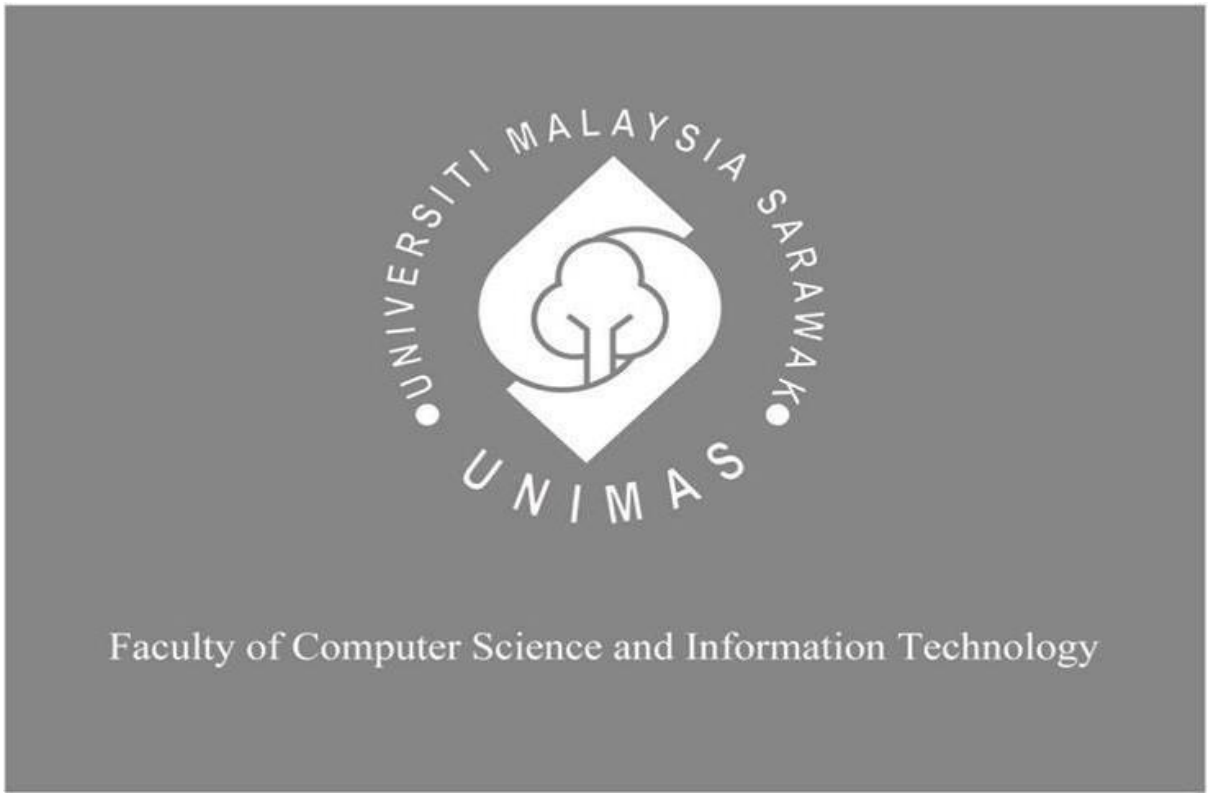

AR LIVING ROOM DECORATION APP

Terence Chiew Wei Chieng

Bachelor of Computer Science with Honours (Multimedia Computing)

2019

AR LIVING ROOM DECORATION APP

TERENCE CHIEW WEI CHIENG

This project is submitted in partial fulfilment of the
requirements for the degree of
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Faculty of Computer Science and Information Technology
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Terence Chiew Wei Chieng

DECEMBER 2019

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ABSTRACT

Augmented reality (AR) has gained explosive growth in recent years. It was hailed as one of the top ten technology in 2018 by Gartner. Nowadays, AR has been applied in many sectors, including medical, manufacturing, architecture, entertainment, education, and art. The purpose of this project is to propose an AR-based living room decoration application that used to address the existing problems, such as great difficulty in decoration idea discussion, lack of image on the final view during decorating, unable to utilize the space effectively and lack of medium to preserve the decoration idea effectively. The objective of this project is to address the issues listed above, as well as provide a more interactive and immersive application. In order to resolve the issues, the existing applications and development toolkits were reviewed. Besides, a survey was also conducted to understand the user workflow, preference, and expectation. After that, a prototype was developed through several iterations and evaluated together with the user.

ABSTRAK

Realiti berperantara (AR) telah mendapat pertumbuhan letupan pada tahun-tahun kebelakangan ini. Ia dipuji sebagai salah satu teknologi sepuluh teratas pada tahun 2018 oleh Gartner. Pada masa kini, AR telah digunakan dalam banyak sektor, termasuk perubatan, pembuatan, seni bina, hiburan, pendidikan dan seni. Tujuan projek ini adalah untuk mencadangkan aplikasi hiasan ruang tamu berasaskan AR yang digunakan untuk menangani masalah yang sedia ada, seperti kesukaran dalam perbincangan idea hiasan, kekurangan imej pada pandangan terakhir semasa menghias, tidak dapat menggunakan ruang secara berkesan dan kekurangan medium untuk menyimpan idea hiasan dengan berkesan. Objektif projek ini adalah untuk menangani isu-isu yang disenaraikan di atas, serta menyediakan aplikasi yang lebih interaktif dan mendalam. Untuk menyelesaikan isu-isu tersebut, aplikasi dan peralatan pembangunan yang sedia ada telah dikaj. Selain itu, satu tinjauan juga dijalankan untuk memahami alur kerja pengguna, keutamaan, dan jangkaan. Selepas itu, prototaip telah dibangunkan melalui beberapa lelaran dan dinilai bersama pengguna.

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1.0 CHAPTER 1: INTRODUCTION

1.1 Introduction

The use of computer-aided home decoration application (also known as home planner) has been practised for years by the interior designers, families and individuals. This kind of application helps people to design the interior and exterior of their house, plan the space adoption; some advanced decoration applications even provide furniture information for user to reference. The home decoration application has evolved from 2D to 3D until recent virtual reality and augmented reality (AR).

In general non-AR home decoration application, the user has to pre-measure the dimension of the living room, create the floor plane and scene. This way of operation has also become a major drawback in existing 2D/3D home decoration applications: they cannot produce a real-time and immersive image like augmented reality. It is inefficiency, inconvenient and lack of intuitive as the user has to model the scene before knowing the result.

Therefore, AR-based home decorating applications are advantageous and valuable. An AR-based home decorating application allows a user to overlay the virtual furniture onto the real-world scene without much more effort to pre-create the virtual scene, instead, AR integrates the virtual object into reality. AR technology also provides an immersive experience to the people and help them better focus on the main task, due to the AR is capable to extend the human sense to the virtual, and vice versa, treating the virtual object as a part of the real world.

1.2 Problem Statement

The motivation of this project was caused by several problems in the existing home decoration application, which often happens to the people who try to plan the decoration of their home. Those problems include:

- illumination and shading of the virtual furniture in existing home decoration application is not well blend with the real world;
- existing home decoration application does not come with the collaboration feature that allows multiple users to take part in the same session of home decoration planning and manipulate the virtual furniture; and
- existing 2D/3D home decoration applications are frustrating and inconvenient to use.

1.3 Aims and Objectives

This project aims to propose an AR apartment's living room decoration application for student to assists them express their decoration idea creatively and as a bridge of communication with others. The objectives of this project are as follows:

- study and design an AR living room decoration application with better shading and illumation;
- develop a collaborative AR living room decoration application to provide an immersive intuitive experience to the user; and
- evaluate the effectiveness and usability of the proposed application.

1.4 Brief Methodology

The development methodology for this project is the prototyping model (Khurana, 2007). As mentioned by Khurana, prototyping model is applied when the detailed information of the input

and output requirements is not available. The prototyping model is suitable for this project because the initial requirements may be unclear due to the users may not know what they want before they interact with the application. Meanwhile, the number of existing home decoration application is insufficient and highly similar, therefore it is difficult for us to study and harvest the possible requirements. Hence, release the prototype iteratively will help us gradually improve the application.

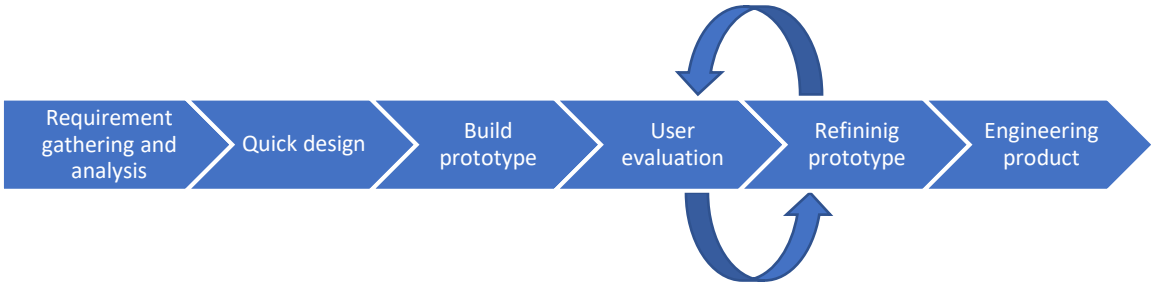

Figure 1.1: Prototyping model proposed by Khurana.

Requirement gathering and analysis

The existing home decoration application will be studied in term of functionalities and user interface. The potential users will be also interviewed to know the existing issues, workflow, requirements and expectation to the application.

Quick design

Once the requirements are obtained and the existing applications have studied, the user interfaces of the proposed application will be designed and sketched. The user interfaces will also evaluate with the user in the user evaluation phase.

Build prototype

The outcome from the quick design will be the basis for the development of the initial prototype. The features of the prototype will be built based on the requirements obtained from requirement

gathering and analysis. This phase includes the development of non-functional low-fidelity prototype and functional high-fidelity prototype.

User evaluation

User will be invited to evaluate the initial or refined prototype in term of functionalities, user interface and usability. This phase also used to identify the design flaw and program fault. The comment and suggestion gave by the user would help in understanding the strengths and weakness.

Refining prototype

Feedback from the user will be considered to refine the prototype and the weakness of the prototype will be tackled at this phase. The feedback obtained will be integrated into the prototype and simple testing will be done on the refinements as a proof-of-concept.

Engineering product

Once the prototype met the requirements and satisfied by the user, the final prototype will be thoroughly tested for the application defect, functionality and usability. System testing such as white box testing will go through by the developer to ensure the correctness of the application. Acceptance testing will be also conducted together with the user to ensure requirements and usability have met the user expectation. If any issues are found during this phase, the application will be further refined.

1.5 Scope

The scope of the project is to build an AR mobile application based on the Google ARCore SDK and only runs on Android. The scope of this project also includes:

- designed to be used by student;

- designed to be used in the apartment living room and serve for the decoration idea visualisation;
- includes common living room furniture with variety texture, colour and size;
- allow the user interacts with the virtual furniture within the scene, including place or remove the virtual furniture and make changes to their position and orientation;
- the virtual furniture in the screen is properly scaled to match the real-world furniture dimension beforehand during the development. In other words, the user is not allowed to change the scale to prevent the incorrect scale rendered;
- the application will only run on the devices supported by Google ARCore; and
- the collaboration feature only support one to one connection mode, thereby only two users will collaborate together at a same time.

1.6 Significance of Project

The significance of this project is it can effectively visualize the decoration idea by utilizing the augmented reality to produce an interactive image. In addition, the collaboration feature implementation the wireless connection technology also can effectively improve the communicate of decoration idea.

1.7 Expected Outcome

The outcome of this project is an AR apartment's living room decoration application with collaboration feature which allows maximum two users to take part in the same session of living room decoration planning.

1.8 Project Schedule

ID	Task Mode	Task Name	Duration	Start	Finish
1		Select supervisor and title	26 days	Wed 04-09-1	Sun 29-09-19
2		Brief proposal	5 days	Wed 25-09-1	Sun 29-09-19
3		Full proposal	20 days	Mon 30-09-1	Sat 19-10-19
4		Chapter 1: Introduction	6 days	Mon 21-10-1	Sat 26-10-19
5		Chapter 2: Literature review	20 days	Mon 28-10-1	Sat 16-11-19
6		Chapter 3: Methodology	18 days	Mon 18-11-1	Thu 05-12-19
7		FYP1 Report and paper	7 days	Fri 06-12-19	Thu 12-12-19
8		FYP1 Symposium preparation	4 days	Fri 13-12-19	Mon 16-12-1
9		FYP1 Symposium	2 days	Tue 17-12-19	Wed 18-12-1
10		FYP1 Final report	24 days	Thu 19-12-19	Sat 11-01-20
11		**Prototype modelling (FYP2)**	**220 days**	**Fri 29-11-19**	**Sun 05-07-20**
12		Requirement study and analysis	7 days	Fri 29-11-19	Thu 05-12-19
13		Quick design	7 days	Fri 06-12-19	Thu 12-12-19
14		Buliding prototype	135 days	Mon 13-01-2	Tue 26-05-20
15		**Iteration and prototype enhancemer**	**119 days**	**Mon 09-03-2**	**Sun 05-07-20**
16		User evaluation	41 days	Tue 26-05-20	Sun 05-07-20
17		Refining prototype	41 days	Tue 26-05-20	Sun 05-07-20
18		Engineering product	7 days	Mon 29-06-2	Sun 05-07-20
19		Chapter 4: Implement and testing	7 days	Mon 29-06-2	Sun 05-07-20
20		Chapter 5: Conclusion and Future Work	7 days	Mon 29-06-2	Sun 05-07-20
21		FYP2 Report and paper	7 days	Mon 29-06-2	Sun 05-07-20
22		FYP2 Symposium	4 days	Tue 21-07-20	Fri 24-07-20

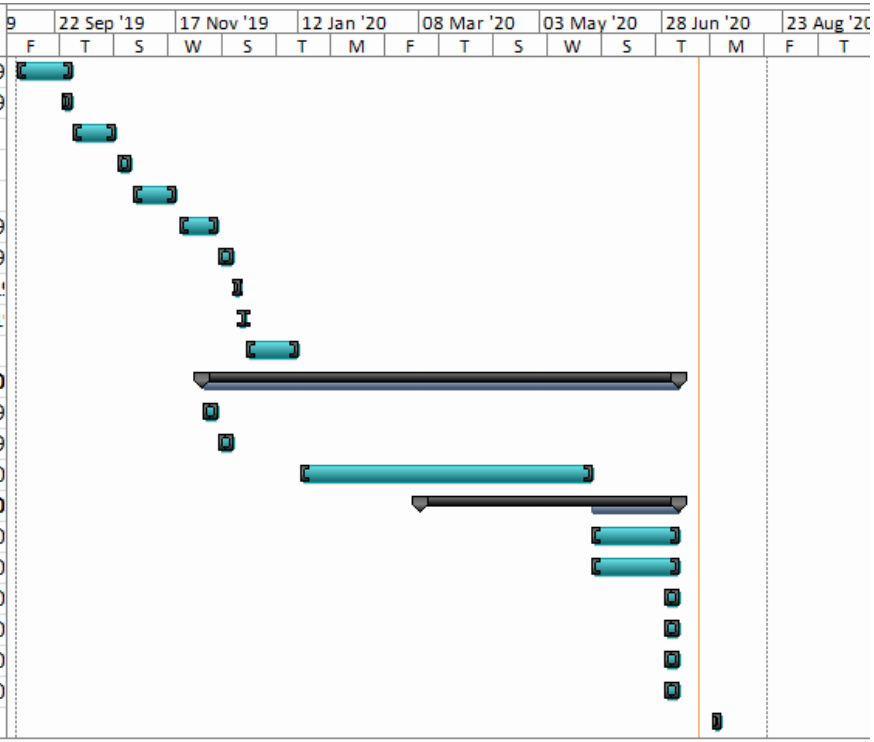

Figure 1.2 Gantt chart of the project schedule.

1.9 Report Outline

This project consists of five chapters. Chapter 1 introduces the background information regarding this project, including the expected outcome and its domain, problems, objectives and opportunities, development methodology, project scope, project schedule and significance. Chapter 2 is a literary review. It further explains the project concept, terminology and definition that related to the domain of the project output. The comparison of existing applications and development kits also will be discussed in this capture. Chapter 3 is the requirement analysis and design. This chapter includes the methods used to record the functional and non-functional requirements from the user. The recorded requirements were analysed and documented in this chapter. Chapter 4 is the implementation and testing. In this chapter, the proposed solution is developed into a prototype based on the design documented in the previous chapter. The application is installed on the support devices and evaluated together with the user. Evaluation in term of functionality, usability, acceptance also carried out and discussed in chapter 4. Chapter 5 is further work and conclusion. In this chapter, the achievements, limitations and further enhancements were summarized.

1.10 Summary

Emergent technology such as AR has brought the shine to the interior design, and the field is quickly transformed. The outcome of this project is an AR-based collaborative living room decoration application that helps people to express their decorating idea and enables them to work together in the same session of living room decoration planning. Due to the use of AR technology, the application provides users with an immersive experience which is lacking in most existing applications. In order to achieve the goal, the prototyping model will be used to

develop the application. The maturity of the prototype and user requirements will be gradually improved and fulfilled for every iteration of prototyping and evaluation.

Problem	**Objectives**	**Methods**	**Outcomes**
Illumination and shading of the virtual furniture in existing home decoration application is not well blend with the real world.	Study and design an AR living room decoration application with better shading and illumination.	Literature review and study the design of the existing application.	Most suitable SDK that can deal with AR, illumination, shading and collaboration.
Existing home decoration application does not come with the collaboration feature.	Develop a collaborative AR living room decoration.	Prototyping model.	A collaborative android application named AR Living Room Decoration App.
Existing 2D/3D home decoration applications are frustrating and inconvenient to use.	Evaluate the effectiveness and usability of the proposed application.	Functional testing: • White-box testing Acceptance testing: • Usability testing	The effectiveness and usability of the proposed application.

Table 1.1: Summary of project.

2.0 CAPTURE 2: LITERATURE REVIEWS

2.1 Introduction

Augmented Reality (AR) is an emerging technology in these recent years. Total of 160 billion USD revenue expected to be reached by 2023 for the AR/VR industry (Liu, 2019). AR presents a virtual world that enriches the real world and user experience. AR comes with three basic principles (Azuma, 1997): (a) Combination of the virtual and real-world objects in a real environment. (b) Real-time interaction by hand gesture or device. (c) Accurately align the virtual and real-world objects.

The initial of the AR can be trackback to 1960s. Ivan Sutherland invented a see-through head-mounted display system, named “The Sword of Damocles” to present the 3D graphics. In the early 1990s, the term “Augmented Reality” was famously used by the Boeing Company. They developed an experimental AR system to help the worker with the wiring harness. In the late 1990s, an open-sourced AR computing tracking library, ARToolkit, was announced for the creation of AR application. And today, AR has been applied to the mobile device. Some common AR mobile application are Pokémon Go, Google Translate and Augmented face on Snapchat. Development kit for mobile platform such as Google ARCore, Apple ARKit has been announced in recent years.

This chapter included three sections, which are the terminology and definition used in AR, review of existing applications and review of existing toolkits.

2.2 Terminology and definition

Augmented Reality

AR is an augmentation of the real environment by blending the computer-generated contents, such as graphical objects, spatial sound, or haptics into the reality to provides an immersive experience and extends the perception of human. However, the term AR usually confuse with Mixed Reality (MR) and Virtual Reality (VR) on the virtual-reality spectrum, as the boundaries between these terms are not clearly defined, and they were frequently misused by the developers and researchers (Flavián, Ibáñez-Sánchez, & Orús, 2019). Generally, these terms are different in degree of involvement of virtual and real in a scene. VR is a highly imitated virtual 3D world that completely generated by the computer, which all the contents do not physically exist. The perspective of the viewer is limited to the virtual world; and they can manipulate all the virtual objects in the virtual environment and experience the stimulus generated from the virtual environment, like Wade Watts of "Ready Player One" who finds the Easter Egg in OASIS (Ontologically Anthropocentric Sensory Immersive Simulation) via an immersive head-mounted display. In VR, the virtual completely replaces reality, whereas AR presence in the real world. AR is not meant to replace the real world but superimpose the virtual contents into the real environment. The viewer can interact with virtual and real objects through the AR, but unlike MR, there is no interaction between virtual objects and real objects in AR, which means the presence of real objects will not affect the visibility, appearance and shape of the virtual objects, and vice versa. In MR, the virtual contents are not superimposed into the real environment; neither real-world contents superimpose into the virtual environment. Instead, MR merges the virtual world and real-world so that the virtual contents and real-world contents can interact with each other in real-time. In other words, virtual content is presented in a way that makes them indistinguishable from real environments in terms of behavior and property.

For example, if there a virtual canvas in front of a viewer, the viewer would not be able to see the virtual canvas when an opaque folding screen comes between them unless the viewer changes his/her perspective or cross over the folding screen, and this phenomenon will not occurs on AR.

	Augmented Reality (AR)	Mixed Reality (MR)	Virtual Reality (VR)
The main environment is the virtual world (V) or the real world (R).	R	R	V
Users interact with the virtual (V), real (R) or both (R-V) worlds in real time.	R-V	R-V	V
Virtual content is superimposed on the real environment.	✓	-	-
Real content is superimposed on the virtual environment.	-	-	-
Virtual content is merged into the real world so that both virtual and real content can interact in real-time.	-	✓	-

Table 2.1: Summary of differences between the reality-virtual realities.

Marker-based and marker-less

There are two types of AR: Marker-based and marker-less. A marker is a static image (for example, QR code or special patterned image) that allows the AR to recognize, track, and register the virtual contents on the real world. The difference between marker-based and marker-less is that marker-based requires a marker to trigger the rendering of virtual objects, while marker-less AR does not need a marker. Instead, marker-less AR uses localized technology, such as Global Positioning System (GPS), Radio Frequency Identification (RFID) and sensor (inertial measuring units, IMU), rather than an image (Cheng, Chen, & Chen, 2017). Some well-known examples of marker-less AR are Pokémon Go and Nokia City Lens. Marker-based AR usually uses identifying algorithm to recognize the marker by extracting the features from the frames captured through the camera (Cheng et al., 2017). The deformation of the identified marker is analysed to understand the orientation, position and distance of the camera (Patkar, Singh, & Birje, 2013). Similarly, marker-less AR uses the same concept to understand its surroundings. However, the source of information is not fed from the optical marker, rather

it uses composite data from the GPS, RFID and sensors to calculate the orientation and position. Related works regarding marker-less AR have been mentioned in some papers (Cheng et al., 2017; Sharma, Kaikini, Bhodia, & Vaidya, 2018).

2.3 Review existing applications

In this section, three existing applications were reviewed in terms of features, operating method, ease of use, and illumination and shading of virtual objects. All the features from the existing applications were summarised in Table 2.2 and become the design criteria for the proposed application. Besides that, the comparison will also include the collaboration feature, because it is a very crucial factor to enhance the communication and expression in a collaborative environment. Related works that implement AR in collaborative environment also have been proposed by some researchers (Kasahara, Heun, Austin, & Hiroshi, 2012; Wei, Zhou, & Xie, 2010). Another researcher, Rekimoto (1996) also discovered that collaborative AR is useful in design.

Easyhome Homestyler

Homestyler is an interior design software provided by EasyHome. Homestyler divided into the web version and mobile version. In this section, we will review the Homestyler mobile.

Unlike other AR application, Homestyler's user does not interact with the real world through streaming video, but through a static image. In other words, when a user overlays a virtual object on the static image, changes in the position and orientation of the device will not result in the change of the viewing angle on the screen.