Universiti Teknologi MARA
Cawangan Melaka

PCMJ

Progress in Computing and Mathematics Journal

volume 1

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Progress in Computing and Mathematics Journal
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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College of Computing, Informatics, and Mathematics
UiTM Cawangan Melaka

TABLE OF CONTENTS

PCMJ

Progress in Computer and Mathematics Journal (PCMJ)
volume 1 [October, 2024]
e-ISSN: 3030-6728
Website: fskmjebat.uitm.edu.my/pcmj

AR MYDREAMHOUSE: AUGMENTED REALITY FOR CUSTOMISING HOUSE

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Article Info

Received: February 2024
Accepted: August 2024
Available Online: October 2024

Abstract

This project employs Rapid Application Development to achieve three main objectives: designing a 3D model for house and environment customization, developing an augmented reality application for personalized house customization, and evaluating the usability of 3D modelling in custom-built houses. The project, assessed through the System Usability Scale, focuses on Learnability, Efficiency, Consistency, and Satisfaction as key usability metrics. Results demonstrate the success of AR My Dreamhouse in providing an intuitive and satisfying platform for users to envision and customize their ideal homes. This project, AR MyDreamHouse, is currently a prototype facing technical limitations, but future work could involve redesigning for iOS compatibility, solving colour picker issues for user satisfaction, and refining scale and rotate functionalities for improved efficiency. In conclusion, the project contributes significantly to the development of an application that serves as an essential medium for potential homeowners to actively engage in the customization of their future abodes within the immersive realm of Augmented Reality.

Keywords: Augmented Reality, Customization, Rapid Application Development, 3D Modelling, Usability Evaluation, Future Work.

INTRODUCTION

A custom-built house is a type of house that is designed and built specifically to meet the needs and wants of a houseowner. Unlike ready-built houses by real estate developers built from pre-designed plans that typically offer relatively limited customization options, custom-built houses are designed to meet the houseowner's

specific needs and preferences. Custom-built houses are usually cheaper than ready-built houses because the house owners can lower the manufacturing costs to a minimum according to their financial capabilities but meet their needs and wants. Basically, we can say that a custom-built house offers many benefits, including the ability to customize every aspect of the house, from the layout and floor plan to the finishes and fixtures.

In the context of custom-built houses, mass customization can be used to streamline the design and construction process, making it more efficient and cost-effective. Mass customization is a manufacturing paradigm that enables customized and personalized design at a cost near mass production. Mass customization's ability to lower unit cost, increase quality, and shorten project duration for customized offerings is considered highly relevant for tomorrow's house building industry (Larsen et al., 2019). Since mass customization allows for greater flexibility in design while reducing the time and cost needed to build a custom house, it has the potential to totally change the construction industry.

Nowadays, many people, especially those who want to start a family, those who have just started working or those who want to retire to own a house. The decision to buy a house is an important matter and should not be taken lightly as it will have a lasting impact on a person's financial situation and overall management of their life. Purchasing a house is considered as the most important achievement for an individual because it is the most expensive things people can buy and involves much consideration as well (Kurniawan et al., 2020). A house is not only a place to live, but also an investment that requires careful consideration and planning. It is important to consider not only the initial cost of the house, but also ongoing maintenance and expenses, as well as potential future changes in the house owner’s living conditions. As such, it is important to approach the decision to buy a house with thoughtful consideration to ensure a successful and not wasted life investment.

This project aims to use 3D models in the process of preparing custom house plans by implementing Augmented Reality (AR) technology. Yunqiang Chen (2019) describe

AR as technology that combines virtual information with the real world. Its principle is to apply computer-generated virtual information, such as text, images, 3D models, music, video, etc., to the real world after simulation(Chen et al., 2019).

The reason for involving the usage of 3D model for this project because to gain the better experience from prospective buyers of the custom-built house while dealing with the architect. Prashant Verma in pass few years says that it has been seen that this augmented reality-based application provides better interface and experience than the traditional 2D maps or the paper maps that are displayed outside buildings to help in the navigation. To evaluate the concept proposed in the research, technical evaluations were performed at a hospital building (Verma et al., 2020). By developing this augmented reality, prospective buyers can easily describe their needs and wants, while the architect can receive the info directly with clear instruction.

LITERATURE REVIEW

Buying House in Malaysia

Scenario

In Malaysia, owning a house is one of the achievements that every individual or family wants to achieve. Home or shelter is one of the necessities that contribute to our living besides food, water, and clothing. Thus, a roof over one head's is one of a few requirements in life. Owning a house, is one of the major goals for Malaysians(Aziz et al., 2022).

Fatin Aziz (2022) stated that it is everyone dream to buy or owning a place that we can called a home or house. Homeownership also can benefit not for only individual point of view but also affect to the communities in the surrounding. It is explained that a higher rate of homeownership creates motivation for homeowners to enhance the quality of their communities and develop homeowner's connection to their neighbors.

PCMJ
Progress in Computer and Mathematics Journal (PCMJ)
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House Price

The rising cost of housing in Malaysia has become a significant concern in recent years. House price in Malaysia has been growing rapidly for the past decades. Malaysian Annual Property Market Report 2013 shows that average value of property in Kuala Lumpur within a year had increased 37.66% from 2012 to 2013. The drastic raise of house price in Malaysia has made many not being able to afford in owning their dream house(Kean Yan et al., 2016).

Rising demand for homes, coupled with limited supply, has caused property prices to skyrocket across the country. Factors such as population growth, urbanization, and economic development contribute to rising prices. In addition, speculation in the housing market and the influence of external factors such as inflation and interest rates also play a role. The high cost of housing poses a challenge to many Malaysians, making it increasingly difficult for them to purchase a suitable home that meets their needs. This issue requires a comprehensive strategy and policy to address the affordability crisis and ensure access to decent housing for all sections of society.

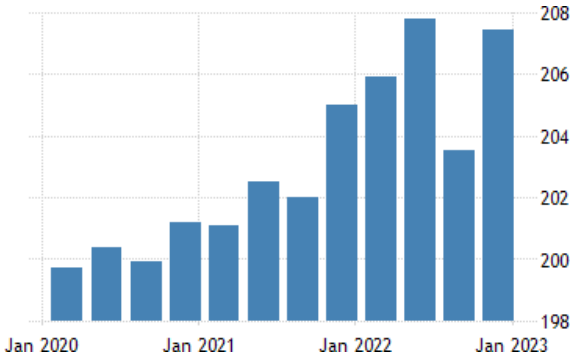

Figure 1: Housing Index in Malaysia in the third quarter of 2022.

Finding Affordable House

An affordable house is a house that everyone wants. This is because a house is a basic need and will be occupied every day, but in the current market situation where house prices are relatively high, it is natural that owners want an affordable house. Housing is the most important and basic need that its provision has globally become

one of the main challenges of urbanisation, which is estimated to increase to 75% by the year 2020(Tobi et al., 2020).

This situation causes those with a middle income to also want to get an affordable house. In fact, an increase in the middle-income group in the urban area has resulted from urbanisation which eventually leads to more demands for affordable housing. In Malaysia private sector or developers, is becoming the main housing provider in Malaysia, therefore the provision of affordable housing has becoming more critical and crucial (Tobi et al., 2020).

Project	Required Average Monthly Household Income	Price of Property
PR1MA (1Malaysia Housing Programme)	RM2,500 – RM15,000	RM100,000 – RM400,000
Residensi Wilayah (a.k.a RUMAWIP)	RM10,000 for individuals, RM15,000 for married couples	RM63,000 – RM300,000
Rumah Selangorku	Less than RM10,000	RM250,000

Table 1: Affordable Housing Schemes in Malaysia

Augmented Reality

Definition

Augmented Reality is a technology that combines virtual elements with the real world, which can improve our perception and interaction with our environment. AR can be summarized as a computer graphic technique where an artificial “virtual” object (CAD model, symbol, picture, writing) is added to a real-time video streaming of the external real environment. The hardware and software necessary to implement it depend on the internal/external application, complexity of the virtual scene to add, device held by the user, real-time, and definition required by the application(Santi et al., 2021).

It overlays digital information, such as images, videos, or 3D objects, onto the real-world environment in real-time. The most common way to experience augmented reality is through a device such as a smartphone, where it can take pictures of the real environment and overlay virtual material on it. However, the minimum hardware required to run AR application is given by a camera framing the external world, a screen or a lens to project a video streaming, and the computational resources (PC, smartphone

processor, microcontroller) necessary to handle the video recording, the pose detection and the superimposition of the visual symbols to it(Santi et al., 2021).

Users can engage with virtual items and information as if they were real by combining the virtual and physical worlds in this way, which results in an immersive and participatory experience. AR has great potential for entertainment, learning, construction, and practical use cases. It has applications in various industries, including gaming, education, navigation, and visualization.

History

Year after year, AR as we know it at this point has gone through various revolutions since the beginning of its existence until today. I break it down into 3 phases which are phases Emergence Era, Evolution Era, and Expansion Era.

In Phase Emergence Era, starting in 1968 where the first head-mounted display (HMD) was created called “The Sword of Damocles” created by Ivan Sutherland. In 1974, Myron Kruger, who is a computer researcher and artist created a laboratory at the University of Connecticut called “Videoplace”. This phase ended with the development of "WearComp 1" which is a wearable computer system for augmented vision built by Steve Mann.

AR grows in the following years, and this leads to the next phase which is Evolution Era. The term "Augmented Reality" was first introduced in 1990 by Tom Caudell who was a Boeing researcher at that time. In 1992, Louis Rosenburg who is a researcher at the USAF Armstrong's Research Lab created the "Virtual Fixture" which is one of the fully functional augmented reality systems. Writer and producer Julie Martin brought AR to the entertainment industry and that was the first time it was brought into the industry in 1994. It was presented with a theater production titled Dancing in Cyberspace. NASA, a well-known company, also participated in the history of AR development when they created the hybrid synthetic vision system of their X-38 spacecraft in 1999. This system uses AR technology to help provide better navigation during their test flights.

Starting around the 2000s until today, augmented reality is in the Expansion Era phase. In 2000, Hirokazu Kato developed an open-source software library called ARToolKit. This package can help other developers build augmented reality software

programs. Sportvision in 2003 improved the 1st & Ten graphics to include a feature on the new Skycam system which provides viewers with an aerial shot of the field with graphics superimposed on it. Then in 2009, Esquire Magazine for the first time, used augmented reality in print media to bring the pages to life. Volkswagen introduced the MARTA app in 2013, which gives technicians step-by-step instructions for repairs in the service manual. Microsoft did not miss an opportunity by introducing a wearable AR technology called HoloLens. HoloLens is more advanced than Google Glass but comes with a higher price tag. In 2017, since its increasing popularity around the world made IKEA launch their augmented reality application called IKEA Place. This application allows users to virtually view their home decoration options before making a purchase.

Deficiency

Despite its great potential, AR Technology faces certain deficiencies that can impact its seamless integration. Two important challenges are connectivity and localization problems, as well as the lack of non-geometric information. Adeeb Sidani(2021) say that AR implementation is far from its desired state, showing several limitations such as connection and localisation problems, lack of non-geometric information, and other challenges in using AR techniques in the construction site (Sidani et al., 2021).

In the first place, AR heavily relies on a stable and fast internet connection, which can be a difficulty in areas with limited connectivity or weak network coverage. Disruptions in the connection can lead to lag, latency, or even complete loss of AR functionality. As for BIM-based AR, limitations were mostly found in the data transfer due to the construction site’s low connectivity levels regarding internet and GPS connections (Sidani et al., 2021).

Other than that, AR often lacks non-geometric information, such as understanding objects' characteristics or contextual data beyond their spatial positioning. This deficiency restricts AR's ability to provide detailed and meaningful information about the physical environment, impacting its utility in certain applications. Most research does not fully integrate non-geometric information into AR interfaces. Interoperability between BIM software and AR systems (e.g., game engines, SDKs, web platforms) still requires further developments to integrate building semantic information.(Sidani et al., 2021).

Progress in Computer and Mathematics Journal (PCMJ)
volume 1 [October, 2024]
e-ISSN: 3030-6728
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Augmented Reality in Custom House

Marker-based AR

Marker-based AR is a technique in augmented reality that utilizes visual markers or images as reference points to anchor virtual content onto the physical world. This type of AR, also known as recognition-based AR or image recognition, relies on identification of markers/user-defined images to function. By recognizing and tracking these markers through a camera or sensor, the AR system can overlay digital information, such as 3D models or text, onto the marker's position in the user's view.

This allows for precise alignment and interaction between virtual and physical elements, creating immersive experiences. Marker-based AR is widely used in advertising, education, gaming, and industrial applications, providing cost-effective solutions for enhanced visualization and interactivity. However, its reliance on specific markers or images limits its flexibility in dynamic environments.

Markerless AR

Markerless AR stands out as an augmented reality technique that eliminates the need for physical markers. Instead of relying on predefined markers or patterns, markerless AR uses advanced computer vision and sensor technologies to overlay digital content seamlessly onto the real-world environment. This approach provides users with an interactive and immersive experience without the constraints of markers.

Markerless AR finds various applications, ranging from gaming and navigation to industrial training and education. It offers the flexibility to integrate virtual elements into everyday surroundings, opening possibilities for engaging and context-aware augmented reality experiences. However, its effectiveness can be influenced by factors such as environmental lighting and the need for robust tracking algorithms, which may impact its performance in certain situations.

Simultaneous Localization and Mapping (SLAM)

AR Simultaneous Localization and Mapping (SLAM) is an advanced technique in augmented reality that combines real-time mapping of the physical environment with precise localization of the user within that environment. The SLAM AR system uses sensors, such as cameras, depth sensors, and inertial measurement units, to

simultaneously track the user's position and orientation while building a 3D map of the surrounding space. This allows virtual objects to be precisely placed and anchored in the real world, creating a seamless integration between the physical and digital realms.

SLAM AR is particularly useful in applications that require precise spatial understanding and interaction, such as indoor navigation, architectural design and industrial training. By continuously updating the map and tracking the user's movements, SLAM AR enables a realistic and interactive augmented reality experience that adapts to the user's environment in real time.

Selected Technology

After studying one by one, the technology that will be chosen for my project is Markerless AR, over SLAM (Simultaneous Localization and Mapping) and Marker-based approaches. The decision to choose Markerless AR was driven by its advanced computer vision and sensor technology, eliminating the need for physical markers or predetermined patterns. This option allows for a more flexible and natural user experience, as it seamlessly overlays digital content onto a real-world environment without the constraints associated with markup. This decision considers the evolving AR technology landscape and prioritizes the user-friendly and marker-free aspects that Markerless AR uniquely provides.

Existing 3D House Apps

Evaluating existing apps involves different aspects such as technology, methods, platform, user interaction, accessibility, and design features of established applications. This analysis provides developers with valuable insights to facilitate informed decisions or improvements. Home Design 3D, VR Home, and Planner 5D were selected for review due to their common use of markerless augmented reality and focus on house customization themes.

Methodology Review

A methodology serves as a structured framework for problem-solving or goal achievement, offering clear guidelines for effective actions. In project management, it establishes procedures and steps to maintain organization and role definition. Typical

methodologies in multimedia project development encompass Agile, Spiral, and Rapid Application Development (RAD), with their usage contingent upon industry requirements. The number of methodologies is flexible and changes as organizations adjust to specific demands, potentially giving rise to new variations over time.

METHODOLOGY

The methodology chosen for this project is Rapid Application Development (RAD) methodology. This project only focuses on four phases of RAD which are requirement planning phase, user design phase, construction phase and cutover phase.

Rapid Application Development (RAD) is a software development methodology that prioritizes speed, flexibility, and user involvement. Key objectives of RAD as: high quality systems, fast development and delivery and low costs(Beynon-Davies et al., 1999). This approach allows for repeated development and frequent feedback, ensuring that the software meets the needs and expectations of end users. RAD emphasizes collaboration between developers, stakeholders, and end users throughout the entire development cycle, promoting effective communication and goal alignment. Through such approach, the RAD model allows developers and clients to accurately track progress and communicate on evolving issues and changes to the system(Abas et al., 2021). By accelerating the software development process and incorporating user feedback early, RAD enables organizations to respond quickly to changing needs, reduce time to market and deliver high-quality software solutions that address evolving user needs.

Since this RAD methodology will be implemented in this project, there are several phases that involves in developing this project. Generally, the model comprises of four main phases which include requirements planning, user design, rapid construction, and cutover(Abas et al., 2021).

PCMJ
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volume 1 [October, 2024]
e-ISSN: 3030-6728
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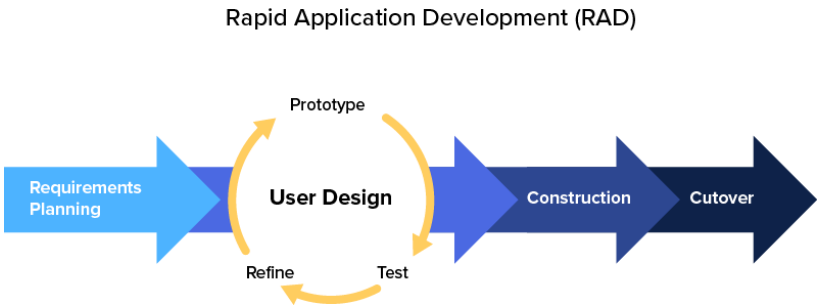

Figure 2: Rapid Application Development Phases

The first phase is requirement planning, where the project scope, objectives and requirements are determined. This is followed by the user design phase, where detailed information about user needs and system requirements are gathered.

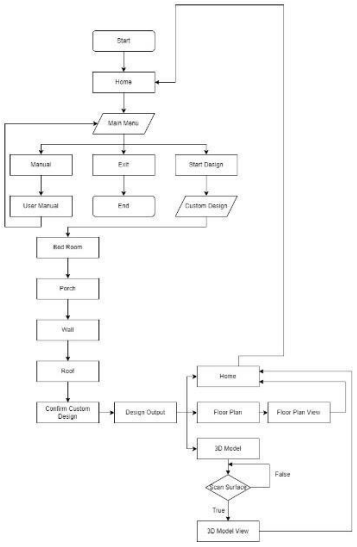

Figure 3: Flowchart

The next phase is the construction phase, where a working model of the software is created to demonstrate its functionality and gather user feedback. Based on feedback received, the developer iterated on the prototype to refine and improve the software. Once the prototype is approved, the construction phase begins, where the software is developed, tested, and integrated. Finally, the cutover phase involves releasing the software to end users, followed by ongoing maintenance and updates. These phases in RAD ensure a collaborative and iterative approach to software development, enabling

faster delivery of functional solutions while maintaining a focus on user satisfaction and quality.

RESULT AND DISCUSSION

In the project's application testing phase, the goal is to systematically assess the augmented reality application's performance using the System Usability Scale (SUS). The testing covers aspects like learnability, efficiency, consistency, and satisfaction. Various range of age that possible to buy a house act as testers. Once the augmented reality application testing is done, an evaluation form will be provided to gather feedback from all the respondents.

No	Question	1	2	3	4	5
1	I think that I would like to use this system frequently.	0	0	3	15	12
2	I found the system unnecessarily complex.	5	3	12	8	2
3	I thought the system was easy to use.	0	0	0	7	23
4	I think that I would need the support of a technical person to be able to use this system.	10	9	9	2	0
5	I found the various functions in this system were well integrated.	0	0	1	14	15
6	I thought there was too much inconsistency in this system.	8	20	1	0	1
7	I would imagine that most people would learn to use this system very quickly.	0	0	0	10	20
8	I found the system very cumbersome to use.	13	16	0	1	0
9	I felt very confident using the system.	0	0	0	12	18
10	I needed to learn a lot of things before I could get going with this system.	13	13	3	1	0

Table 2: AR MyDreamHouse SUS Evaluation Result

PCMJ
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Table 3 shows the questionnaire for the respondent, the total number of questions is 13 with five different aspects of questionnaire: learnability, efficiency, consistency, and satisfaction. The total acquire of respondents is 30 people. To calculate the System Usability Scale (SUS) Score, the following formula is applied. For odd-numbered questions, the score is subtracted by 1, and for even-numbered questions, the score is subtracted from 5. This process is essential in obtaining a comprehensive assessment of the usability of the system, considering both positive and negative responses across the questionnaire's set of questions.

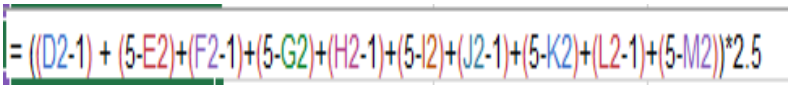

Figure 4: SUS Score Formula

The SUS score is calculated using Google Sheets, where columns labelled with alphabet sequences like (B2-1) represent odd-numbered questions, requiring a subtraction of 1 from their scores while columns like (5-C2) presented as even-numbered questions where the score of those questions must be subtracted from 5. This pattern continues until (5-M2) and (N2-1), which mark the final odd and even-numbered questions. After that, the total of number score from the questions will be multiply by 2.5.

SUS Score
80
75
72.5
72.5
77.5
85
82.5
87.5
92.5
77.5
80
75
65
52.5
92.5
92.5
80
100
77.5
100
87.5
100
82.5
92.5
70
75
92.5
70
65
85
81.25

Figure 5.12 SUS Final Score

Figure 4 shows the spread sheet of questionnaire and the score of each questionnaire from the respondents. At the far right of each row is the SUS score and the final row at the is the average value needs to be identified through the total of SUS score. The total average SUS Score that been calculated is 81.25.

A SUS score of 81.25 suggests favourable usability for the application. Users who have tested the application perceive it as user-friendly and easily navigable. Additionally, there is potential for improvement in the application.

1

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eISSN 3030-6728