causing flooding above ground.

The technology applied in this project is AR. AR is the interactive process of placing information created by computers in the real environment. This is accomplished by adding digital imagery anchored to specific locations in the environment to real-time visuals of the surrounding environment (Tomkins & Lange, 2019). Furthermore, AR can help users visualize the real situation during flood disasters and provide interactivity to users.

LITERATURE REVIEW

The literature review of this project began by delving into the concept of flood disaster. A flood is defined as the flooding of water onto otherwise dry land, and its occurrence may be attributed to numerous factors, including excessive rainfall, slow water drainage, dam breaches, and severe atmospheric conditions, according to the US National Weather Service. Furthermore, climate change is expected to raise the occurrence and severity of floods due to the inconsistent rainfall trends observed in Southeast Asia throughout the Northeast and Southeast monsoons (Ahmed et al., 2018; Barros et al., 2014; Mohd Taib et al., 2016).

Over the last three decades, the frequency of flood disasters has grown substantially worldwide (Kourgialas & Karatzas, 2011). Though the number of casualties for each flood disaster was practically consistent between 1980 and 1990, it significantly declined after 2000, despite a considerable rise in the frequency of floods (Parker et al., 2007). It is estimated that the frequency of natural disasters will exceed current numbers by double before 2050, impacting more people (Abid et al., 2021).

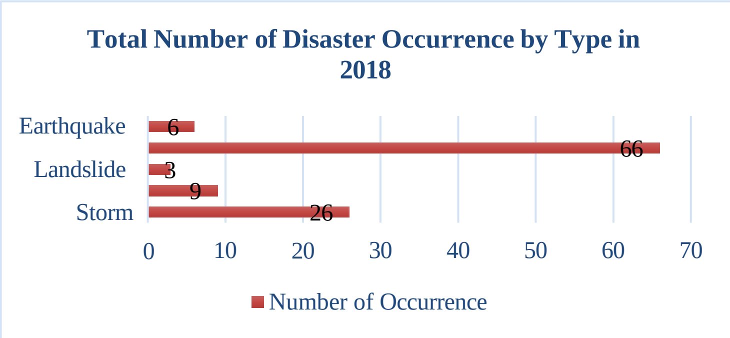

Figure 1: Total Number of Disaster Occurrence by Type in 2018

(Source: Agensi Pengurusan Bencana Negara (NADMA), 2018)

Based on Figure 1, the National Disaster Control Centre (NDCC) identified a total of 110 disasters that occurred within the country in 2018 (Agensi Pengurusan Bencana Negara (NADMA), 2018). Out of them, 66 occurrences were classified as floods. A table comparing disaster occurrence in Malaysia from year 2014 to year 2018 is shown in Table 1.

Table 1: Comparison of Disaster Occurrence from Year 2014 to Year 2018

Type of Disaster/Year	2014	2015	2016	2017	2018
Earthquake	0	1	0	0	6
Flood	14	46	95	81	66
Landslide	4	11	4	2	3
Fire	2	1	6	1	9
Storm	11	4	3	2	26
Total	31	63	108	86	110

Based on both Table 1 and Figure 1, it is evident that the number of disasters increased in 2018. Flooding is consistently recorded as the most frequently occurring disaster in Malaysia, impacting a significant number of people in the country. Approximately 4.8 million people could be affected by this disaster, considering that 9% of the land in Malaysia is highly prone to flooding.

Expanding beyond the concept of flood disaster, the study delved into the domain of AR to explore its origin and types. The word ‘Augment’ from Augmented Reality, commonly abbreviated as AR, means adding or enhancing something. In 1990, a Boeing Researcher with the name Tom Caudell was the person who coined the term. According to (Azuma, 1997), AR primarily deals with the overlay of virtual or digital components in a real-world environment, allowing the real environment to be perceived together with virtual elements by users. However, instead of creating a completely virtual environment, augmented reality enriches the existing environments with computer-generated elements (Carmigniani et al., 2011).

There are four distinct types of AR: marker-based AR, Markerless AR, projection-based AR, and Superimposition AR. This project used markerless AR, which uses the user's location data to augment virtual elements (Amity University & Institute of Electrical and Electronics Engineers, 2019). This data is obtained through digital compasses, accelerometers, velocity meters, or GPS technology integrated into the user's device. The location detection capabilities found in modern smartphones is the key factor that made this form of AR possible. This AR type can recognise elements not explicitly preloaded into the application. Instead, it must only identify patterns, colours, and other features to deliver the desired outcomes.

Resolving the Lack of Awareness of Flood Risks Among Residents

The lack of awareness of flood risks among residents in flood-prone areas hinders effective flood risk management and preparedness efforts (Hall et al., 2014). Research has shown that individuals often underestimate the potential impact of rare or extreme flood events, leading to inadequate response and preparedness measures (Chiew et al., 2021). This lack of awareness can result in increased damage and loss of life during flood events (Liu et al., 2022). Therefore, there is a need to address the lack of awareness of flood risks among residents to enhance their preparedness and resilience.

Moreover, flood disasters are more frequent and severe than ever, causing huge economic casualties in many parts of the world. Several states in Malaysia have experienced some of the worst flood disasters in recent years, forcing many residents to evacuate their homes in search of safety. Even though floods are increasingly frequent, many residents of flood-prone areas are ignorant about the risks associated with flooding. According to a study by (Alias et al., 2020), most people who received the order to leave for a safer area followed it and were ready to leave. However, a fifth of those instructed to leave chose to stay until the water level reached dangerously high levels. This scenario demonstrates that they are not mindful of the flood's dangers to their safety.

Resolving the Lack of Preparation in Facing Flood Disasters

The lack of adaptive capacity and preparedness measures among residents in flood-prone urban communities is a pressing issue that exacerbates their vulnerability to flood disasters (Elum & Lawal, 2022). Studies have shown that many households have low awareness of flood risks and exhibit low levels of adaptive capacity, with little or no measures taken to deal with flood disasters. This lack of awareness and preparedness can lead to increased damage and loss of life during flood events. Factors such as age, location, household size, and flood risk perception have been found to influence the level of preparedness among residents (Elum & Lawal, 2022).

Moreover, in recent years, Malaysia has experienced some of the biggest flood disasters that have affected several states. Despite the frequent flooding, many people who live in flood-prone areas are still inadequately prepared to handle such emergencies. In a survey conducted by (Sufian et al., 2022), the findings indicate that the people of Melaka are still not sufficiently prepared for flooding. The respondents know it is important to turn off all gas and electrical equipment before leaving their residence amidst a flood because it would reduce the dangers during flooding. They also agree that they should be alert to the news to learn whether their neighbourhood may experience flooding. However, many people in Melaka are unsure where evacuation centres are located and are less likely to buy disaster insurance.

METHODOLOGY

The selected methodology to develop this project is the Agile Methodology, which is a lightweight software development model. Agile is a term for “moving quickly,” emphasising its incremental and iterative methodology. This methodology also strongly emphasises flexibility and adaptation to changes while developing software. Due to the iterative nature of the Agile process, the software design is not finalised and may experience several unplanned adjustments. Agile approaches incorporate iterative development plans that aim to improve the results with each iteration, in contrast to a single time-consuming and rigid development timeline. Each iteration covers the entire design, coding, and testing process flow.

For this project, Agile Methodology was chosen for several reasons. Firstly, this methodology allows developers to adapt the software to changing requirements, which is particularly beneficial for small projects. Secondly, as modifications primarily occur during the design process to accurately represent flood preparedness during a flood disaster, the methodology can save developers time and effort. Thirdly, it was selected because it can facilitate rapid development to ensure the project is completed within a constrained timeline.

The requirement phase, design phase, development phase, testing phase, deployment phase, and review phase were the six phases that make up this methodology. A comprehensive literature review was conducted to gather sufficient information and knowledge for initiating the development of the mobile application. The review encompassed topics related to flood disasters, preparedness, augmented reality, and how augmented reality can effectively raise awareness about the hazards associated with flood disasters.

Following the requirement phase, a proper flowchart and storyboard were built to show the beginning of the simulation until the end in the design phase. This diagram is a useful tool for developers since it provides a complete plan of action from the project's beginning, ensuring that no important steps are missed. The process flow in this simulation application was visualised in this flowchart in Figure 2. This phase also included creating high fidelity storyboards to provide a more intricate visualisation that closely mirrors the final product to give a more comprehensive understanding of the application's anticipated appearance and user experience.

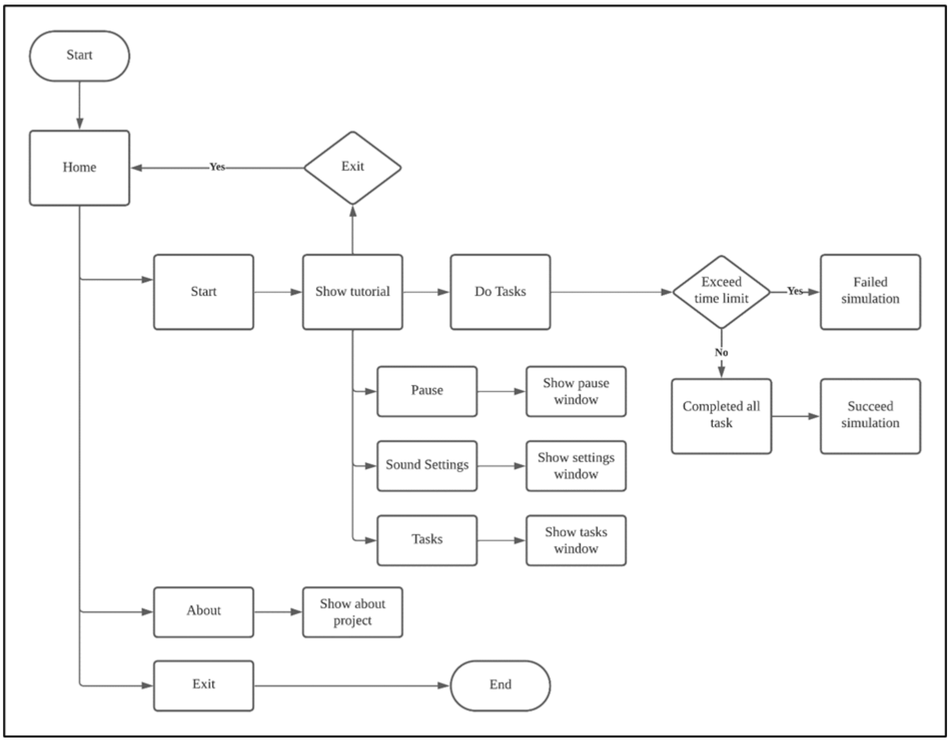

Figure 2: Flowchart

Following the design phase, the project also went through application development which involves assets creation, objects modelling and designing the environments. New assets creation and modification downloadable assets is done using Blender, Adobe Photoshop, and Adobe Illustrator. Unity was used to create the simulation scene. The testing phase started after the completion of the development phase. The application was carefully reviewed to find any problems and ensured it complied with the project requirements during this phase (Mccormick, 2012). The written code was also examined to ensure it was easily understood and fully functional. The review phase was the last in agile methodology. In this phase, users were provided with a questionnaire through Google Forms to assess the application after they had finished using it. The goal was to determine whether the application had effectively solved the problem statements and fulfilled this project's objectives.

RESULT AND DISCUSSION

The assessment in this project focuses on evaluating the application's usability, as outlined in the project objectives. Questionnaires from the System Usability Scale (SUS) were used for the evaluation. The data gathered through the Google Form is exported to Google Sheets. This process enables the developer to analyse and visualize the data easily, allowing the developer to examine the findings.

According to the SUS survey responses, the respondent's age falls within the range of 18 to 24 years old with a total of 34 participants (n=34), and above 25 years old with a total of 3 participants (n=3). No participants below the age of 17 were recorded in the response. The majority of the participants identified as female, comprising 78.4% of the sample (n=29), whereas the male participants accounted for 21.6% of the sample (n=8).

SUS questionnaire comprises 10 items, each rated on a scale from 1 to 5. To determine the SUS score, respondents' answers are processed based on their level of agreement with the statement. The formula to calculate SUS scores for odd-numbered items (1, 3, 5, 7, and 9) involve subtracting 1, while scores for even-numbered items (2, 4, 6, 8, and 10) are subtracted from 5 (Guerci, 2020). The individual final item scores are then summed up and multiplied by 2.5 for each respondent. The average score is calculated across all respondents. Table 2 presents the total scores for each item, individual respondents, and the overall average score.

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Table 2: Total SUS Scores for Each Respondent

N / Item	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	Raw Score	Total Score
1	3	2	3	3	3	3	3	3	3	3	21	52.5
2	5	5	5	5	5	1	5	1	5	1	32	80
3	5	1	5	1	5	1	5	1	5	5	36	90
4	4	4	4	2	4	2	4	2	4	2	28	70
5	4	2	5	2	4	2	5	3	5	4	30	75
6	5	2	5	2	5	2	5	1	5	3	35	87.5
7	4	1	4	1	4	2	5	1	4	1	35	87.5
8	1	5	1	1	1	5	1	1	1	1	12	30
9	1	5	1	1	1	1	1	1	1	1	16	40
10	5	5	5	5	5	5	5	5	5	5	20	50
11	5	2	5	3	5	2	5	1	5	3	34	85
12	5	2	5	3	5	1	5	1	5	3	35	87.5
13	3	4	4	1	4	2	4	2	4	2	28	70
14	5	1	5	3	5	1	4	1	5	3	35	87.5
15	5	1	5	3	5	2	5	3	5	2	34	85
16	4	3	4	2	3	4	5	2	4	2	27	67.5
17	5	3	5	3	5	3	5	3	5	3	30	75
18	4	2	4	2	4	2	4	2	4	3	29	72.5
19	4	2	5	1	4	3	4	3	4	3	29	72.5
20	5	1	5	1	5	2	4	2	4	1	36	90
21	5	1	5	3	4	3	4	2	5	1	33	82.5
22	4	1	5	1	5	1	5	2	5	1	38	95
23	4	2	4	4	4	3	4	2	4	4	25	62.5
24	4	4	3	4	5	2	3	3	4	4	22	55
25	4	2	4	1	4	2	4	1	4	2	32	80
26	4	3	4	4	4	3	4	3	4	4	23	57.5
27	2	2	3	3	3	2	4	3	4	3	23	57.5
28	4	3	3	4	4	2	4	3	3	4	22	55
29	5	1	5	3	5	1	5	1	5	1	38	95
30	4	2	4	2	4	2	4	2	4	5	27	67.5
31	5	1	5	1	5	1	5	1	5	1	40	100

32	**3**	**2**	**4**	**2**	**4**	**2**	**4**	**2**	**4**	**3**	**28**	**70**
33	**5**	**2**	**4**	**2**	**4**	**2**	**5**	**2**	**4**	**2**	**32**	**80**
34	**5**	**1**	**5**	**1**	**5**	**1**	**5**	**1**	**5**	**1**	**40**	**100**
35	**2**	**3**	**2**	**1**	**4**	**3**	**5**	**2**	**5**	**1**	**28**	**70**
36	**5**	**5**	**5**	**1**	**5**	**1**	**5**	**1**	**5**	**4**	**33**	**82.5**
37	**3**	**3**	**5**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**22**	**55**
										Average	**29.4**	**73.5**

The overall average usability score for the application stands at 73.5% after rounding off the average score to one decimal place. As the SUS score exceeds 68, the application is deemed to be above average, indicating that the system has good usability (Will, 2019). As a conclusion, the application provides positive user experience for the participants as evidenced by the elevated average score.

CONCLUSION

As a conclusion, Flood Survival is a method to learn about flood preparedness and raise awareness about floods in an immersive way, as indicated by positive feedback from the SUS questionnaire. The limitations of the project include the fact that it is not developed as a cross-platform application and can only run on Android mobile devices, does not encompass all preparedness actions, is not available in languages other than English, and the application may experience a drop in FPS sometimes due to complex 3D models used. However, despite these limitations, it could be improved by developing the application as cross-platform, allocating more time and resources, collaborating with experts to enhance the application, implementing other languages, and simplifying the 3D objects used.

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