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ARCHITECTURE VISUALIZATION USING AUGMENTED REALITY

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BACHELOR’S DEGREE OF CS DEPARTMENT
2019-2020

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Architecture Visualization using Augmented Reality

DONE BY
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This Project Was Submitted in Partial Fulfillment of the Requirements for the Bachelor's Degree of CS Department
2019-2020

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Signature:		**Date:**	

We hereby declare that the bachelor project thesis is based on our own work, except for quotations and summaries, which have been duly acknowledged. We also declare that it has not been previously or concurrently submitted for any other degree at FCIT or other institutions.

Declaration by Supervisor

This is to confirm that:

The project conducted and the writing of this thesis was under my supervision.

Signature: ______________________

Name of Supervisor: Dr. Aqeel A. Al-Surmi

DEDICATION

There is no stars without gases, no fire without fuel, no trees without water, and no success without encouraging.

First and foremost, all thanks and gratitude are forwarded to the lord, our god, and the only provider of light, Allah.

Also, not to forget our motivating parents whom without we could never reach the peak of our graduation pyramid. Throughout the whole journey of building up this project, we have encountered desperation, tiredness, suspicion, and disappointment, and If it wasn't for our families and friends, we would not proudly accomplish one of our best projects in our bachelor's roadway. For that, we dedicate all our efforts, enjoyment, and success to them and only them.

Thanks for being there, thanks for contributing to the success.

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LIST OF ABBREVIATION

AR	Augment Reality
3D	Three Dimensional
2D	Two Dimensions
AVAR	Architecture Visualization using Augmented Reality
UI	User Interface
PC	Personal Computer
HW	Hardware
SW	Software
HD	Hard Disk
CPU	Central Processing Unit
GHz	Giga Hertz
RAM	Random Access memory
GB	Gigabyte
MB	Megabyte

CHAPTER ONE

INTRODUCTION

1.1. Background

Augmented reality is the technology that expands our physical world, adding layers of digital information onto it. With the help of advanced augmented-reality technology such as computer vision and object recognition, the information about the surrounding real world of the user becomes interactive and able to be digitally manipulated. In augmented reality, computer software must derive real-world coordinates, independent from the camera or from camera images.

The current practices of architecture visualization, design process, building construction processes and engineering management systems need to be facilitated for regular people. Since navigating in an AR application may appear difficult and seem frustrating, visual cue design can make interactions seem more natural. AR displays extend the viewer's perception via the addition of app generated information easily.

This application is used to design and visualize the model data on top of the real world view using augmented reality, which is used in construction and architecture projects by placing a 3D model of a proposed design onto an existing space using mobile devices and 3D models that engages the user. User interface (UI) are designed to improve the graphic interface elements and user interaction, in order to help the user to know how to use the application that takes the real world and adds a 3D architecture model of their design to it.

1.2. Problem Statement

Designing the model of a building using the traditional methods has some problems:

- The high cost of the sample which sometimes may not impress the customer, leading to disposal of expensive materials like the papers used by architecture engineers and the waste of time.
- The need of people to visualize the first model of their buildings, yet they do not have the required skills and have some difficulties in conveying their perspectives or understanding the usual architectural design presented by architecture engineers.

1.3. Objectives

There are objectives can help achieve a successful 3D building design project as follows:

- Reconstructing an easy interactive 3D environment that help reducing the costs and resources, in addition to the ease of understanding to all users.
- Helping any person including experienced and unexperienced ones to have a simple overview of any desired building designed by their owns.

1.4. Acceptance Criteria

- Make sure that the application will work completely before publishing any advertisement.
- The application will be implemented with unity environment at least.
- Test the application with group of people with different skills to make sure that the application is useable and helpful.

1.5. System Definition

An application that help people in designing and visualization their first prototype of the building they intend to construct via AR technology.

1.6. Purpose

- **Society**

  Provide society with creative and new designing.

- **User**

  a. Save time and effort.

  b. Facilitates modeling process.

1.7. Goal

To construct an application that allow users to design a building model that they desire. Then they have the ability to identify markers of an existed model wither on a paper or a device.

1.8. User Characteristics

User	**Age**	**Qualification**	**Needed Skills**	**Permissions**
Any person	18 – above	None	Ability to use PC	-Design a building model. -Scan markers.

Table 1.1 User characteristic

1.9. Limitations

During implementation, the user can encounter some difficulties and obstacles that limit the application from working efficiently which are described as following:

- The necessity of having high quality printed images to help the application to recognize markers.
- The need of high storage capacity since the data of the program will be offline.
- Shortage of time.

1.10. Assumptions and Dependencies

AVAR has concluded some methods to solve the limitations of the project using the following:

- Giving the program the ability to identify markers from other devices not only from papers.
- Minimize the redundancy in codes.
- Plan well and use appropriate methodology.

1.11. Scope

Application working with Augmented Reality technology to provide people with ability of creating and visualizing 3D building models.

1.12. Life Cycle Model

The Waterfall Model is a linear-sequential life cycle model. It is very simple to understand and use. In a waterfall model, each phase must be completed before the next phase can begin and there is no overlapping in the phase. The Waterfall model is the earliest SDLC approach that was used for software development. The waterfall Model illustrates the software development process in a linear sequential flow. This means that any phase in the development process begins only if the previous phase is complete.

It was used because

- It’s easy to use and understand.
- System requirements has been already known.
- Changes are not expected, so no need to change system design.
- System steps are constant, it will not get together and we will not come back to the previous step.
- It’s easy to document the system.
- what will be delivered is agreed early in the development lifecycle. This makes planning and designing more straightforward.
- Progress is more easily measured, as the full scope of the work is known in advance.
- Except for reviews, approvals, status meetings, etc., a customer presence is not strictly required after the requirements phase.
- Because design is completed early in the development lifecycle, this approach lends itself to projects where multiple SW components must be designed (sometimes in parallel)

1.12.1. Waterfall methodology phases

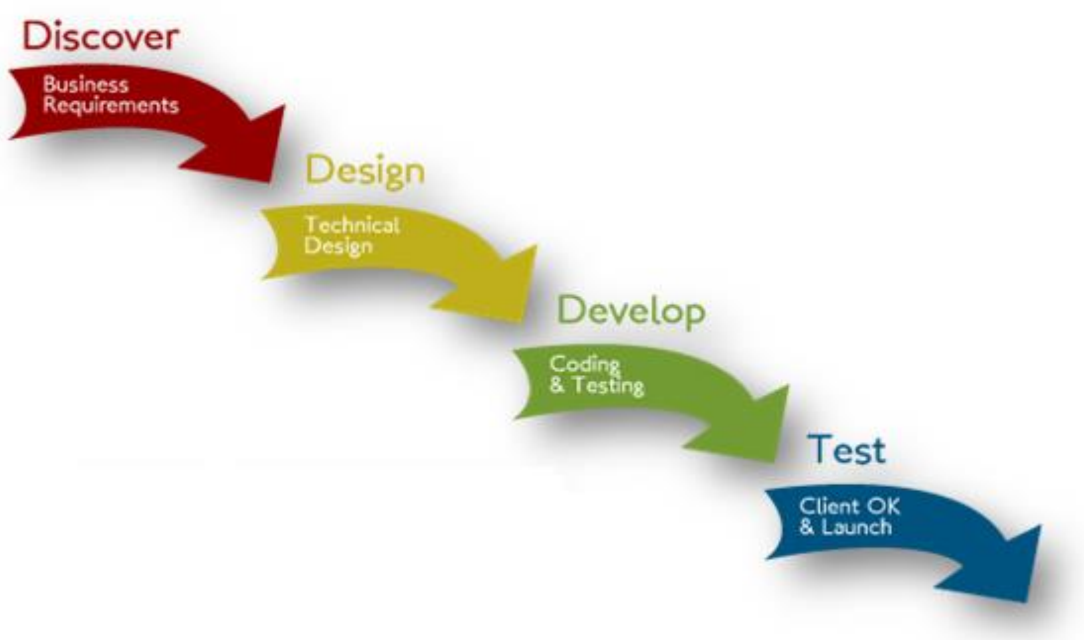
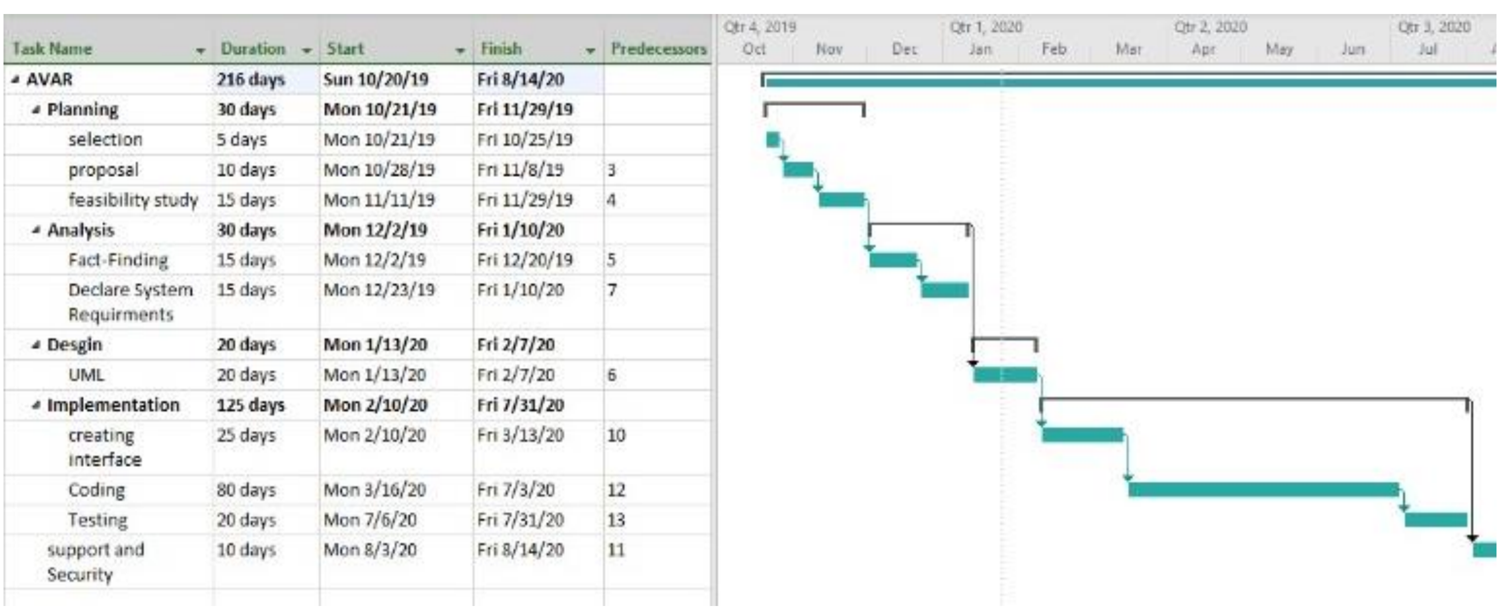


Figure 1-1 Waterfall Model

1.12.2. Project Plan



Task Name	Duration	Start	Finish	Predecessors
AVAR	216 days	Sun 10/20/19	Fri 8/14/20	
Planning	30 days	Mon 10/21/19	Fri 11/29/19	
selection	5 days	Mon 10/21/19	Fri 10/25/19	
proposal	10 days	Mon 10/28/19	Fri 11/8/19	3
feasibility study	15 days	Mon 11/11/19	Fri 11/29/19	4
Analysis	30 days	Mon 12/2/19	Fri 1/10/20	
Fact-Finding	15 days	Mon 12/2/19	Fri 12/20/19	5
Declare System Requirments	15 days	Mon 12/23/19	Fri 1/10/20	7
Desgin	20 days	Mon 1/13/20	Fri 2/7/20	
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Implementation	125 days	Mon 2/10/20	Fri 7/31/20	
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Coding	80 days	Mon 3/16/20	Fri 7/3/20	12
Testing	20 days	Mon 7/6/20	Fri 7/31/20	13
support and Security	10 days	Mon 8/3/20	Fri 8/14/20	11

Figure 1-2 Project Plan

CHAPTER TWO

THEORETICAL SIDE

2.1 Overview

As a theoretical side, a small background of augmented reality and 3D technology is defined to help knowing some of their history and understand it easily. Also, it covers the feasibility study of the project from all of its different sides to have a clear and understandable vision. In addition, it will explain different types of fact-finding tools used to meet the specified requirements.

2.2 History of AR

Augmented Reality got exponentially more popular in recent years but it's been around for longer than you might think. AR tech dates back to the 60s. Over the last 50 years, augmented reality technology has reshaped the way we consume content in the real world.

Augmented reality technology was invented in 1968, with Ivan Sutherland's development of the first head-mounted display system. However, the term 'augmented reality' wasn't coined until **1990** by Boeing researcher Tom Caudell. In 1974: Myron Kruger, a computer researcher and artist, built a laboratory at the University of Connecticut called 'Video place' that was entirely dedicated to artificial reality, projection and camera technology was used to emit onscreen silhouettes which surrounded users for an interactive experience.

In 1998: Sportsvision broadcasts the first live NFL game with the virtual 1st & Ten graphic system – aka the yellow yard marker. The technology displays a yellow line overlayed on top of the feed to that views can quickly see where the team just advance to get a first down.

In 2000: Hirokazu Kato developed an open-source software library called the ARToolKit. This package helps other developers build augmented reality software programs. The library uses video tracking to overlay virtual graphics on top of the real world. In 2017: IKEA released its augmented reality app called IKEA Place. The app allows customers to virtually preview their home decor options before actually making a purchase.

All in all, as we become increasingly dependent on our mobile devices, the adoption of augmented reality technology will begin to rise. AR software advances will be the way forward as the overwhelming majority of consumers have a smartphone and already take it everywhere with them, making it a convenient medium to bring AR to nearly every consumer.

2.3 History of 3D Technology

The long history of 3D technology can be drawn the way back to the start of photography. A new invention by David Brewster in 1844, Stereoscope could take 3D photographic images. At the Great Exhibition in 1851, a picture of Queen Victoria taken by Louis Jules Duboscq, using the improved technology became very well known throughout the world. Soon, the craze for steroscopic cameras caught on and these were quite commonly used by World War II.

In 1855 the Kinematascope, a stereo animation camera, was devised. It was able to make 3d motion pictures. In 1915 the first anaglyph film was produced. Anaglyph technology utilized 3d glasses with two different color lenses which would direct an image to each eye. In 1890 William Friese-Greene, a British film pioneer filed a patent for the 3D film procedure. In 1922 the first public 3D movie, “The Power of Love”, was exhibited. In 1935 the first 3D Shade movie was created. Using the technology would stay dormant for more than a decade.

From the 1950s, 3D technology made a return. In this age, TVs had become extremely popular and had begun appearing in many families. In the 50s a range of 3D films was being produced.

In 1952″Bwana Devil” by United Artists was shown across the USA. This was the first 3D picture of the 50s. The film was shot with a process called Natural Vision. This procedure was pitched to Hollywood studios but they passed. Not all movie theaters were equipped with the 3D technology. 3D movies were also being developed out the United States. In 1947 The Soviet Union released their first full-length 3D film,” Robinson Crusoe”.

In the 1960s a new technology named Space-Vision 3D was published. This technology took two pictures and printed them over each other on a single strip. Unlike previous 3D technology, it took a single projector using a unique lens. This new technology eliminated the requirement to use two cameras to show 3D movies. Two camera systems were hard to use since it required that the two cameras were perfectly synced. The first film to use this technology has been ”The Bubble”. The film was panned by critics, however, the 3D experience still attracted enormous crowds. It turned into a profitable movie, making the new technology ready for advertising to other studios.

In 1970, Allan Silliphant and Chris Condon developed Stereovision. This was a brand new 3D technology that places two pictures squeezed together side by side on a single strip of 35-millimeter film. This technology utilized a special anamorphic lens which would widen the picture by means of a set of Polaroid filters.

In the early 1980s, many films were released in 3D with the identical procedure as Space Vision. A few of the movies which were published were Amityville 3-D, Friday the 13th Part III, and Jaws 3-D. In the mid-1980s, IMAX started producing documentary films in 3D. IMAX’s 3D technology highlighted mathematical correctness and this removed the eye shadow which was seen in previous 3D technology. In 1986, Canada had developed the first 3D film that used polarized glasses. It was known as “Echoes of the Sun” and has been made for Expo 86.

Throughout the 1990s, many movies were released in IMAX 3D. The most successful IMAX 3D movie released in this period was”Into the Deep”. The first IMAX 3D fiction film, “Wings of Courage” was published in 1996.

During the 2000s, many major studio films were released in 3D. In 2003, James Cameron published Ghosts of the Abyss. This was the first full-length 3D IMAX feature film. This movie used the newest IMAX 3D technology known as the Reality Camera System. The technology used the newest HD video cameras and was designed by Vince Pace. The same technology has been used in ”Spy Kids 3D: Game over”, “Aliens of the Deep”, and ”The Adventures of Sharkboy and Lavagirl in 3-D”. In 2004 the first full length animated 3D film was released. It was known as ”The Polar Express”. This movie was so powerful in 3D it prompted an excellent interest in 3D animated movies. The 3D version of the movie earned 14x as much per display as the 2D version. In 2005, The Mann’s Chinese 6 theatre in Hollywood became the first commercial movie theater to have the Digital 3D technology. In 2007 Scar 3D was released globally, and it was the first movie to be filmed using an entirely digital workflow.

The long history of 3D technology still continues. As expected, 3D technology will continue and expand in the coming years.

2.4 Related projects

There are several projects that are built with similar technologies as AVAR, we choose to show some of various, including:

- **ILar:** an android application that help educators in teaching process and allow student to interactively relevant information based on AR technology and markers on a book.

- **AR EduVision:** an android application that will view an interactive information and 3D models by using AR environment, which will help students to understand computer HW component easily.
- **3D Design for Home:** an android application for smart phones, that allow users to create a design for his home in different shapes and angles, and allowing him to insert doors, windows and some furniture. Then showing the design using 3D technology with ability to move inside the design using camera.

2.5 Feasibility Study

2.5.1 Technical Study

Hardware:

- A laptop that has the following features:

- **CPU**: **Intel Core i7**-3770 @ 3.4 **GHz** or AMDFX-8350 @ 4.0 **GHz** or better.
- **RAM**: 8GB or more.
- **Video Card**: **NVIDIA GeForce GTX 780** or **AMD** Radeon R9 290X (3GB VRAM)

Software:

They must be genuine versions.

- Operating System: Windows 10 Pro 1909
- Antivirus: Kaspersky
- Game engine: Unity 2018.2.11f1
- Editor: Visual Studio Professional 2019
- Designing: Adobe illustrator 2018

Other:

- Internet (8MB)

2.5.2 Financial Study

	Requirements	Cost	Count	Total
1	**HR:**			
	- Analyst	500$*12m	**1**	500$*12m
	- Designer	600$*3m	**2**	1200$*3m
	- Programmer	800$*6m	**2**	1600*6m
	- Team Leader	300$*12m	**1**	300$*12m
2	**HW:**			
	- Computer (Core i7) RAM 8G	1000$	**3**	3900$
	- Printer	500$	**1**	500$
	- Android device	400$	**1**	400$
	- Web cam	50$	**1**	50$
3	**SW:**			
	- Windows 10 Pro	200$	**3**	600$
	- Kaspersky	10$	**3**	30$
	- Unity engine	150$*m	**3**	450$
	- Visual Studio	474$	**3**	474$
	- Adobe illustrator	20$	**2**	40$
	Other:			
	- Modem (8MB)	52$	**1**	52$

Table 2.1 Financial Feasibility

2.5.3 Operational Study

Performance

- **Response Time**

The application has reliably high speed; nevertheless, the quality of the camera may affect the time of showing the result.

- **Throughput**
  - Reduce the consumed time between the user and the architect.
  - Save costs for the architect in case the user does not like the presented architecture design.
  - Help the user easily visualize the design of their building on their own.

Information

- **Input**
    - Two variables at the beginning of the application which are **height** and **width.**
    - The markers of the printed pdf file which is saved in the designing phase.
- **Output**
    - 3D Model.
- **Stored data**
    - Markers
    - 3D Model

Cost

- **Hardware**
    - Computer (Core i7) RAM 16G AMD graphics 4.0G.
    - Printer.
    - Web cam
- **Software**
    - Windows 10
    - Kaspersky
    - Unity engine
    - Visual Studio 2017
    - Adobe illustrator 2018
    - Vuforia extension
    - Vuforia developer
- **Others:**
    - Internet connection at 8MB speed

Control

- **Errors**
    - Warning messages will be seen in case of any error occurs.
- **Effort**
    - Analyzing and designing effort of the application.

2.5.4 Scheduling feasibility

- **Planning phase**

◢ AVAR	216 days	Sun 10/20/19	Fri 8/14/20	
◢ Planning	30 days	Mon 10/21/19	Fri 11/29/19	
selection	5 days	Mon 10/21/19	Fri 10/25/19	
proposal	10 days	Mon 10/28/19	Fri 11/8/19	3
feasibility study	15 days	Mon 11/11/19	Fri 11/29/19	4

Figure 2-1 Planning phase

- **Analysis phase**

◢ Analysis	30 days	Mon 12/2/19	Fri 1/10/20	
Fact-Finding	15 days	Mon 12/2/19	Fri 12/20/19	5
Declare System Requirments	15 days	Mon 12/23/19	Fri 1/10/20	7

Figure 2-2 Analysis phase

- **Design phase**

◢ Desgin	20 days	Mon 1/13/20	Fri 2/7/20	
UML	20 days	Mon 1/13/20	Fri 2/7/20	6

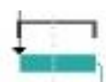


Figure 2-3 Design phase

- **Implementation**

◢ Implementation	125 days	Mon 2/10/20	Fri 7/31/20	
creating interface	25 days	Mon 2/10/20	Fri 3/13/20	10
Coding	80 days	Mon 3/16/20	Fri 7/3/20	12
Testing	20 days	Mon 7/6/20	Fri 7/31/20	13

Figure 2-4 Implementation phase

- **Security and support**

support and Security	10 days	Mon 8/3/20	Fri 8/14/20	11

Figure 2-5 Security and Support phase

2.6 Fact Finding Tools

2.6.1 Literature Review

The common and the known ways of designing buildings and facilities usually consume huge efforts and high cost. However, new technologies aided in easing the process of the design. Augmented reality concept made large contributions in architecture design leading new, interesting and beneficial software systems and phone applications to appear. For example, AutoCAD 360 and Autodesk ForceEffect.

2.6.2 Research and Site visits

- **Researches:**

  - **Augmented Reality Research for Architecture and Design:**

    A growing body of research has shown that Augmented Reality (AR) has the potential to contribute to interaction and visualization for architecture and design. While this emerging technology has only been developed for the past decade, numerous journals and conferences in architecture and design have published articles related to AR. This chapter reviews 44 articles on AR especially related to the architecture and design area that were published from 2005 to 2011. Further, this research discusses the representative AR research works in terms of four aspects: AR concept, AR implementation, AR evaluation, and AR industry adoption. The research draws conclusions about major findings, research issues, and future research directions through the review results.

  - **Augmented Reality in Architecture and Design: Potentials and Challenges for Application**

    Recent advances in computer interface and hardware power have fostered Augmented Reality (AR) prototypes for various architecture and design applications. More intuitive visualization platforms are necessary for efficient use of digital information nowadays in the architecture and design industries. As a promising visualization platform to address this need, this paper introduces the concept and associated enabling technologies of AR and also presents a survey of its existing applications in the area of architecture and design. Another focus of the paper is to discuss how the identified key technical issues could potentially be addressed in the context of architecture and design applications.

-Site Visits:

- **Stack Overflow:**

It is an open community for anyone that codes. We help you get answers to your toughest coding questions, share knowledge with your coworkers in private, and find your next dream job.

- **ArchDaily:**

As the architectural community and the world looks forward to a new year, and a new decade, we do so from rapidly shifting grounds. The world around us is being transformed by a variety of factors in the built environment, from the opportunities of new materials and technologies, to pressing challenges such as climate change and inequality. At ArchDaily, we continue to proactively respond to this changing world, evolving as a tool for knowledge and inspiration for all those involved in shaping the built environment, be they architects, designers, or our growing audience of ‘DIY architects;’ everyday citizens taking an active interest in shaping their own homes and communities.

- **Unity:**

Unity is so much more than the world’s best real-time development platform – it’s also a robust ecosystem designed to enable your success. Join our dynamic community of creators so you can tap into what you need to achieve your vision.

2.6.3 Questionnaire

AVAR team distributed a briefed questionnaire asking about major interesting aspects of the project to various kinds of users including architecture engineers and others. There were 82 responses, 18 of them were from engineers. A sample of the questionnaire will be shown in Appendix A later in chapter 5.

2.6.4 Prototyping

A simple prototype of the AVAR was designed to represent the main interfaces of the application as shown in the next Figures.

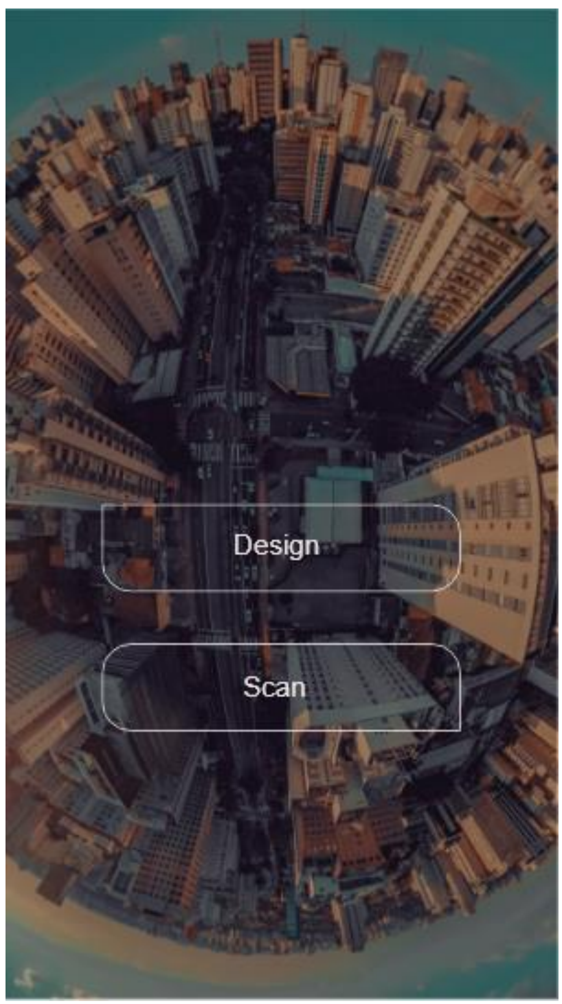


Figure 2-6 Main Interface Prototype

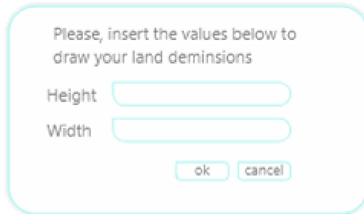


Figure 2-7 Enter Dimensions Dialog Prototype

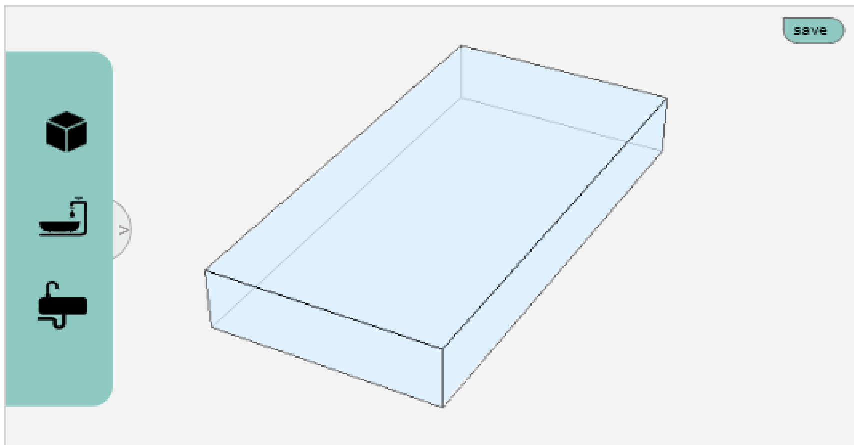


Figure 2-8 Design Interface Prototype

2.6.5 CASE Tools (Computer Aided Software Engineering)

2.6.5.1 Upper-case Tools

- **Requirement tools**
  - Microsoft office (Word, Microsoft Project, Power point)
  - E-drew Max
- **Design Tools**
  - Adobe suit (Photoshop CS, Illustrator 2019)

2.6.5.2 Lower-case Tools

- **Programming and Debugging Tools**
  - Unity
  - Visual Studio
  - Kaspersky
  - Vuforia Package

CHAPTER THREE

PROPOSED SYSTEM

3.1 Overview

The proposed system will cover all requirement needed to make a complete project that meet what the user expect to have in the application, and be sure that it will be able to perform only necessary tasks without confusing. This chapter also shows the system models used to represent the whole functions and operations.

3.2 User requirements

- Comfortable colors to the eye.
- Easy to learn and use.
- Clear steps to follow to have a complete model.
- Enjoyable inexpensive design of buildings.

3.3 Functional Requirements

- Draw a land with specified dominations.
- The ability to drag and drop facilities into the land.
- Changing the sizes of any room.
- Having a complete view of your design.
- Save the model as an AR object.
- Run the camera to visualize your design upon the marker.

3.4 Non-Functional Requirements

3.4.1 Usability

It is implemented throw understandable simple steps and options that help to avoid any complication that can lead to miss understanding of the operation process.

3.4.2 Dependability

- **Reliability**: the ability of the app to do all main required functions in different conditions.
- **Robustness**: highly ability to perform correctly in all cases. It checks the entered data to insure its validity even in the case of stressful environment conditions, also it make sure there will not be any missing data.
- **Safety**: prevent the environment mistakes that may cause the app to crush.
- **Security**: provide protection from any potential external attacks, and does not ask for any personal information from the user.

3.4.3 Performance

- **Response time**: fast responding and recognition, it takes only few milliseconds to execute.
- **Throughput**: rapidly productivity and performance, usually takes less than milliseconds.
- **Availability**: ready in any moment for use, and have a quick running time.
- **Accuracy**: precise validating before any entering or storing of data.

3.4.4 Supportability

- **Adaptability**: AVAR accept changes on the system in the case of additional requirements or any other conditions.

- **Maintainability**: recurring maintain operations can be done to add new technologies.
- **Internationalization**: currently, AVAR only support English language.
- **Portability**: easy to transfer the system –or part of it between different environments, hardware or software.

3.4.5 Validation

- **Complete**: all possible scenarios are described including exceptional behavior in requirement model.
- **Consistent**: the app does not contradict in design and performance because the operations are done by series of steps.
- **Unambiguous**: predefined requirements defining only one system. –
- **Correct**: requirement specification represents accurately the system that the client need, and the developers intend to build.

3.4.6 Others

- **Realistic**: implemented within predefined constraints to visualize 3D objects on 2D markers.
- **Verifiable**: AVAR have some tests to ensure it function according to the predefined requirements.

3.5 System Models (UML)

3.5.1 Scenarios

3.5.1.1 Designing Scenario

The user opens the application where the first interface contains the logo of AVAR and two buttons named **design** and **scan**. Clicking the design button transfers the user to the second interface. Small dialog appears asking the user to enter the dimensions of the land. Then the land should be drawn on the workshop. At the left side, a toolbar that contains various types of facilities appears. Now, the user can drag and drop rooms into the land. After positioning the room, it can be resized by stretching or shrinking the object. After finishing the whole design, the user can save it by clicking the save button on the top side of the interface. It must be saved as a 3D object in unity files.

3.5.1.2 Scanning Scenario

If the user wants to visualize his model, he must press the scan button in the first interface to launch the camera then positioning it to the marker. All saved AR models appears in a scroll bar at the bottom of the interface. Furthermore, when the user clicks on one of the models, it immediately appears on top of the marker.

3.5.2 Use Case Models

- **Application use case**

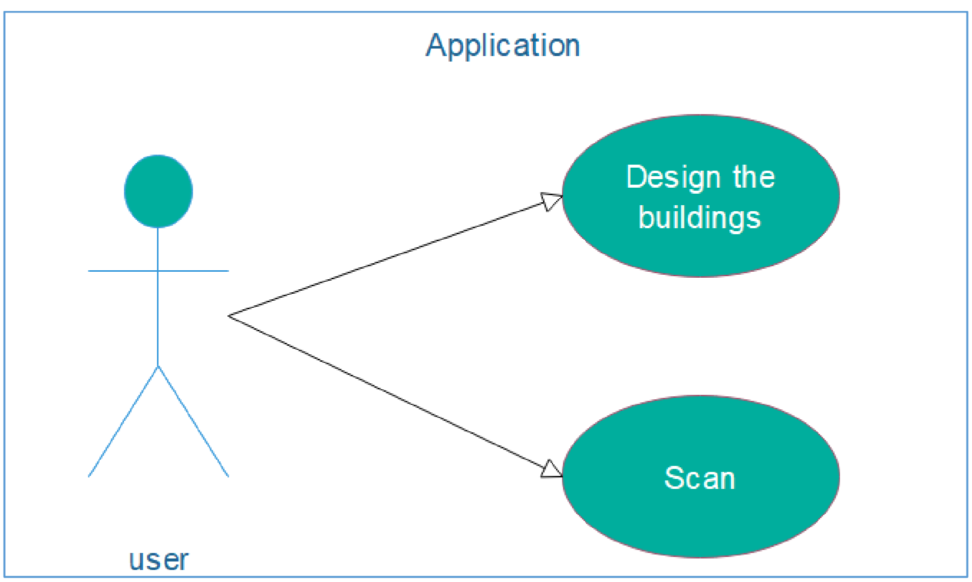


Figure 3-1 Application use case

- **Scan use case**

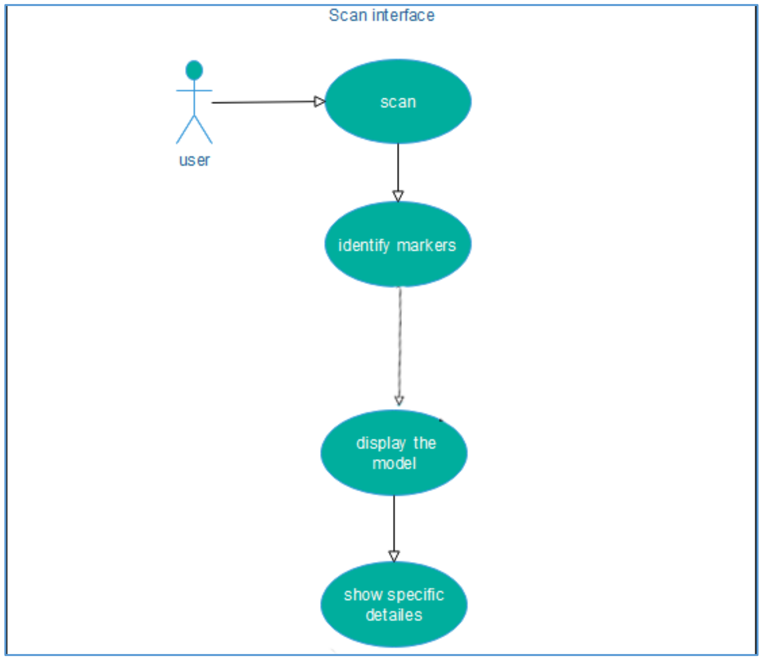


Figure 3-2 Scan use case

- **Design use case**

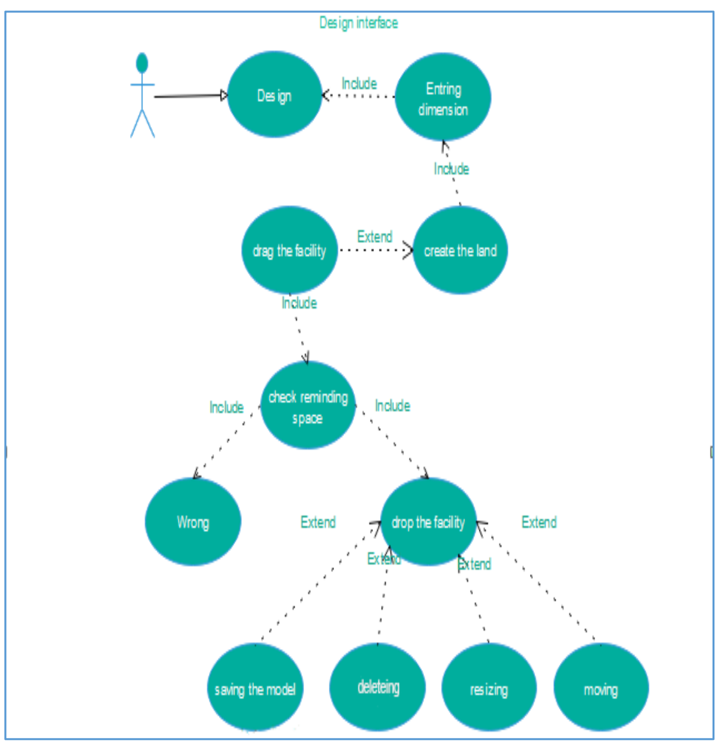


Figure 3-3 Design use case

3.5.2.1 Actors

AVAR application has only one actor (Architecture engineer, or casual user) as shown in table 3.1:

Actor name	Actor type	Access Type Need	Comments
User	Primary	Scan Desig	Scan the marker Drag and drop facilities

Table 3.1 Actor Information

3.5.2.2 Use Case Details

<table>
<tr><td>Importance Level: <u>High</u></td><td>ID: <u> 1</u></td><td>Use Case Name: Design buildings</td></tr>
<tr><td colspan="3">Area: AVAR Application</td></tr>
<tr><td colspan="3">Primary Actor: User</td></tr>
<tr><td colspan="3">Short Description: This use case describes how the user design a 3D building.</td></tr>
<tr><td colspan="3">Trigger event: User click design button.
Type: External</td></tr>
<tr><td>Information for steps

-None
-None
-specified dimensions
-None
-facilities(type, size)
-facility size
-3D object</td><td colspan="2">Major steps performed

• Open the application.
• Click the design button in the main interface.
• Enter the dimensions of the land.
• draw the land on the workshop.
• Drag and drop facilities.
• Resizing facilities.
• Save the whole model after finishing.</td></tr>
<tr><td colspan="3">Precondition: entering land dimensions and start dragging facilities</td></tr>
<tr><td colspan="3">Postcondition: saving the final designed object model</td></tr>
<tr><td colspan="3">Assumption: The application runs in unit environment</td></tr>
<tr><td colspan="3">Success guarantee: reach the final model which the user desired</td></tr>
<tr><td colspan="3">Minimum guarantee: drag one facility to the land space</td></tr>
<tr><td colspan="3">Requirement met: PC with unity environment.</td></tr>
<tr><td colspan="3">Outstanding issue: a small remaining space that does not fit a one facility</td></tr>
<tr><td colspan="3">Priority: High</td></tr>
<tr><td colspan="3">Risk: Low</td></tr>
</table>

Table 3.2 Use case Details (Designing)

Importance Level: High	ID: 2	Use Case Name: Scan
Area: AVAR Application		
Primary Actor: User		
Short Description: This use case describes how the user scan markers to display the object model.		
Trigger event: User click scan button. Type: External		
Information for steps -None -None -Saved markers -None -3D object model	Major steps performed • Open the application. • Click the scan button in the main interface • Position camera on the marker saved before • Recognize the marker • the 3D object model appears above the marker	
Precondition: scan saved markers		
Postcondition: view 3D object model		
Assumption: The application runs in unity environment		
Success guarantee: show the 3D object model		
Minimum guarantee: the camera will be open		
Requirement met: PC with unity environment.		
Outstanding issue: cannot identify markers		
Priority: medium		
Risk: Low		

Table 3.3 Use case Details (Scanning)

3.5.3 Sequence Diagram

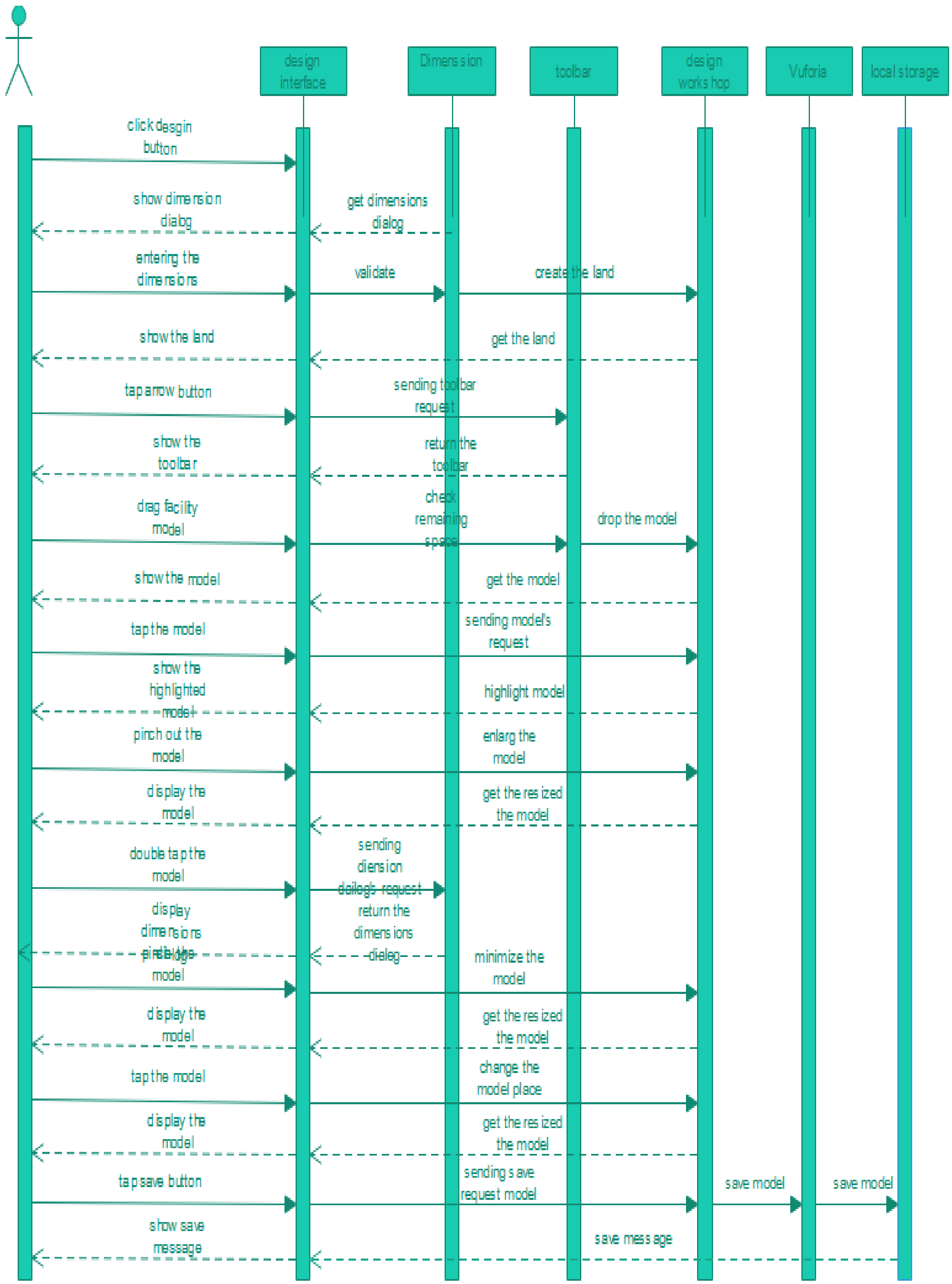


Figure 3-4 Designing Sequence Diagram

3.5.4 Activity Diagram

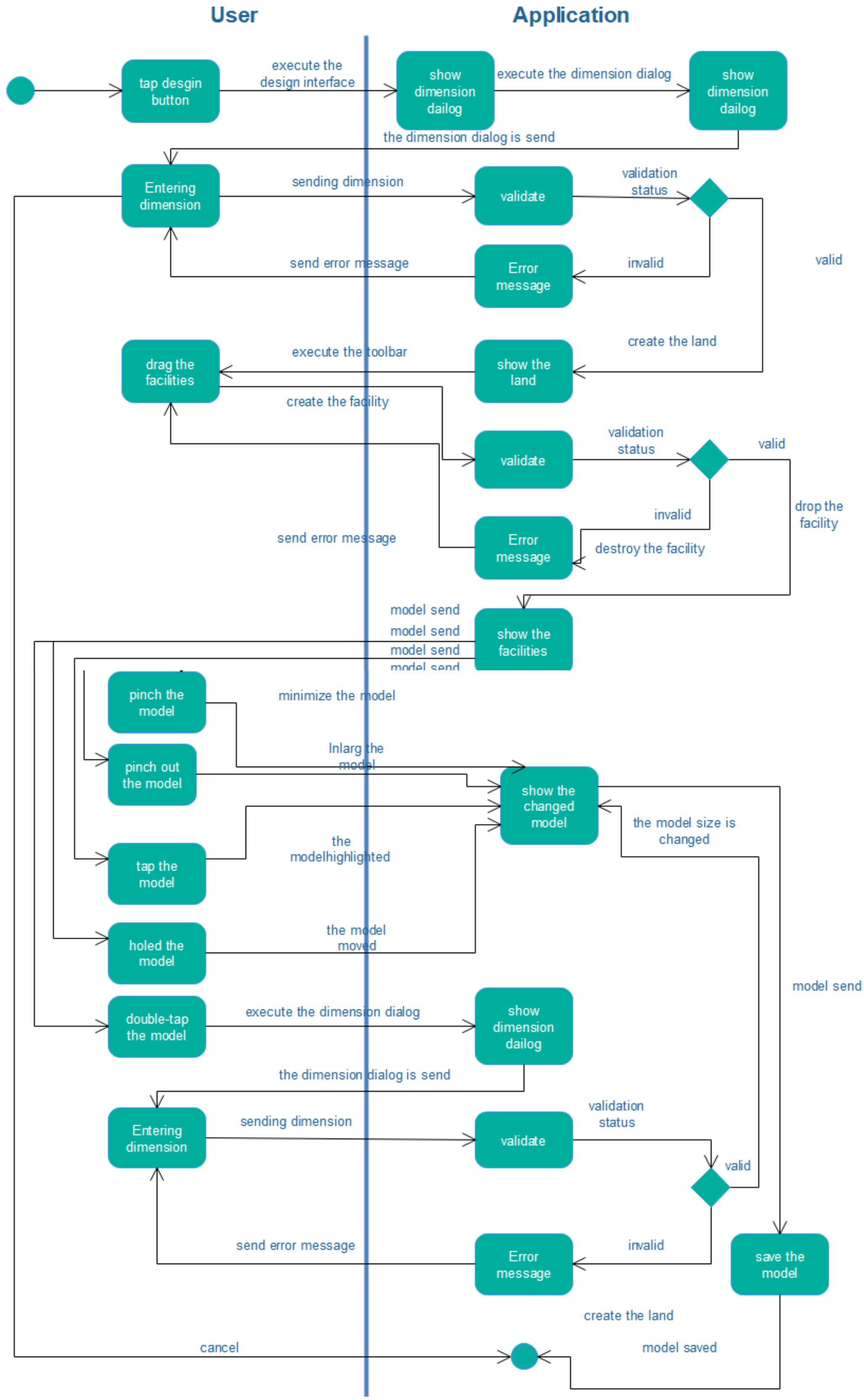


Figure 3-5 Designing Activity Diagram

CHAPTER FOUR

SYSTEM IMPLEMENTATION

4.1 Overview

AVAR application was developed using unity environment as its main tool. It is an architecture application that is used to design 3D building models and visualize them as an AR object. In this chapter, we will explain the implementation of the application in details, from the application design to the application evaluation.

4.2 Application Design

The application start with the main interface, which contain the application logo, and two buttons, **Design button** and **Scan button**. As shown in Figure 4-1.

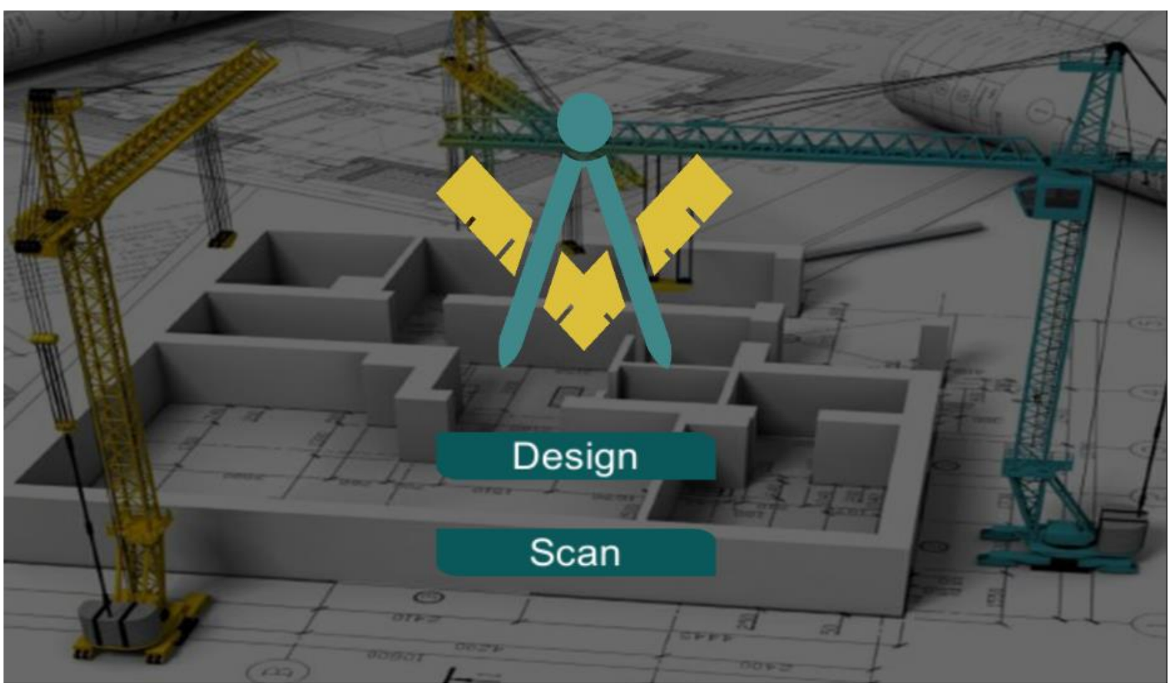


Figure 4-1 Main Interface

The design button give you the ability to start designing your own building. The **Scan button** visualize the models that have been built and saved as AR objects. First, when you click the **Design button**, the next interface will be opened as shown in Figure 4-2.

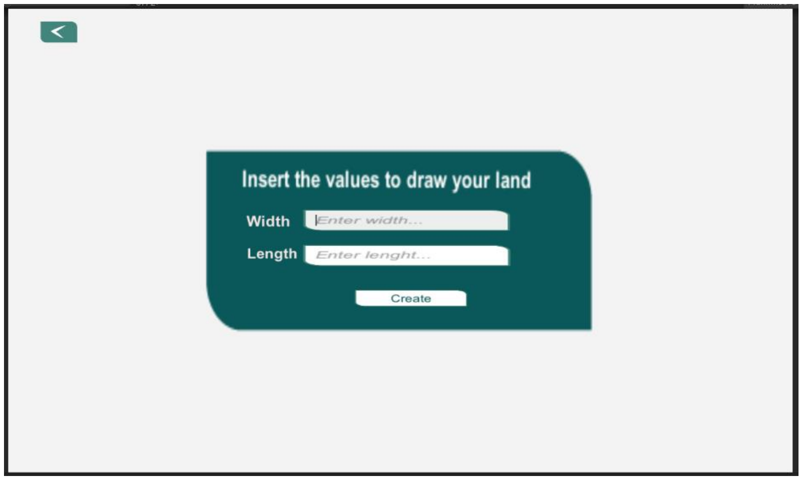


Figure 4-2 Enter Dimensions Dialog

This interface consists of back button  and dimensions dialog. The back button return you to the main interface. The dialog contains two input field Width and Length to insert the diminutions of the land by the user. Then clicking create button to instantiate the land as shown in Figure 4-3.

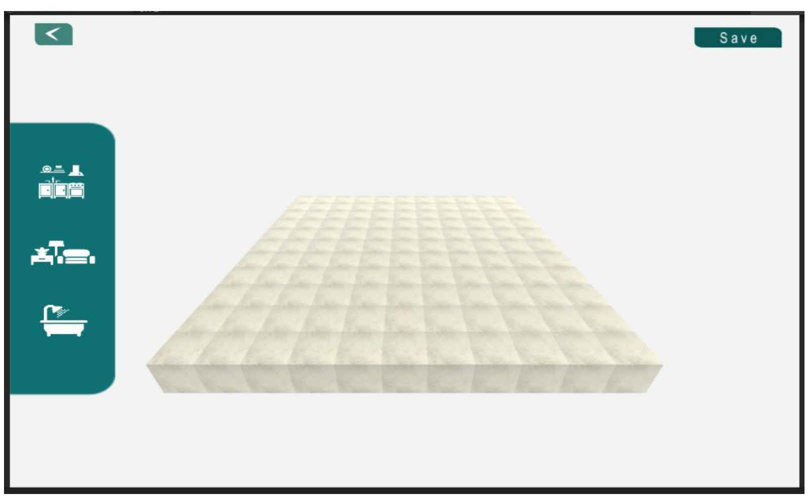


Figure 4-3 Design Interface

It also contain **Save button** and facilities bar that appear after creating the land, in the bar there is three facilities Kitchen, Room and Bathroom. You can drag and drop as much facilities as you want to the land. As shown in Figure 4-4, and Figure 4-5.

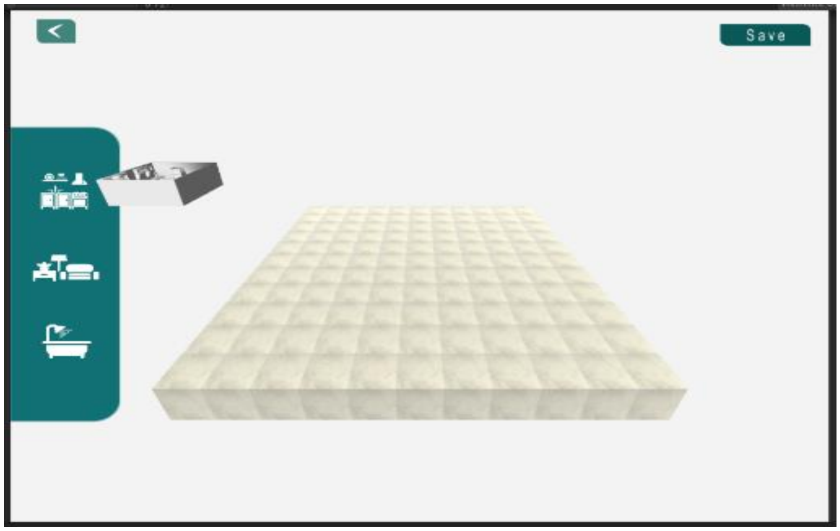


Figure 4-4 Dragging Room

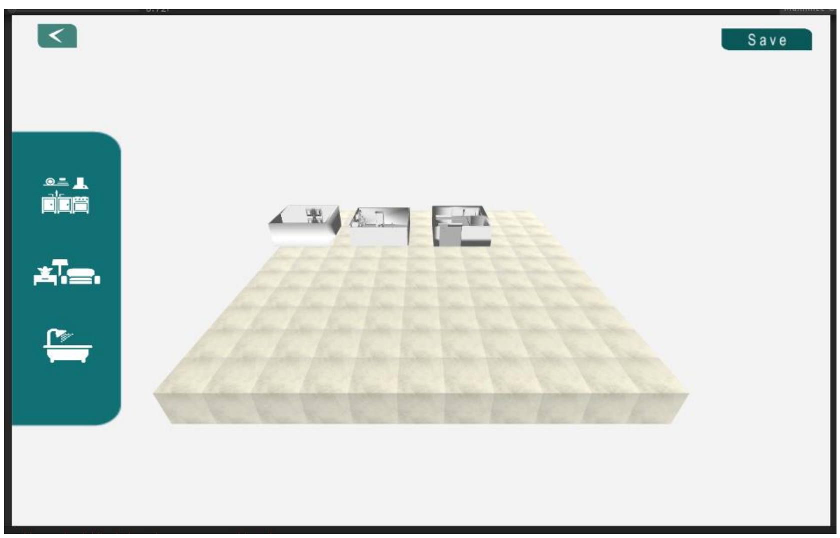


Figure 4-5 Dropping Rooms

There are some operation you can perform on rooms; **Delete**, **Move**, **Rotate** and **Scale**. If you want to delete a room, you must press the letter **X** in the keyboard then click on the room. If you want to move any room, click on the room and use the arrow on the keyboard. You can rotate or scale the room by clicking on the room and using two fingers as shown in Figure 4-6.

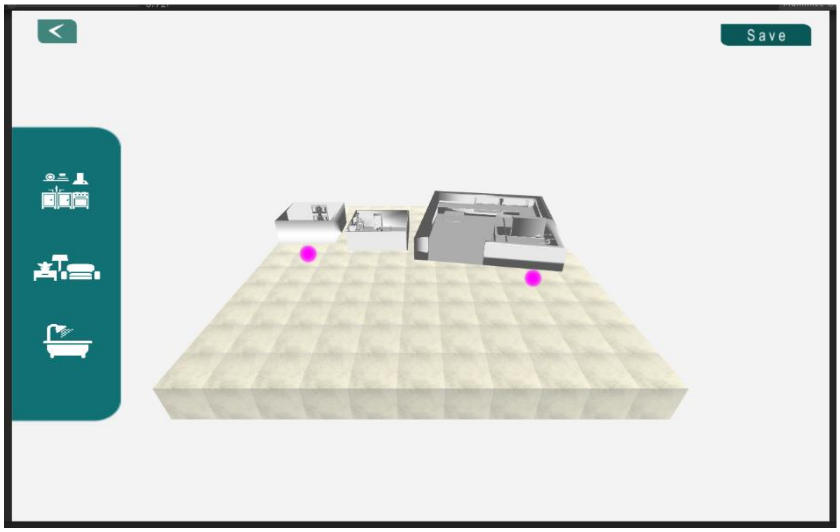


Figure 4-6 Rotate and scale Interface

In case you want to move the camera forward you can use the key **W**, while the key **S** is used to move the camera backward, the key **A** to the west and the key **D** to the east. As shown in Figure 4-7

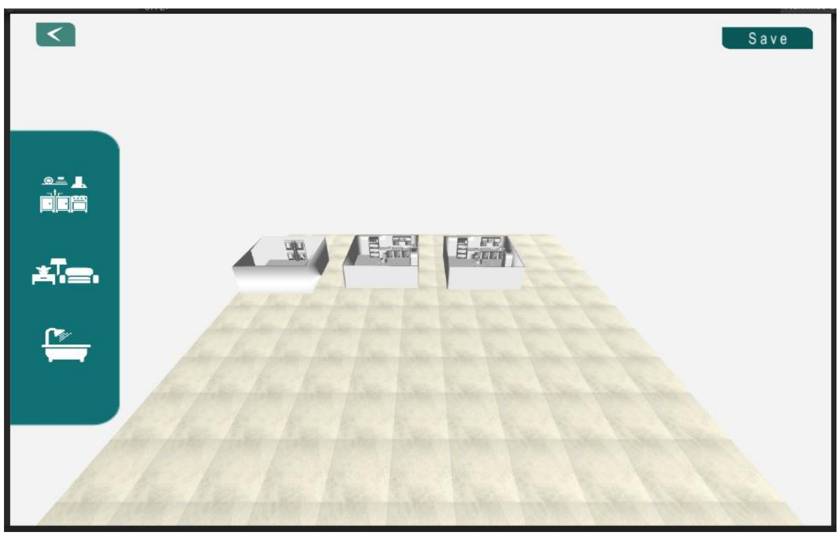


Figure 4-7 Move the camera

After finishing the whole design, you can click the **Save button**. Now you finish the design phase.

The Scan button; when you click on it, it will open the scan interface with camera, that contain a scroll bar displaying previously saved models to choose one. Finally scanning the marker by the camera appears the 3D model. As shown in Figure 4-8.

Figure 4-8 Scanning Interface

4.3 Application evaluation

The AVAR application were evaluated by end users. They liked the interface design and colors, they said it was interesting and entertaining. Also they said that the application help them to represent their ideas of their desired building designs in a better way. Some of them mentioned that it needs to be simpler for new users.

CHAPTER FIVE

CONCLUSION, FUTURE WORK AND RECOMMENDATIONS

5.1 Conclusion

AVAR is an architecture application that gives users ability to design and display their own building using 3D and AR technology. Various tools were used to develop the project in easy understandable ways to be usable by different kinds of users. In this chapter, future plans and recommendations of AVAR are mentioned.

5.2 Future Work

- Designing more than one floor.
- Specify number of windows in each room.
- Adding new facilities to design different type of buildings.
- Developing the application to work on android platforms.
- Add different languages to make AVAR international.
- Calculate the cost of whole used material.

5.3 Recommendations:

- Publishing AVAR app to Contractors' offices for their clients so they can demonstrate their visualization of their desired buildings.
- Uploaded to app store to be available for individual.

Appendices

Appendices A

A sample of AVAR questionnaire is shown below:

استبيان حول AVAR

تطبيق يساعد المستخدم على تصميم معماري لأرضه باستخدام تقنية 3D ليعرضها بعد ذلك بواسطة الواقع المعزز، فكرة عمل الواقع المعزز هي اضافة ودمج عناصر افتراضية للعالم الحقيقي عن طريق الكاميرا. مثل تطبيق Snapchat ولعبة Pokemon

1. ماهو مؤهلك التعليمي ؟

- مهندس معماري
- غير ذلك

2. هل واجهتك مشاكل في تكاليف تصميم مخطط معماري لأرضك؟

- نعم
- لا

3. هل سبق وشعرت بأن المهندسين المعماريين قد لا يفهمون متطلباتك؟

- اوافق
- لا اوافق
- محايد

4. هل تعتقد بأن تصميم مخطط معماري مجهد جداً؟

- اوافق
- لا اوافق
- محايد

5. أتعتقد انه من الصعب فهم المخططات المعمارية او مساعدة الناس على فهمها؟

- اوافق
- لا اوافق
- محايد

6. أتريد تصميم منزلك بنفسك؟

- نعم
- لا

7. هل سبق و استخدمت تطبيق يدعم تقنية ثلاثية الإبعاد ؟

- نعم
- لا

8. هل سبق و استخدمت تطبيق يدعم الواقع المعزز(Augmented reality) ؟

- نعم
- لا

9. هل كان استخدامه سهل؟

- اوافق
- لا اوافق
- محايد

10. هل تدعم فكرة تطبيق يستخدم ثلاثيات الابعاد ليساعدك في تصميم منزلك بسهولة؟

- اوافق
- لا اوافق
- محايد

11. أتظن أنه من الجيد استخدام الواقع المعزز(Augmented reality) في هذا التطبيق؟

- اوافق
- لا اوافق
- محايد

12. كمهندس معماري أتدعم فكرة هذا التطبيق ؟

- اوافق
- لا اوافق
- محايد

13. أتظن بأن المجتمع سيتقبل ويستخدم هذا التطبيق؟

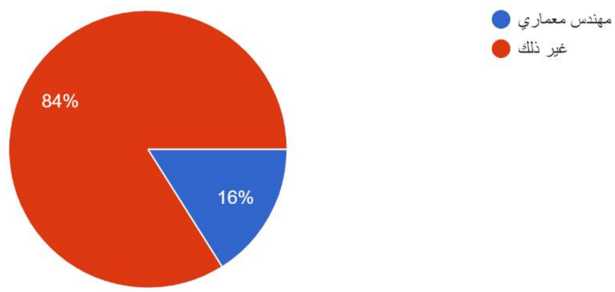
- اوافق
- لا اوافق
- محايد

Appendices B

AVAR questionnaire responses are shown in the next figures:

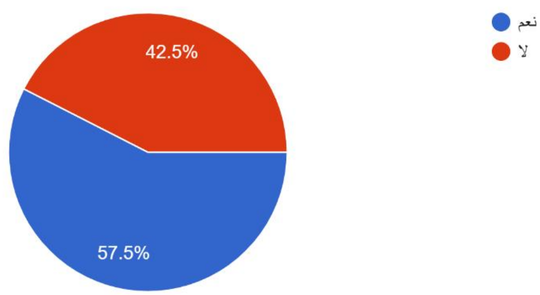
1. ماهو مؤهلك التعليمي ؟

81 responses



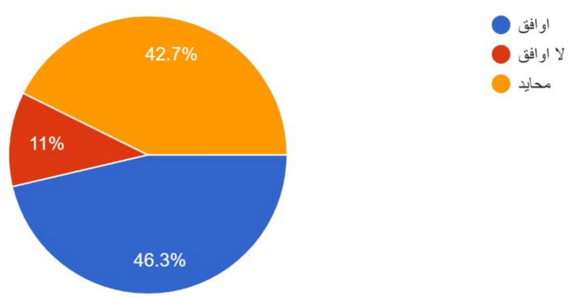
2. هل واجهتك مشاكل في تكاليف تصميم مخطط معماري لأرضك؟

80 responses

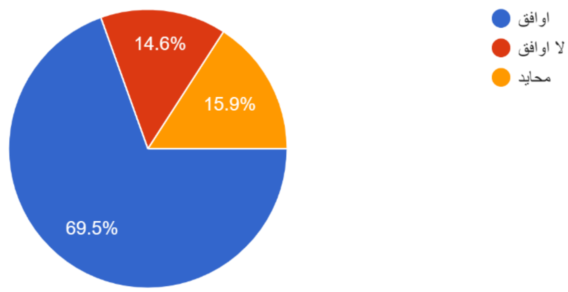


3. هل سبق وشعرت بأن المهندسين المعماريين قد لا يفهمون متطلباتك؟

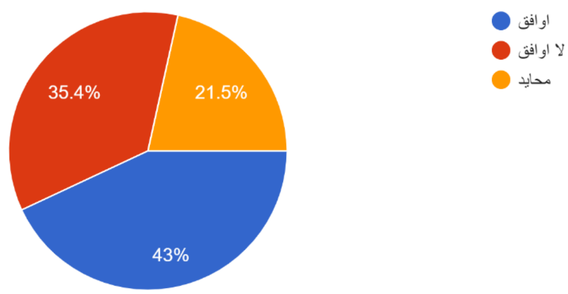
82 responses



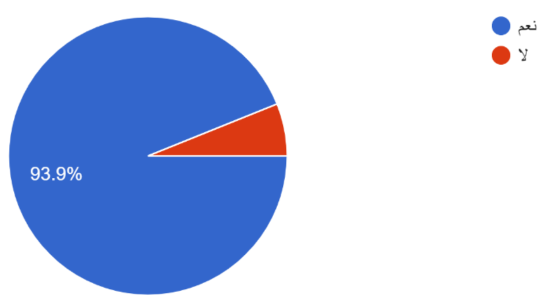
4. هل تعتقد بأن تصميم مخطط معماري مجهد جداً؟
82 responses



5. أتعتقد انه من الصعب فهم المخططات المعمارية او مساعدة الناس على فهمها؟
79 responses

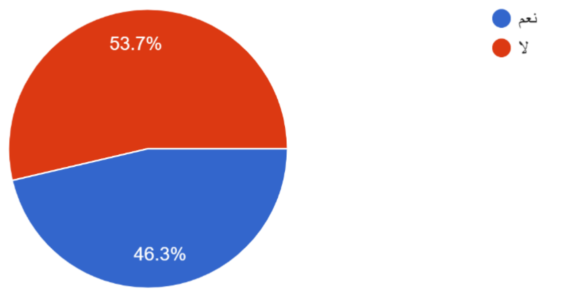


6. أتريد تصميم منزلك بنفسك؟
82 responses



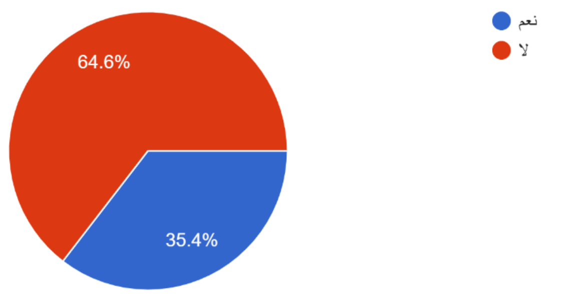
7. هل سبق و استخدمت تطبيق يدعم تقنية ثلاثية الابعاد ؟

82 responses



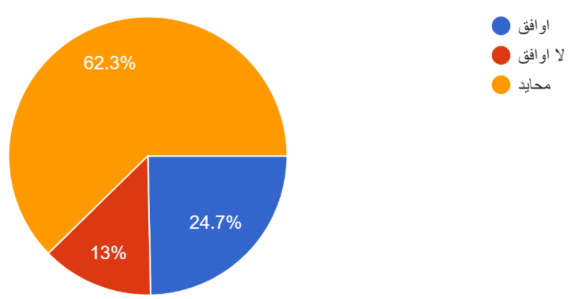
8. هل سبق و استخدمت تطبيق يدعم الواقع المعزز (Augmented reality) ؟

79 responses

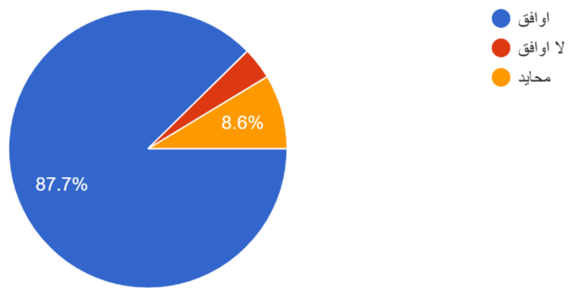


9. هل كان استخدامه سهل؟

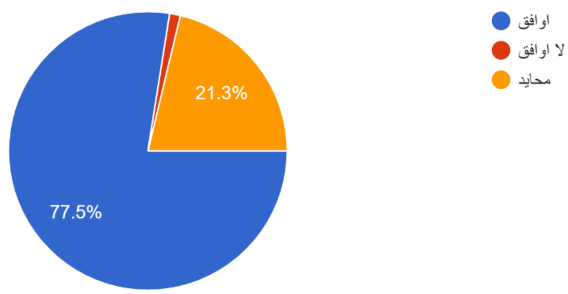
77 responses



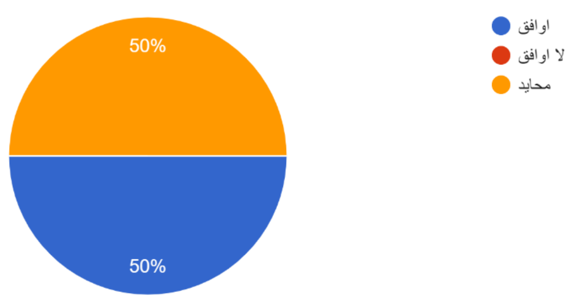
10. هل تدعم فكرة تطبيق يستخدم ثلاثيات الابعاد ليساعدك في تصميم منزلك بسهولة؟
81 responses



11. في هذا التطبيق؟ (Augmented reality)أتظن أنه من الجيد استخدام الواقع المعزز
80 responses

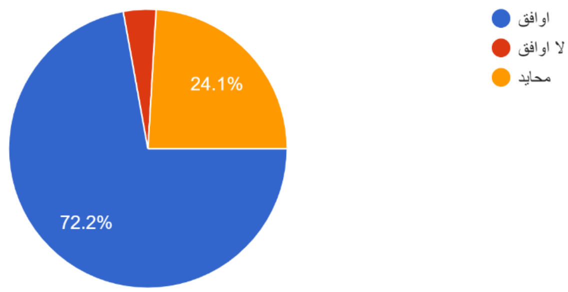


12. كمهندس معماري أتدعم فكرة هذا التطبيق ؟
76 responses



13. أتظن بأن المجتمع سيتقبل ويستخدم هذا التطبيق؟

79 responses



Appendices C

A sample of AVAR evaluation response is shown below:

AVAR Evaluation

AVAR (architecture visualization using augmented reality):

تطبيق يساعد المستخدم على تصميم معماري لأرضه باستخدام تقنية 3D ليعرضها بعد ذلك بواسطة الواقع المعزز، فكرة عمل الواقع المعزز هي إضافة ودمج عناصر افتراضية للعالم الحقيقي عن طريق الكاميرا.

1. من خلال استخدامك لتطبيق AVAR هل وجدته مرن؟

○ نعم ● محايد ○ لا

2. هل سهل التطبيق تصميم المبنى؟

● نعم ○ محايد ○ لا

3. هل ساعدك التطبيق في إيصال فكرتك بشكل أفضل؟

● نعم ○ محايد ○ لا

4. هل مازلت تؤيد استخدام التطبيق بدلا من استخدام المخطط المعماري التقليدي؟

● نعم ○ محايد ○ لا

5. هل وجدت واجهة التطبيق مناسبة من ناحية الألوان وحجم الخط وما الى ذلك؟

● نعم ○ محايد ○ لا

6. هل وجدت التطبيق ممتع بحيث يجعلك ترغب في استخدامه أكثر من مرة؟

● نعم ○ محايد ○ لا

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