KULLIYYAH OF INFORMATION TECHNOLOGY AND COMMUNICATION

DEPARTMENT OF INFORMATION SYSTEM

INFO 4402 REPORT

SWITCHAR
(AR VIRTUAL SWITCH CONTROL FOR IOT-BASED SMART HOME AUTOMATION)

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SEMESTER I 2023/2024

FINAL YEAR PROJECT REPORT

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In partial fulfillment of the requirement for the
Bachelor of Information Technology

Department of Information System
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A Final Year Project paper submitted to the

Department of Information System
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Approved by the Examining Committee:

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CERTIFICATE OF ORIGINALITY

I declare that the contents of this research paper are original and are solely my effort, except for the acknowledged and referenced sections which are derived from the work of others. I also recognize and explicitly mention any contributions made by my collaborators during this project.

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ACKNOWLEDGEMENT

We would like to express our gratitude and praise Allah SWT for paving us the way to complete this project successfully.

Our heartfelt appreciation goes to Dr. Zainatul Shima binti Abdullah, our Final Year Project supervisor, for her invaluable guidance, support, and encouragement throughout this journey. Your influence has been a cornerstone in our achievements.

We are immensely grateful to our parents, Rizal bin Abu Bakar and Sahida binti Saad (Haikal's parents), and Abd Aziz bin Sulaiman and Nyonya Md Sani (Amir's parents), for their unwavering support and sacrifices. Your dedication and love have been our constant motivation to strive for excellence.

A special note of thanks to our friends and lecturers for their relentless support and encouragement, and to everyone who contributed to our project. Your collective efforts have played a vital role in our success.

ABSTRACT

SwitchAR is a mobile app that combines augmented reality (AR) and Internet of Things (IoT) technology to make controlling smart home devices easy and fun. This app is specially designed for homeowners, including elderly and disabled individuals who might find it hard to move around or use regular switches. With SwitchAR, they can control lights, temperature, and other home appliances directly from their smartphones, making daily tasks simpler and more accessible.

The project aims to address the challenges faced by many in using current smart home systems, which can be complex and difficult to manage. SwitchAR simplifies this by offering a single, easy-to-use platform that brings together all home devices. It's particularly beneficial for those with mobility issues, providing a way to control their home environment easily and independently, enhancing their quality of life.

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CHAPTER 1
INTRODUCTION

1.0 PREAMBLE

SwitchAR is a mobile application that combines augmented reality technology with IoT smart home devices to give users a more accessible and interactive way to control their house switches. The primary target users for the application are homeowners, elderly and disabled individuals who may have difficulty moving around their homes or using traditional switches. By using SwitchAR's application, users can easily interact with their smart home devices and appliances, which requires no physical coordination or mobility. This unique and innovative solution could change the way people interact with their smart home devices, making them easier to use and more convenient. SwitchAR could simplify the control and monitoring of IoT-enabled appliances and switches. This would encourage more people to use IoT technology, which would reduce costs for homeowners and improve the energy efficiency of their homes.

1.1 PROBLEM DESCRIPTION

In this section, the developers of the project will address the issue encountered by the target audience. To tackle this issue, it is necessary for the project developers to examine and articulate the challenge prior to the development of the device.

1.1.1 Background of the problem

The Internet of Things (IoT) has made smart homes more common. But, many people, especially the elderly or those with disabilities, find these smart homes hard to use. Picture an older person who can't easily turn up the heat on a cold night, or someone in a wheelchair who struggles to switch off lights. These aren't small issues; they make everyday life harder and take away their independence. Today's smart homes are complicated because they use too many different apps, making it tough for these people to get the most out of this technology. Our project is about making a simple, user-friendly system that combines augmented reality (AR) with IoT. The developers want to make smart homes easy for everyone to use, not just as a fancy feature, but as a real help in their daily lives. This is about giving people back their independence and making their

days easier. The developers need to create a solution that turns smart homes into a true support tool, not just a gadget.

1.1.2 Problem Statement

Right now, there are not many AR-integrated IoT mobile applications available in the market. Despite the fact that smart home automation has had a significant impact, there is still a market demand for a unified solution that is user-friendly and can meet the specific needs of homeowners, especially the elderly and disabled. For example, an elderly person who has difficulty moving around may find it difficult to reach and use traditional light switches. Furthermore, smart home devices lack customization and control options, making it difficult for users to fully utilize and control their devices. By using SwitchAR, they can easily control these devices with their smartphone while also increasing interactivity with smart home devices via augmented reality.

1.2 PROJECT OBJECTIVES

- To develop an AR-integrated IoT mobile application (SwitchAR) that can allow users to easily control switches in their home environment.
- Implement an automation feature where users can set conditions to automatically control devices.
- Simplify setup and customization for users by automatically adding and configuring switches in SwitchAR, ensuring a hassle-free experience.
- Integrate SwitchAR with Google Home Assistant for voice command capabilities, allowing users to control their smart home devices through spoken instructions.

1.3 PROJECT SCOPE

Developers will establish the project's scope by determining the information necessary for starting the project and for testing the device.

1.3.1 Scope

This project aims to develop SwitchAR, a cutting-edge mobile application that seamlessly integrates Augmented Reality (AR) and Internet of Things (IoT) technologies.

Primarily targeting Android devices, the app will facilitate easy control and automation of smart home devices like ESP32, temperature sensors, switches, and light bulbs, streamlining daily tasks for users. A key feature of SwitchAR is its user-friendly interface, designed to simplify interaction with a variety of smart home devices and enhance overall home management. This scope is dedicated to advancing smart home technology through innovative AR applications and intuitive user experiences.

1.3.2 Target Audience

The target audience for this project are homeowners, elderly people as well as those with disabilities that have mobility issues.

1.3.3 Specific Platform

Software	Hardware
Unity Hub	ESP32 Devkit V1
Vuforia	3 Light Bulbs (Red, White, Yellow)
Blynk	4 Relay Module
Arduino IDE	2 Pin Plug
Visual Studio Code	Multi Thread Wire
Flutter	USB Cable
IFTTT	9V Battery
Google Assistant	Android Smartphone
	12V Fan
	Breadboard
	Jumper Wire
	DHT 11 Temperature Sensor
	LED

Table 1.3.3.1 Specific platform

1.4 CONSTRAINTS

The restriction and limitations for developing this application is that it might have compatibility issues when dealing with different mobile operating systems commonly Android and iOS. It might require more time for debugging and testing as different operating systems have different functionality. Therefore, the developers will only focus on building the mobile application on the android operating system. On the other hand, the environment of the room when using the augmented reality camera needs to be clear and bright to capture the object in a more precise manner. In terms of time, developing the application might require more time for research, debugging and testing. With developers' lack of expertise, this can become a huge barrier for the developers to try as many alternatives as possible to develop the application. For budget, the software used to develop the project is free, but some of the features are limited unless subscriptions are involved. Plus, the need to buy some components required money so the developers might need to consider the use of subscriptions platforms as well as purchasing the components if needed in future.

1.5 PROJECT STAGES

The project comprises two distinct phases: FYP1 and FYP2, each with a specific focus. In FYP1, the developers concentrate on completing Chapters 1, 2, and 3, encompassing the introduction, literature review, and methodology. FYP2 is dedicated to Chapters 4 and 5. To illustrate these timelines clearly, the developers utilize a Gantt chart for visual representation.

Task Title	March			April				May				June		
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
Project Proposal														
Course Briefing														
Seminar 1: Chapter 1 (Introduction)														
FYP Consultation with Supervisor														
Seminar 2: Chapter 2 (Literature Review)														
Consultation (Group)														
Seminar 3: THE FYP- Is your project worth doing?														
Submission Chapter 1 & Chapter 2														
Mid Semester Break														
Seminar 4: Chapter 3 (Analysis & Design:Methodologies)														
FYP Consultation with Supervisor														
Seminar 5: Prototype Design (UI/UX)														
Consultation (Group)														
Seminar 6: FYP Showcase/Technical Paper/Poster Briefing														
Submission Poster and Final Report														
FYP Consultation with Supervisor														
FYP Showcase														
Submission Final Report														

Figure 1.5.1 FYP 1 Gantt chart for switchAR project

Task Title	October			November				December				January		
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
Seminar 1: Final Year Project 2 Briefing														
Manage Project Work														
Seminar 2: Library Copyright														
Set up Hardware and Software														
Seminar 3: Final Report (Chapter 4: Result & Discussion)														
Seminar 4: Final Report (Chapter 5: Conclusion)														
Test Hardware and Software														
Mid Semester Break														
Seminar 5: Technical BootCamp														
Testing System with end users														
System Debugging														
Seminar 6: FYP Showcase/Poster Briefing/Technical Report														
FYP Consultation with Supervisor														
Documentation														
FYP Consultation with Supervisor														
Submission Poster and Final Report														
FYP Showcase														
Submission Technical Report														

Figure 1.5.2 FYP 2 Gantt chart for switchAR project

1.6 SIGNIFICANCE OF THE PROJECT

This project aligns with the United Nations Sustainable Development Goals (SDGs), specifically targeting SDG 9 (Industry, Innovation, and Infrastructure) and SDG 11 (Sustainable Cities and Communities). By improving accessibility, efficiency, and sustainability in home automation, it contributes to creating smarter and more inclusive living environments, thus promoting progress towards these global sustainability goals.

Bringing together Augmented Reality (AR) and Internet of Things (IoT) has the potential to revolutionize home automation technology. It offers a straightforward way for elderly individuals and those with disabilities to manage their living spaces effectively. This approach makes complex network systems and smart homes easier to navigate, leading to higher user satisfaction and increased adoption of IoT devices.

The combination of AR and IoT also proves effective in reducing energy consumption. By efficiently controlling household appliances, users can cut down on energy costs. AR technology simplifies power management, allowing precise control over devices, temperature regulation, and real-time power monitoring. This not only saves money but also reduces carbon emissions. Additionally, using appliances responsibly can extend their lifespans, resulting in fewer repairs and replacements, leading to cost savings.

AR technology paired with IoT devices provides a practical and efficient way to control various smart home appliances through a central interface. This innovation can serve as an inspiration for academics and developers looking to integrate augmented reality into healthcare and education. By making technology more user-friendly, this project could attract increased investment, fostering significant growth in the smart home automation market.

1.7 PROJECT SUMMARY

The SwitchAR project is dedicated to enhancing the user experience in smart home device control. This mobile application seamlessly integrates Augmented Reality (AR) and Internet of Things (IoT) technologies to provide a user-friendly solution for homeowners, elderly people and people with disabilities. The primary objectives of the project include developing an AR-integrated IoT mobile application (SwitchAR) for simplified switch control in home environments, implementing automation features for user convenience, streamlining setup and customization processes, and integrating voice command capabilities through Google Home Assistant. This project aligns with the United Nations Sustainable Development Goals (SDGs), particularly SDG 9 (Industry, Innovation, and Infrastructure) and SDG 11 (Sustainable Cities and Communities). By enhancing accessibility, efficiency, and sustainability in home automation, it contributes to the creation of smarter and more inclusive living environments, thus advancing progress toward these global sustainability goals. Despite the challenges it may encounter, such as compatibility and lighting conditions, the ultimate goal is to empower users and pioneer innovations in smart home technology, utilizing AR and IoT on the Android platform.

CHAPTER 2
LITERATURE REVIEW

2.0 OVERVIEW OF AR AND IOT TECHNOLOGY

As defined by Investopedia (2022), augmented reality involves integrating digital images and data onto the user's physical surroundings. It differs from virtual reality since it takes place outside of a simulated environment. Augmented reality technology uses cameras, sensors or software to detect a real-world setting where users' movements are tracked in real-time before projecting virtual objects that appear merged into their actual surroundings.

With the rise of the Internet of Things, an ever-increasing number of physical devices are being linked together via the internet in order to share information with one another. Enabled by state-of-the-art sensors and communication modules built into these devices themselves, they seamlessly connect with both other devices within their local networks. Currently comprising over 7 billion installed IoT components around the world according to Oracle (2020), industry experts predict that these numbers will soar even higher - perhaps up to more than triple its present size by way of reaching a network size totaling up to approximately 22 billion separate IoT elements by 2025.

In recent years, the integration of AR and IoT has increased, creating new and innovative applications. For example, using AR technology to create virtual interfaces that can be used to control IoT devices, allowing users to control their smart home devices in a more interactive and natural way. Research by Syahidi et al. (2021) suggests that IoT technology can provide AR data that enables realistic and informative virtual overlays. In general, AR and IoT innovation is a rapidly changing field with great potential for cutting-edge and innovative applications in various areas, such as smart home automation.

2.1 CURRENT STATE OF SMART HOME AUTOMATION

Smart homes have gained momentum due to ongoing technological advances that enable homeowners to control their household equipment effortlessly. One such advancement is found in home automation - a concept that has been present for many years but is increasingly relevant today. Home automation technology has changed significantly due to two key factors -

rapid advancements in internet connectivity and increasing prevalence of smartphones. As a result, features that were once considered luxurious such as remote controls for garage doors are now standard equipment or even entry-level standards for many homeowners. IoT devices are more common than ever today, and the cost of smart home systems continues to fall, making them an attractive option for homeowners (Zeus Integrated Systems, 2014).

2.1.1 Types of smart home automation

Types	Description	Advantages	Disadvantages
1. Power Line	Uses existing electrical power lines to send data and control signals between devices Smart Home Works. (2022, November 3). *What are the Types of Smart Home Automation Systems?*	Greater reliability and security compared to wireless networks	May not be compatible with all devices or appliances and limited by the quality and age of home wiring
2. Wired	Uses Ethernet cables or control wiring to connect and control devices Smart Home Works. (2022, November 3). *What are the Types of Smart Home Automation Systems?*	Faster and more reliable communication, better security, and ability to support a large number of devices	Requires extensive planning, installation work, and specialized knowledge and skills, making it more expensive and time-consuming than wireless or powerline systems
3. Wireless	Uses Wi-Fi or Bluetooth technology and a central hub as a controller to oversee household appliances Smart Home Works. (2022, November 3). *What are the Types of Smart Home Automation Systems?*	Convenient control of devices from anywhere with a solid internet connection	Range and dependability of Wi-Fi signals can be a drawback

Table 2.1.1.1 Types of smart home automation

2.2.2 Augmented reality in smart home automation

Augmented reality home design, smart mirrors, and smart glasses are all examples of augmented reality application in smart home automation (Software Testing App, 2023). AR-enabled home design tools give users the ability to create a virtual environment in which they can plan the optimal home environment before actually putting it into action. Augmented reality and smart mirrors both have the ability to provide event and weather information in real time. Last but not least, smart glasses make it possible to communicate with automated systems without using your hands. Augmented reality, also known as AR, is a technology that is becoming increasingly important in the development of advanced home automation systems.

This modern trend benefits people with limited hand dexterity as well as those who want to try new things. According to recent research, AR technology in smart remote controls may help people understand and control complex systems (Software Testing App, 2023). Active visualization could help to facilitate the learning process. Furthermore, by providing feedback in both audio and visual formats, augmented reality has the potential to improve the accessibility of smart home automation systems for users with disabilities, such as those who are blind or visually impaired (Žilak et al., 2022).

Despite providing potentially game-changing benefits, augmented reality-based smart home automation systems continue to face a number of obstacles. The main issue with them is their high price, which might prevent widespread adoption. Given their propensity for gathering sensitive data, AR-based systems are also hampered by worries about privacy and safety (Kaspersky, 2021). The ability to accurately display virtual objects can also be hampered by the difficulty of obtaining ideal lighting conditions. Finding solutions to these issues is essential if consumers are to have confidence in and security in AR-based smart home automation systems.

2.3 LIST OF EXISTING APPLICATION

2.3.1 Phillips Hue

Figure 2.3.1.1 Phillips Hue Mobile Application

The Philips Hue mobile app lets users control their smart lighting system. IoT connects the app to the user's Philips Hue lights, allowing them to control them remotely with their smartphone or voice assistant. The app lets you set schedules, create custom lighting scenes, and control lights by room. Hue Preview, the app's AR feature, lets users use their phone's camera to see how different lighting setups would look in their homes. AR lets users experiment with lighting configurations and create custom scenes to automate their lighting throughout the day, improving their smart home experience.

2.3.2 IKEA Place

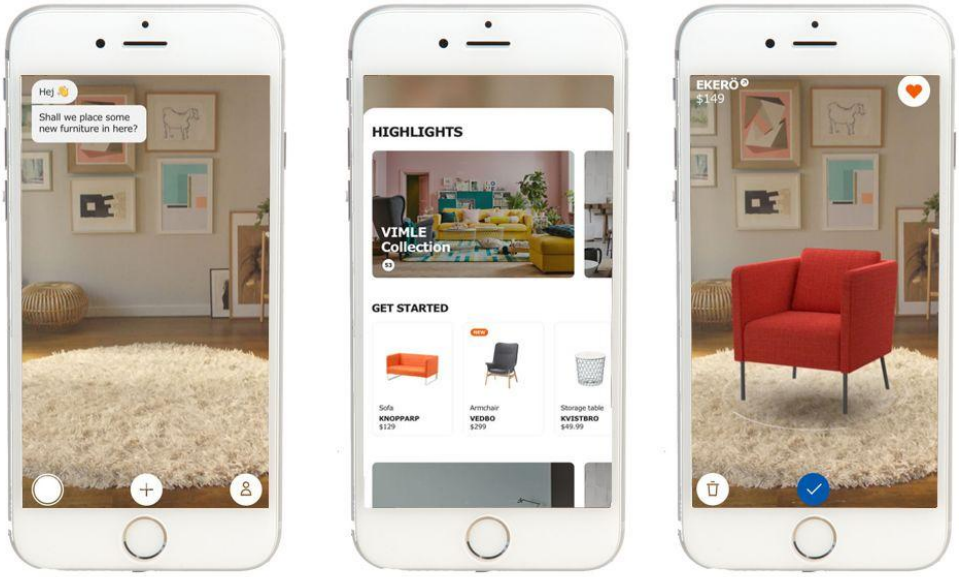

Figure 2.3.1.2 IKEA Place Mobile Application

IKEA Place is an app that uses IoT and augmented reality to show users how IKEA furniture will look in their homes before they buy it. Computer vision and cloud servers create a 3D model of the user's room and position virtual furniture precisely. The app makes use of IoT to access IKEA's product catalog and allows users to buy items from their website. The app provides access to IKEA's cloud-based product catalog, which displays current and accurate information about IKEA furniture products such as dimensions, materials, and availability.

2.3.3 Smart AR Home

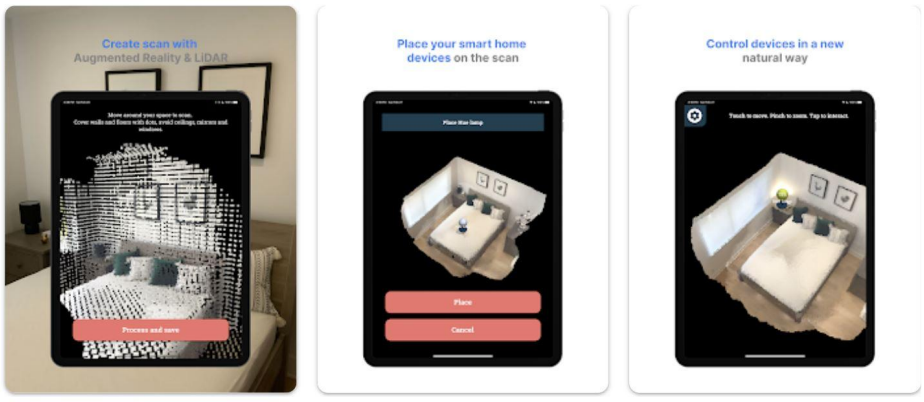

Figure 2.3.1.3 Smart AR Home Mobile Application

Smart AR Home uses augmented reality and 3D technology to create a visual map of the user's home and interact with Samsung SmartThings and Philips Hue light switches and dimmers via a smartphone's camera. The app uses image recognition to find an anchor point in the home, like a framed painting or book cover, and then users can walk to their connected devices and interact with them through the camera view. Users can manage light switches, dimmers, and shades and export/import settings to other mobile devices.

2.3.4 Samsung SmartThings

Figure 2.3.1.4 Samsung SmartThings Mobile Application

Samsung SmartThings lets users control and monitor many smart home devices from one interface. The app connects to compatible devices like lights, thermostats, and security systems using Internet of Things (IoT) technology and lets users control them remotely from their smartphone or tablet. Samsung SmartThings also uses AR to improve user experience. AR lets users place virtual SmartThings devices in their home before buying and installing them.

2.4 ADVANTAGES AND DISADVANTAGES

Existing System	Advantages	Disadvantages
1. Phillips Hue	1. The app's user interface is straightforward, making it simple to navigate and operate. 2. Popular voice assistants like Amazon Alexa and Google Assistant can work with the app. 3. The app allows you to set up schedules and automation routines. 4. The app's controls include the ability to turn lights on and off, dim, change color, and set timers.	1. The app has limited compatibility where it only works with Phillips Hue smart bulbs and accessories. 2. The augmented reality functionality is only limited to how the lighting would look in the home. 3. Requires users to add Phillips Hue devices manually. 4. Users looking to expand their smart home setup may be limited by the high price of Philips Hue devices
2. IKEA Place	1. The app has a great virtual placement accuracy of 3D models in a real environment. 2. The app's user interface is straightforward, making it simple to navigate and operate. 3. The app uses markerless augmented reality (AR) technology. 4. The app can integrate well with IKEA devices.	1. The app has limited compatibility where it only works with IKEA devices and not all IKEA devices are integrated with AR as it requires time and effort to produce accurate 3D models of furniture. 2. The app has limited automation and customization options, you can just place 3D models only. 3. The augmented reality functionality is only to place 3D models of IKEA products. 4. Since the app uses markerless AR and relies on lidar scanning the environment to place objects, it may not be compatible with all

		smartphones.
3. Smart AR Home	1. You can control smart home devices through 3D scanned rooms. 2. Integrates with Samsung SmartThings to connect with smart home devices. 3. Offers augmented reality control for smart home devices.	1. Not compatible with all smartphones as scanning is required. The app only supports iOS devices. 2. The app has stability issues and augmented reality often glitches. 3. Users will have to scan their rooms to integrate their devices which may be a hassle as AR cameras do not produce accurate results in certain conditions. 4. The app has limited compatibility where although it is compatible with a lot of different devices it doesn't work with all smart home products.
4. Samsung SmartThings	1. SmartThings lets people make their own automations and routines based on certain actions and triggers. 2. Compatible with many smart home devices from different brands. 3. The app is easy to use and navigate, which makes setting up and controlling the smart home devices simple.	1. The app has limited functionality such as the ability to set temperature limits on thermostats. 2. The app has connectivity problems where the devices are going offline or the app is not working. 3. The app has limited compatibility where although it is compatible with a lot of different devices it doesn't work with all smart home products. 4. The shop is the only feature that can utilize the Augmented Reality functionality for users.

Table 2.4.1 Advantages and Disadvantages

2.5 EXISTING SYSTEM FUNCTION

Application	Internet of Things (IoT)	Markerless Augmented Reality	Marker-based Augmented Reality	Compatibility	Customization	AR Virtual Buttons
Philips Hue	✓	✓	-	-	✓	-
Ikea Place	✓	✓	-	-	-	-
Smart Home AR	✓	✓	-	-	-	-
Samsung SmartThings	✓	✓	-	-	✓	-
switchAR	✓	-	✓	✓	✓	✓

Table 2.5.1 Literature Review for Existing System Function

2.6 SYSTEM ADAPTATION

Features / Functionality	Explanation
1. Marker-based Augmented Reality	• Marker-based AR enables more smartphone options for users to use. • Marker-based AR is easy to implement and use by users. • The app will provide clear instructions and guidelines for using the marker to control smart home devices in AR mode. • This technology can increase the app's user adoption and satisfaction by reducing the learning curve and potential confusion.
2. Integration of Blynk IoT Platform	• Blynk is a flexible IoT platform that supports many hardware devices, including Arduino, ESP8266, and Raspberry Pi development boards, sensors, actuators, and other components. • Blynk's extensive widget and API library lets developers create custom smart home app interfaces

	and functions. ● Blynk is suitable for beginners and experienced developers due to its simple interface. ● Blynk's cloud-based app can be used anywhere with an internet connection, making it more convenient and flexible for users.
3. Augmented Reality Virtual Switches	● AR virtual switch buttons make smart home device control more intuitive and immersive. ● AR virtual switch buttons are flexible and adaptable to various devices and use cases. ● AR virtual switch buttons reduce cognitive load and learning curve. ● AR virtual switch buttons make control more engaging and interactive, improving user satisfaction and retention. ● AR virtual switch buttons allow users to directly target and interact with the buttons in 3D space, reducing errors and misinterpretations. ● Users with disabilities or physical impairments may find AR virtual switch buttons easier to use.

Table 2.6.1 System Adaptation

2.7 SUMMARY

The developers of SwitchAR came to the conclusion, after conducting a literature review, that there are several components or features that would work well if they were incorporated into the mobile application. The system that is currently in place possesses its own distinctive characteristics, and it adopts distinct strategies in response to the various platforms. These functions are amenable to modification and will be implemented in SwitchAR. Therefore, in the following chapter, the developers will conduct a data collection in order to learn the requirements that users have for SwitchAR.

CHAPTER 3
ANALYSIS AND DESIGN

3.0 INTRODUCTION

The next step in this project is to carefully analyze and design, aiming to gain a deeper understanding of the subject matter. This phase involves gathering relevant data and identifying important patterns in current trends related to IoT and AR principles. It allows developers and researchers to assess the information collected, draw meaningful insights, and meet customer needs effectively. Additionally, this phase plays a crucial role in improving the visualization and design of the final product based on customer requests.

3.1 DEVELOPMENT APPROACH

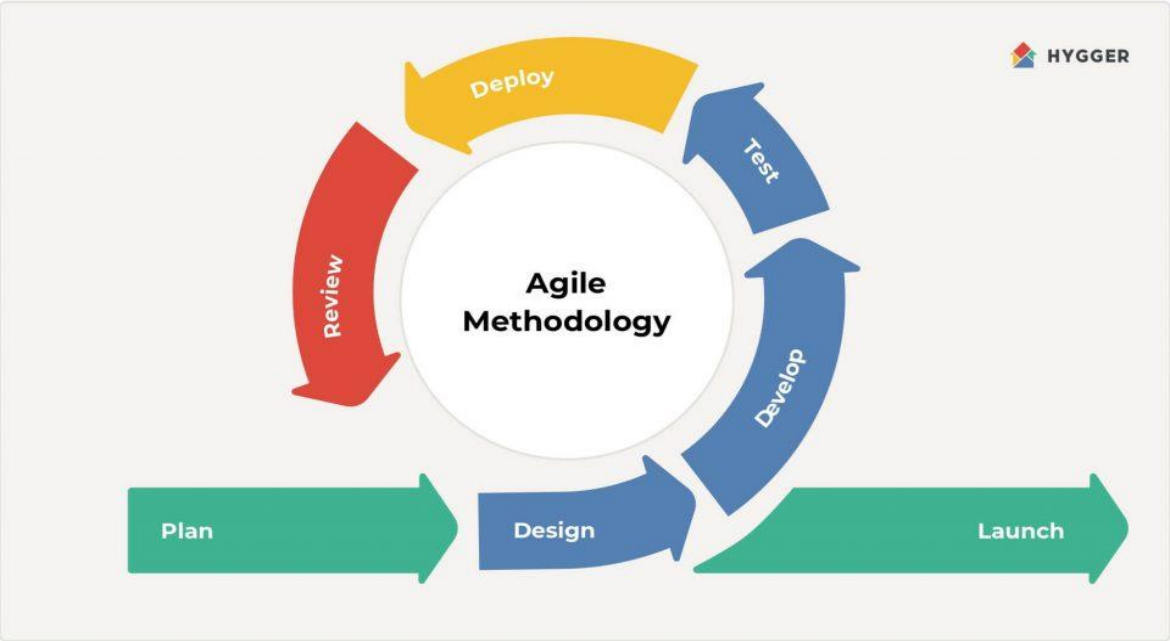

Figure 3.1.1 Agile development process

Agile methodology has emerged as the ideal approach for our project due to its ability to mitigate risks through early and frequent releases. Furthermore, it offers greater flexibility and responsiveness to changes, ensuring that users receive the added value and business solutions

they demand. Agile practices enable developers to create more streamlined, efficient, and manageable applications, emphasizing adaptability and the delivery of smaller, rapid iterations to achieve these goals.

3.2 REQUIREMENTS SPECIFICATIONS

In this particular section, the developers have intended to provide an automation feature that will make the management and configuration of devices much simpler. Certain conditions can be set on switches by users, which will cause other switches to turn on. In addition to that, there is a voice assistant and an augmented reality feature that will further improve the experience of the users. It will be possible for users to control their switches in a variety of ways.

3.2.1 Findings

Developers conducted a survey using Google Forms to understand the specific features that end users are seeking in smart home automation and to gather feedback on potential additional features. This survey was made available to the public, and received responses from 60 individuals. Below, attached all the findings of the survey, which shed light on the preferences and expectations of users regarding smart home automation features.

a. Users Background Information

In this section of the survey, developers collected important background information from a total of 60 respondents. This information includes their age distribution, mobility or accessibility challenges, and the difficulties they face in using home switches. The majority of our respondents fell within the age groups of 18 to 34, with a diverse representation of age ranges. Additionally, a significant portion of the participants reported having mobility or accessibility challenges, which is a key consideration for our project. Moreover, a substantial number of respondents found it challenging to use home switches due to inconvenience or inaccessibility. Understanding these demographics and challenges is crucial for tailoring our AR-based smart home automation solution to the needs of our target audience.

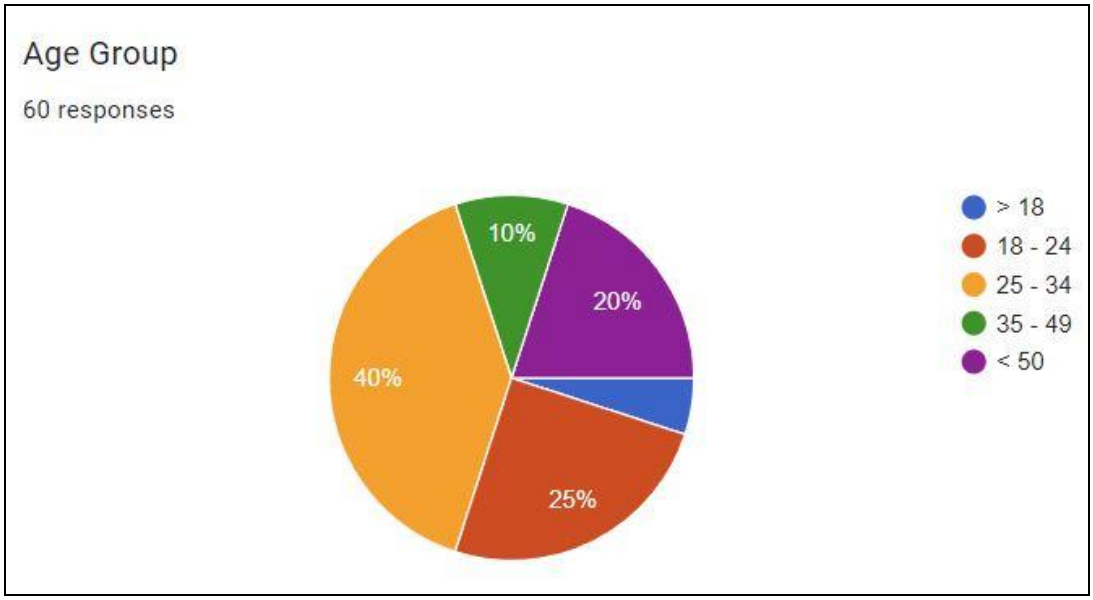

Figure 3.2.1 Respondent age group details

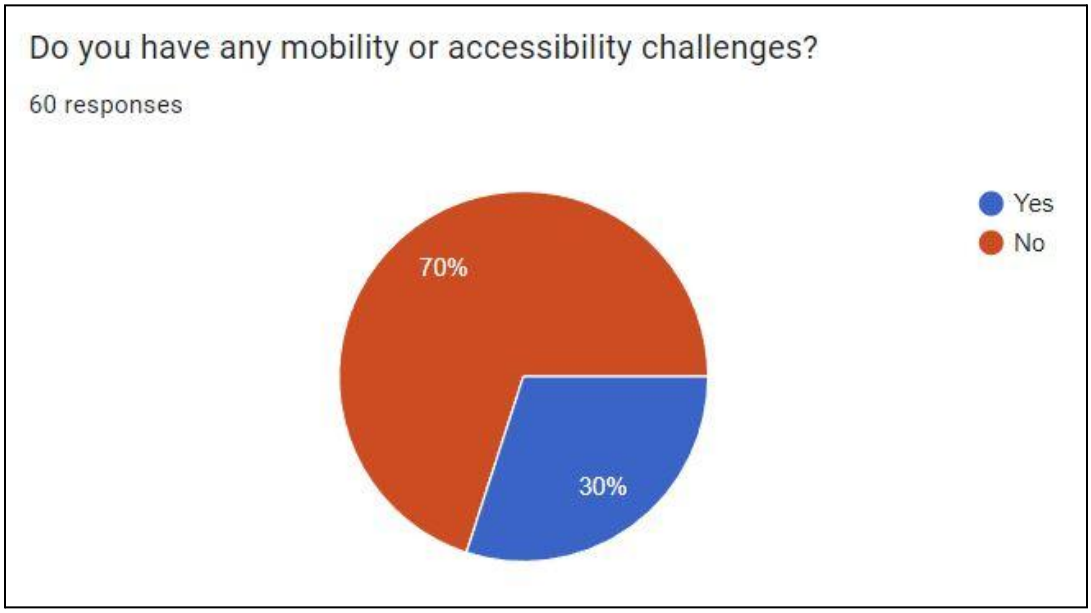

Figure 3.2.2 Respondent mobility issues details

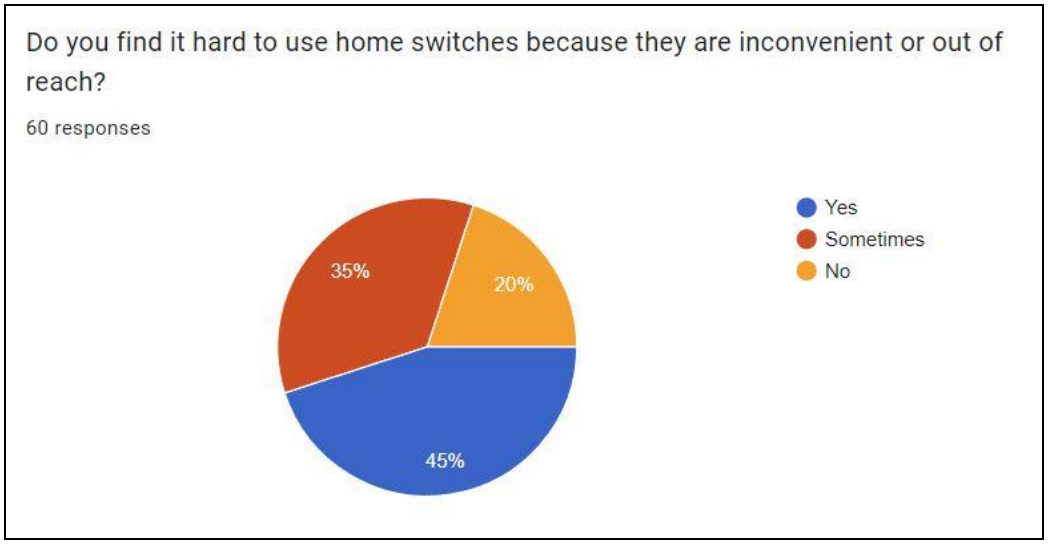

Figure 3.2.3 Respondent home switches inconvenience details

b. Experiences with Smart Home Automation

In the context of users' experiences with smart home automation, the survey revealed that a significant majority, 56 individuals, have prior experience with such devices or systems. Among these users, a common challenge cited by 56 respondents is the difficulty in understanding how to set up and effectively use smart devices. Additionally, 41 respondents highlighted issues related to controlling multiple devices using different applications. These insights underscore the importance of developing a user-friendly and integrated solution to address these challenges.

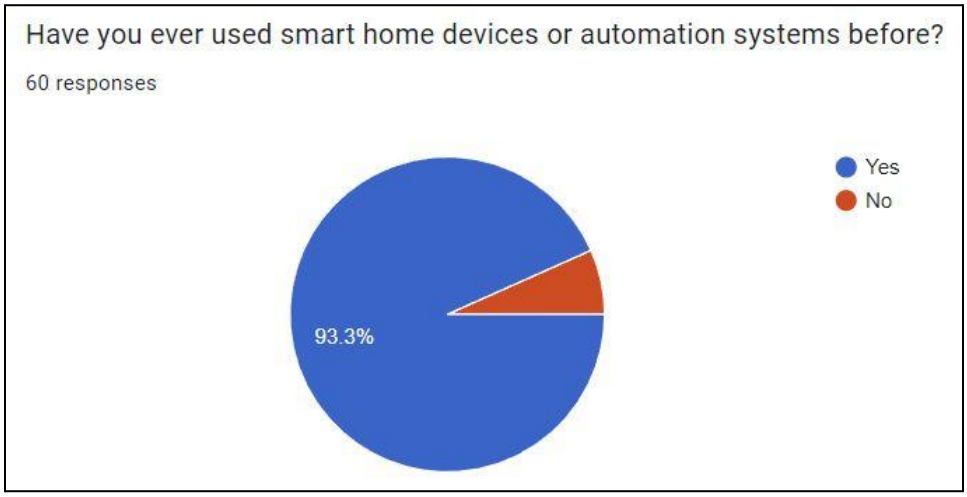

Figure 3.2.4 Respondent experience with smart home systems

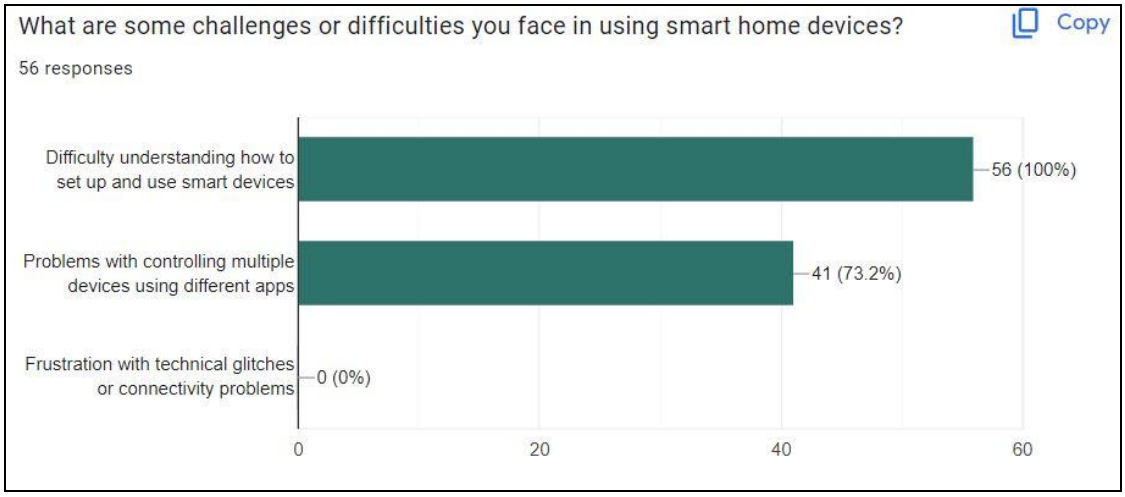

Figure 3.2.5 Respondent home switches challenges details

c. Users Technology Preference

In terms of users' technology preferences, the survey findings reveal that ease of use in controlling switches and devices within the home is of paramount importance to respondents, with a significant 90% expressing it as "very important." Additionally, a substantial majority, approximately 74.5%, expressed interest in using an AR mobile application for controlling and automating smart home devices, while 11.8% were open to the idea ("maybe"). Moreover, an overwhelming 88.3% of respondents indicated a preference for controlling their smart home devices through voice commands. Lastly, regarding automation features in smart home devices, a significant 83.3% of respondents expressed a positive inclination toward such features, while 10% maintained a neutral stance, and 6.7% expressed dislike for them. These preferences emphasize the potential appeal and relevance of AR and voice-command capabilities in smart home solutions.

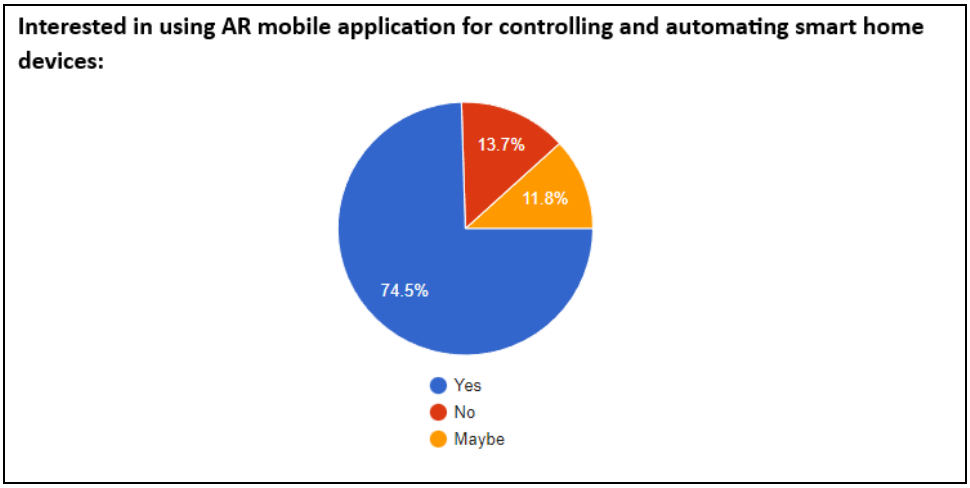

Figure 3.2.6 Respondent opinion towards the switchAR project

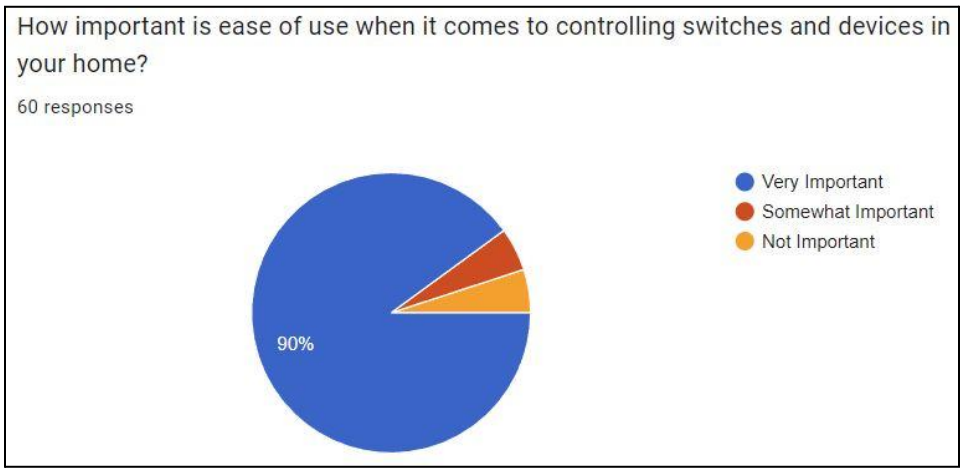

Figure 3.2.7 Respondent opinion towards the ease of use

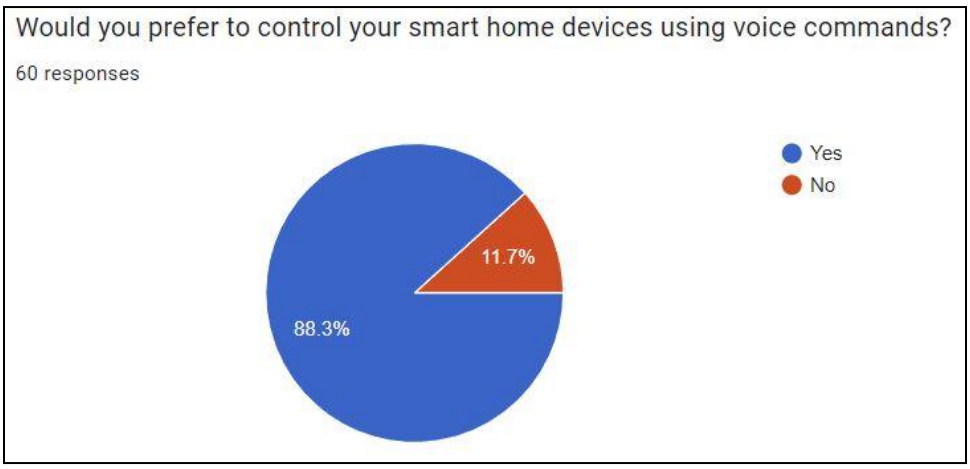

Figure 3.2.8 Respondent opinion towards usage of voice commands

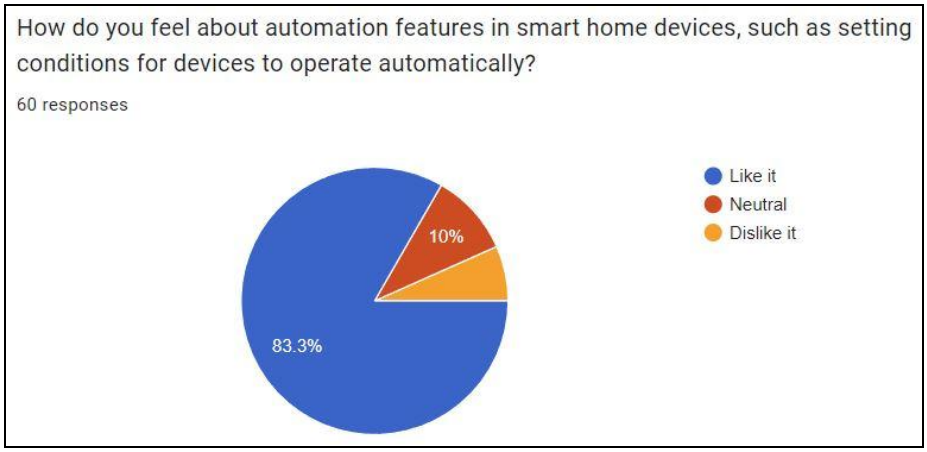

Figure 3.2.9 Respondent opinion towards automation

d. Users Feedback on SwitchAR

In users' feedback on SwitchAR, they expressed a clear desire for specific features and functionalities in an AR-based smart home automation app. These include interactive data usage, ease of use, cost-effectiveness, the ability to control multiple devices, power usage monitoring, seamless integration across platforms, unique AR features, and a simplified single-button control for managing all smart devices. These insights underscore the importance of user-friendly design, affordability, energy monitoring, and innovative AR capabilities to meet the expectations of our target audience effectively.

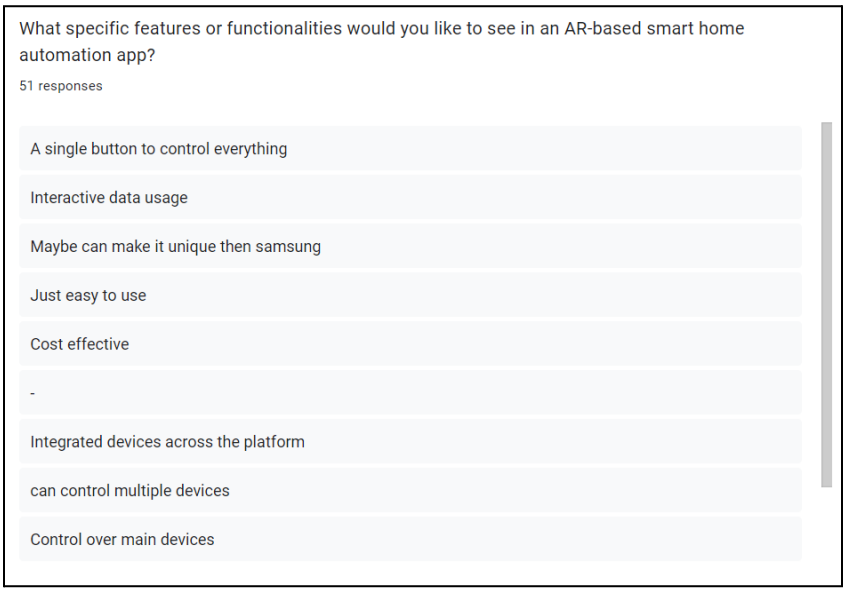

Figure 3.2.10 Respondent expectations for features and functionalities

3.3 LOGICAL DESIGN

A visual representation of the functionality of the mobile application is required of the developers for this phase. The System Architecture diagram, the Use Case diagram, the Activity diagram, the Sequence diagram, and its explanation will all be included in the System Analysis and Design diagram after it is completed. These diagrams will show the precise objective of the project's development. To put it simply, the purpose of each and every figure in this logical design is to demonstrate the progression of how the project will be developed.

3.3.1 System Analysis and Design Diagram

a. System Architecture

Figure 3.3.1 depicts the system architecture used by the SwitchAR mobile application. When you launch the app, it uses image tracking to track specific images, allowing you to visualize augmented reality (AR). The AR visualization contains virtual buttons with which the user can interact. A command is sent to the Blynk IoT Platform when a virtual button is pressed. The Blynk platform then updates the ESP32, which causes the prototype switches to activate, effectively controlling the corresponding IoT devices.

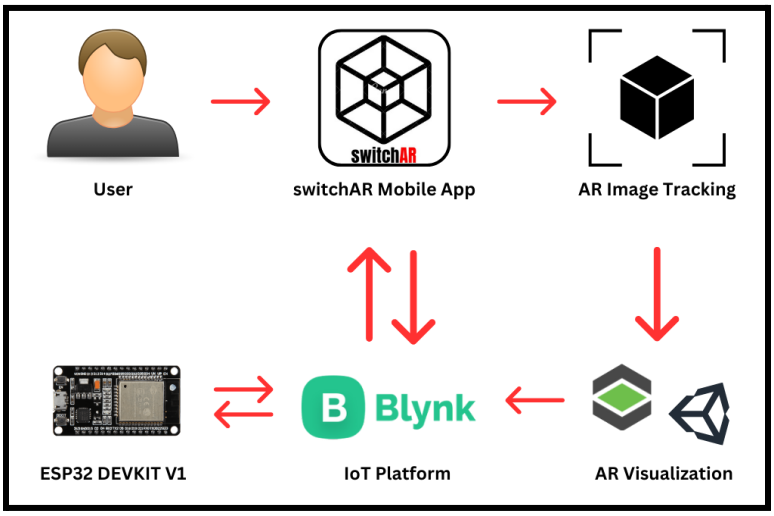

Figure 3.3.1.1 SwitchAR Mobile Application System Architecture

b. Use Case Diagram

Below use case diagram is used to demonstrate the interactions that happened between two actors.

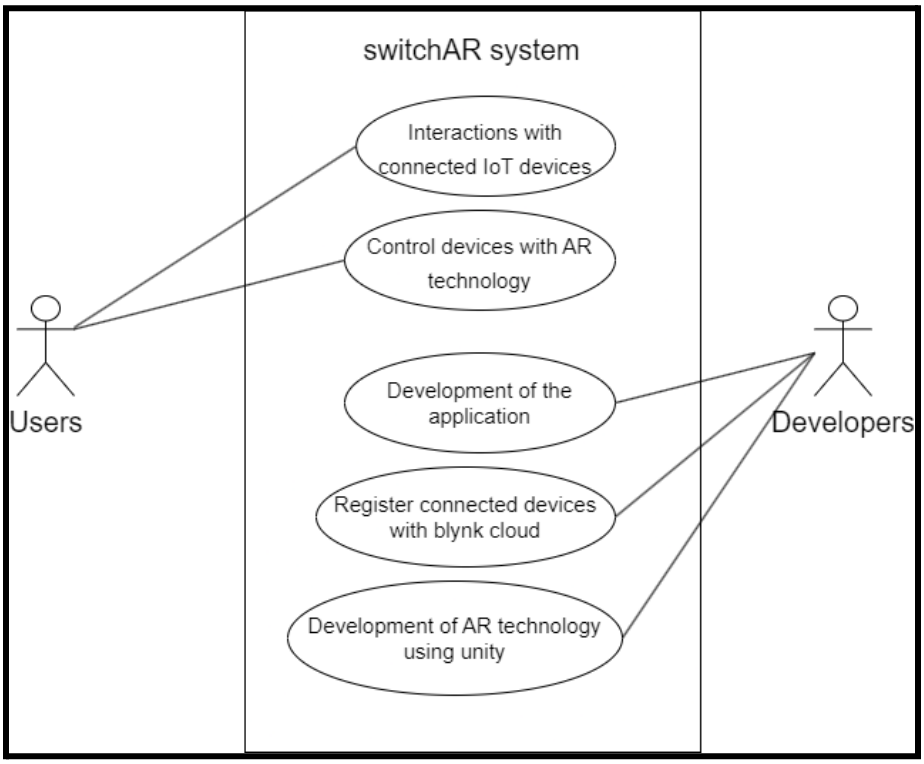

Figure 3.3.1.2 Use case diagram for switchAR application

c. Use Case Narrative

The two pictures below show how a user presses the virtual button and how a developer adds a new device to the selected user's account. These two tasks show different sides of the user and the developer. The user does simple tasks, while the developer goes through a careful process.

- User Presses Virtual Button

Use Case Name:	Virtual Button Switched On
Assumption:	1. The SwitchAR mobile application is installed and functional on the user's device. 2. The user has a stable internet connection.
Preconditions:	The virtual buttons for controlling the light switches are visible in the AR visualization.
Initiations (Trigger Event):	The user selects the virtual button corresponding to the desired light switch.
Main Flow of the Events:	1. The user launches the SwitchAR mobile application. 2. The AR visualization is activated, displaying the virtual buttons for controlling the light switches on the surface. 3. The user taps the virtual button for the desired light switch. 4. The corresponding physical light switch connected to the SwitchAR app is activated, turning on the light.
Exceptional:	If the internet connection is lost, the light bulb does not turn on.
Post Conditions:	The selected light switch is successfully turned on.

Table 3.3.1.1 Use Case narrative for user pressing virtual button

- Developer Adds New Device to Selected User

Use Case Name:	New Device for Selected User
Assumption:	1. The developer has access to the User's SwitchAR development environment. 2. The new device is compatible with the user's SwitchAR system.
Preconditions:	The developer has access to the necessary device information and specifications.
Initiations (Trigger Event):	The developer initiates the process of adding a new device to the user's SwitchAR system
Main Flow of the Events:	1. The developer logs into the SwitchAR development environment. 2. The developer opens the selected user's Arduino project for ESP32. 3. The developer adds new codes related to the configuration of the new device, including its functionality and interaction with the SwitchAR system. 4. The developer establishes the physical connection between the ESP32 and the new device by linking them in the electrical wiring. 5. The developer adds and edits the metadata for the Blynk IoT Platform, specifying the new device's properties and behavior within the system. 6. The developer checks the state of the new device through the Blynk IoT Platform, ensuring its connectivity and functionality. 7. The developer opens the Unity project to

	add new buttons related to the new device, enabling users to interact with it in the AR visualization. 8. The developer builds the user's newly added device version of the application, incorporating the updates for the new device. 9. The developer runs the updated user's application, ensuring that the new device is properly integrated and functional within the SwitchAR system. 10. The developer tests the new device by interacting with it through the user's application, verifying its behavior and functionality. 11. The new device is turned on, activating its intended operations and responding to user commands within the SwitchAR system.
Exceptional:	If the new device does not respond as expected or exhibits unexpected behavior, the developer may need to review the code, configuration, or wiring to identify and rectify any issues.
Post Conditions:	The developer can now access and manage the new device within the SwitchAR development environment, including defining its behavior, interactions, and functionality within the system.

Table 3.3.1.2 Developers add new devices to selected users

d. Activity Diagram

The figure below shows the activity diagram for users and developers. It demonstrates the actions that are happening when developing and using the system.

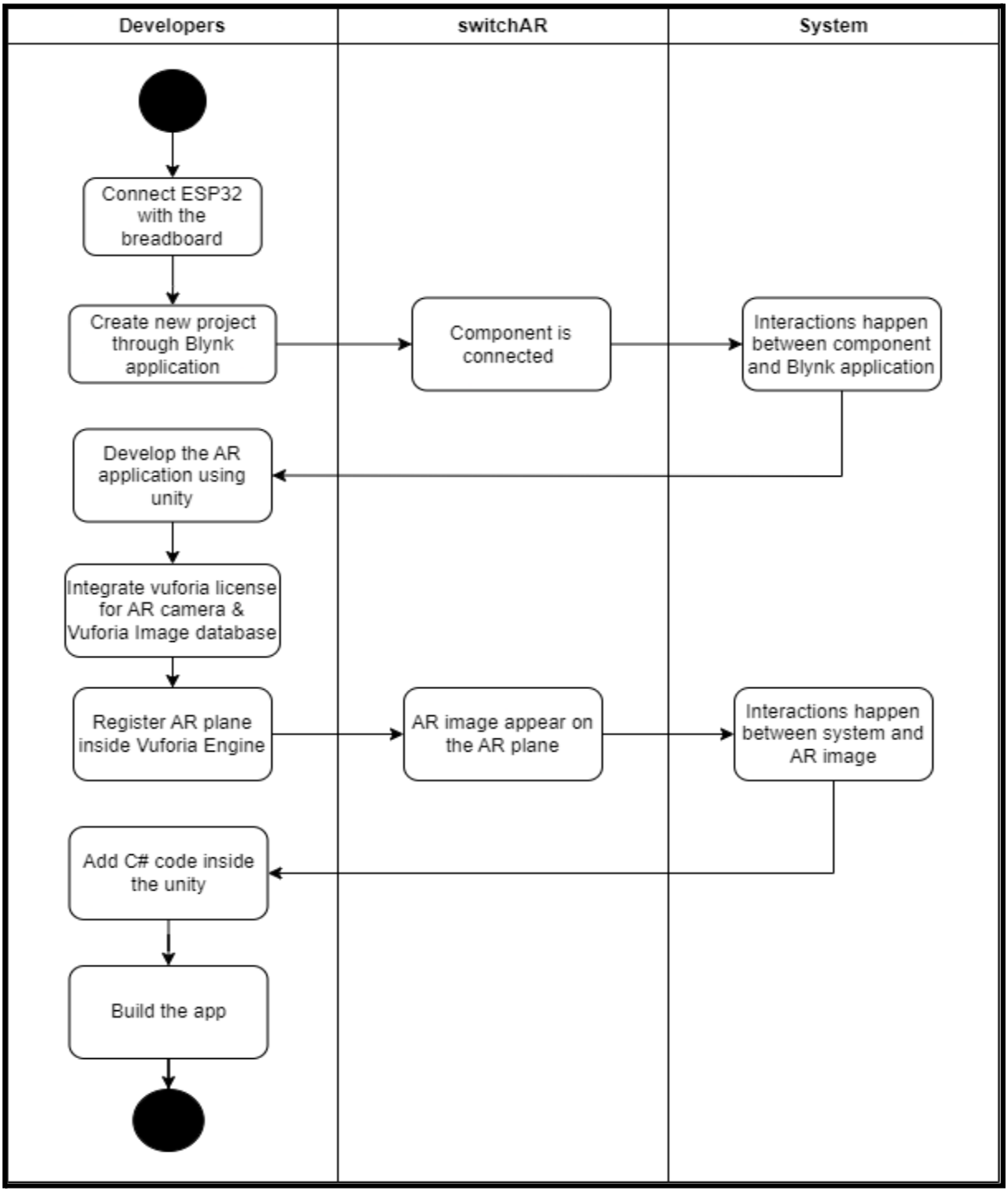

Figure 3.3.4 Activity diagram for developers

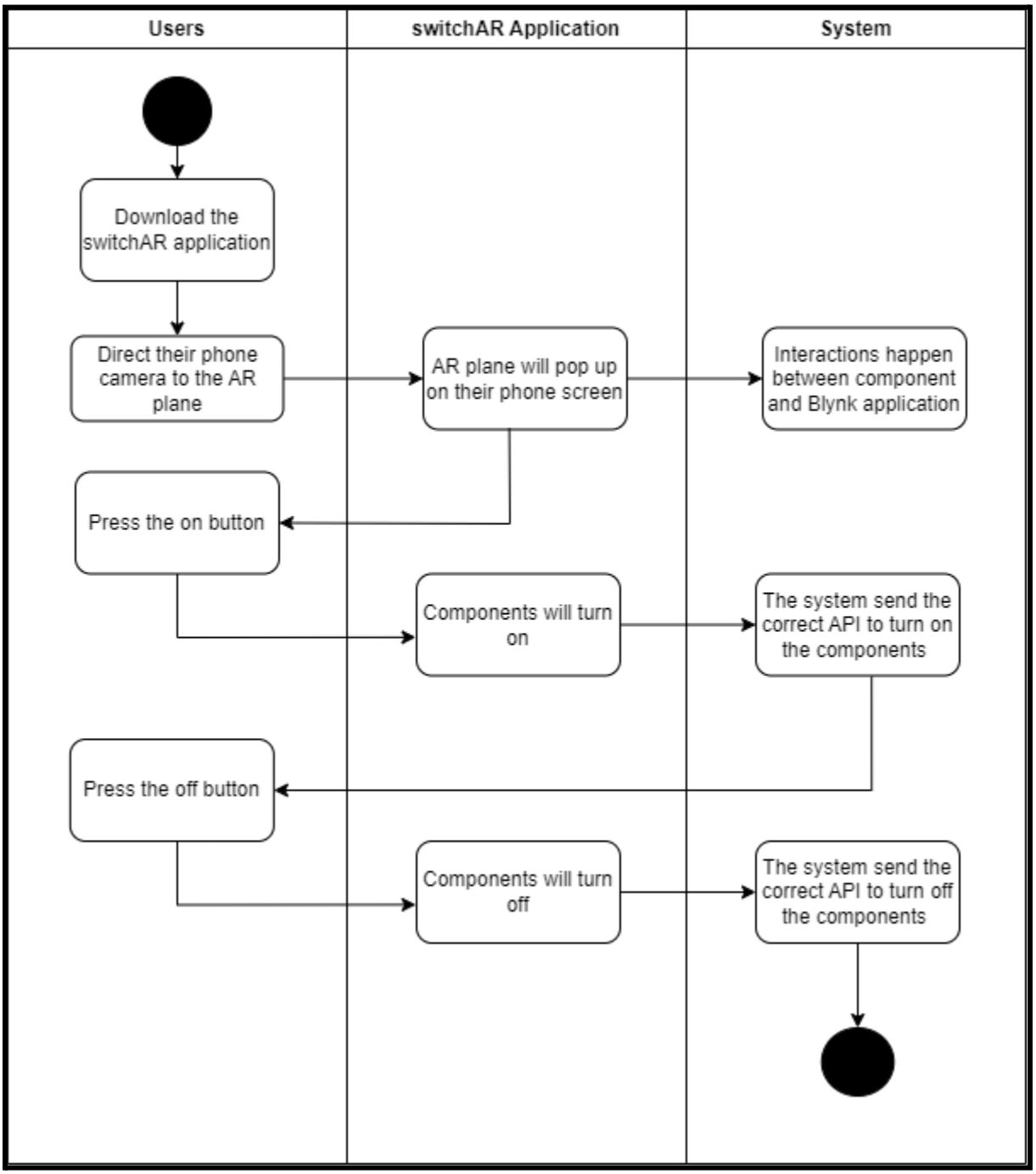

Figure 3.3.5 Activity diagram for users

e. Sequence Diagram

Figure 3.4.6 below shows the sequence diagram of the SwitchAR application starting from the beginning. The process starts when the user launches the SwitchAR Mobile App, which activates the Image Tracking functionality via Unity and Vuforia. Vuforia detects and recognises a specific image from its database, causing Virtual Buttons to appear in the AR visualization. The SwitchAR Mobile App sends an IoT command to the Blynk IoT Platform when a Virtual Button is pressed. The command is received by the Blynk IoT Platform and forwarded to the ESP32 device. The command is executed by the ESP32 device, which updates the state of the prototype switches. After the ESP32 executes the command, the Blynk IoT Platform updates the ESP32, and the SwitchAR Mobile App confirms the update with the ESP32, ensuring app-device synchronization.

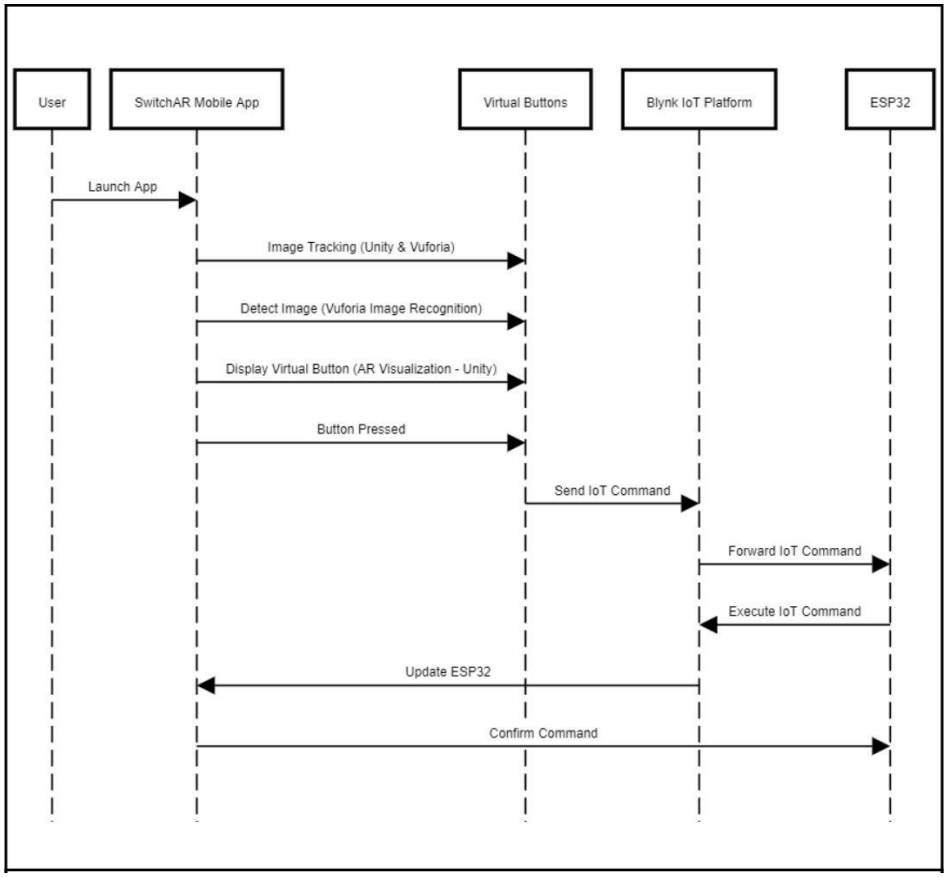

Figure 3.3.6 Sequence Diagram of SwitchAR Mobile Application

3.4 PROTOTYPE DESIGN

The prototype design is shown in Figure 3.5.1 below. It consists of the integration of ESP32 with 3 light bulbs and a 12V DC fan, all of which could be operated via the switchAR mobile application.

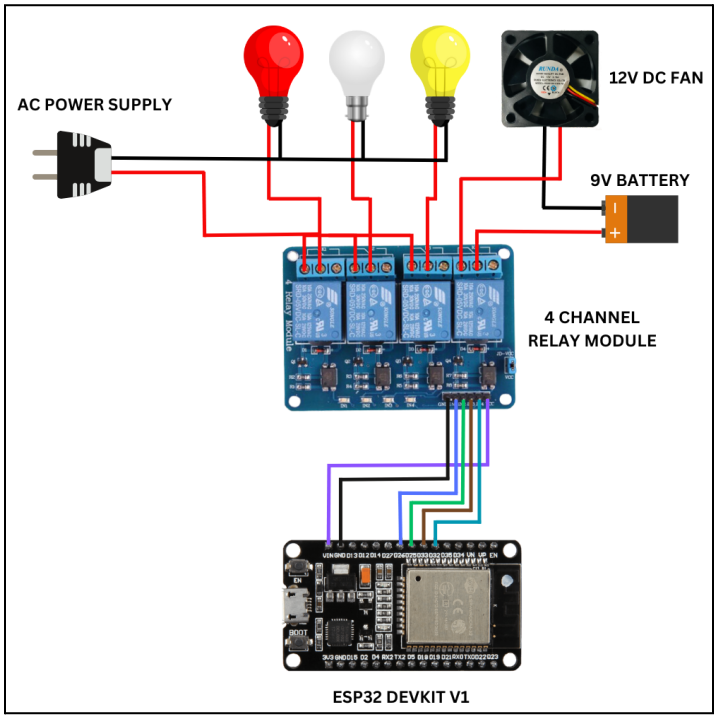

Figure 3.4.1 Prototype Design of SwitchAR Prototype

Mobile application prototype design is shown below in Figure 3.5.2. A simple single screen application that acts as a switch for each of the components of the bulb. Users can also click on the icon on the top right so that they can easily access the AR environment to interact with the virtual switches.

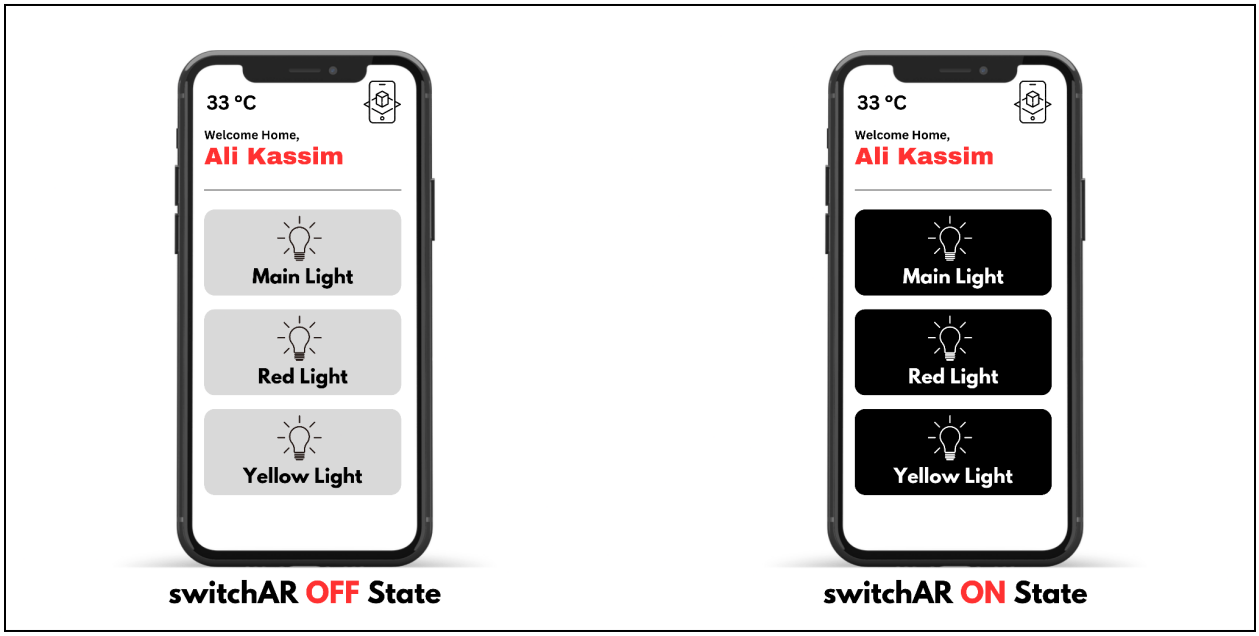

Figure 3.4.2 Prototype Design of SwitchAR Mobile application

CHAPTER 4
PROJECT DEVELOPMENT, IMPLEMENTATION AND EVALUATION

4.0 INTRODUCTION

This chapter provides an overview of the development process, functionality, and evaluation of the SwitchAR application. The developers will explore how SwitchAR successfully incorporates Augmented Reality (AR) and Internet of Things (IoT) technologies to deliver its key features. Additionally, the application underwent a User Acceptance Test (UAT), where it was tested by actual users. This testing phase is crucial for identifying and resolving any issues, as well as for making enhancements that will improve SwitchAR's performance in future updates.

4.1 SYSTEM INTEGRATION

This project explores how the SwitchAR project brings together different technologies from both Augmented Reality (AR) and Internet of Things (IoT). On the AR side, the developers use a tool called Vuforia to recognize and track images, which are then incorporated into Unity for AR development. For IoT, the developers create connections between ESP32 - a small but powerful microcontroller - and Blynk, an app that allows us to control various types of switches like standard switches, dimmers, and temperature controls.

The most critical part of this integration is combining AR with IoT to ensure they work seamlessly together. This is achieved by using Blynk's API (Application Programming Interface), which allows the scripts in Unity to communicate with IoT devices. This integration enables users to interact with their home appliances in a more intuitive and efficient way through the SwitchAR app.

4.2 SYSTEM OUTPUT

Presenting the completed Smart Home System, showcasing both the hardware components and the software interface (Mobile Application).

- Smart Home System Device Output

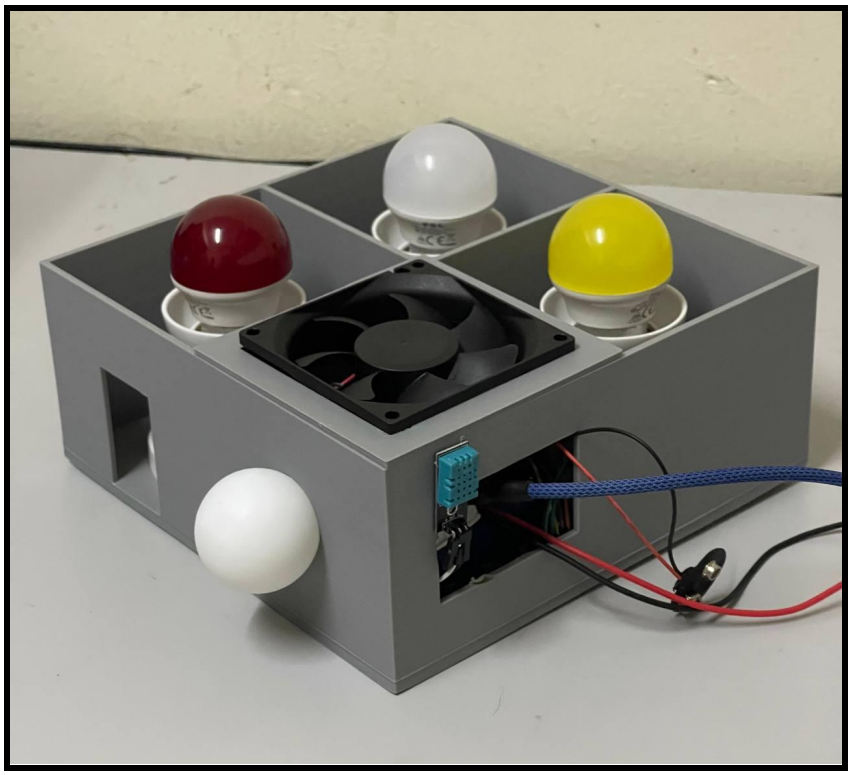

Figure 4.2.1 Smart Home System Device Output

- switchAR Mobile Application Interfaces

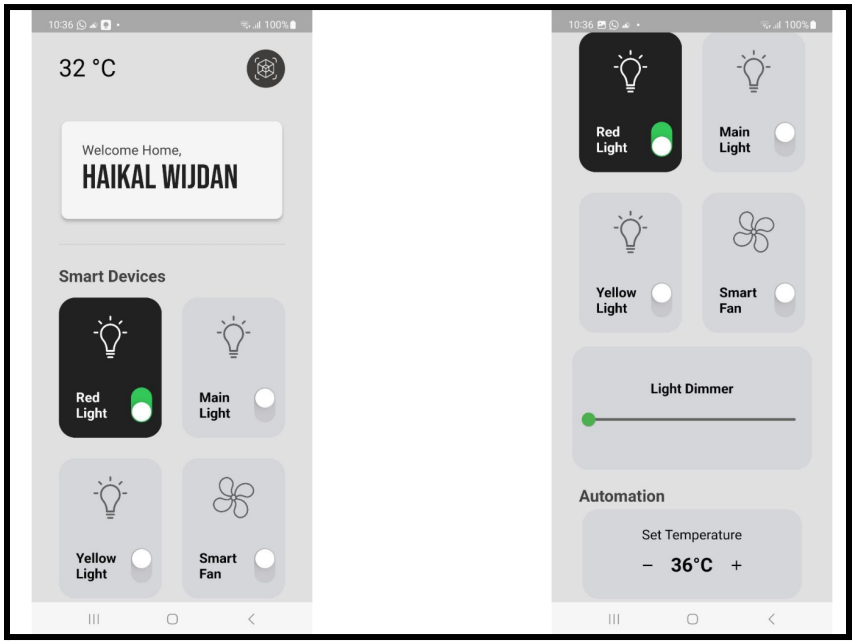

Figure 4.2.2 SwitchAR Mobile Application Interfaces

4.3 SYSTEM TESTING

System testing is a vital step in the development of SwitchAR, ensuring that the final product meets the specific requirements and objectives of the project. This phase allows for comprehensive evaluation by the end users, confirming that SwitchAR effectively addresses the needs of its target audience, particularly the elderly and disabled.

To execute the system testing for SwitchAR, the development team conducted extensive beta testing and user acceptance testing. These tests involved real-world scenarios to assess the application's performance in controlling and managing smart home devices through AR integration. Feedback was collected to identify areas for improvement, ensuring that SwitchAR offers an intuitive, user-friendly experience that enhances the daily lives of its users, especially in terms of accessibility and ease of use.

4.3.1 Test Plan

The testing phase for SwitchAR occurs at the 100% completion stage, where the developers diligently ensure that all functionalities are operating precisely as intended. This rigorous testing process aims to identify any potential issues or flaws that can benefit from enhancements before the application's finalization. Participants are provided with a User Manual for reference, and their responses to the User Acceptance Test Form are documented.

4.3.2 User Acceptance Test (UAT)

UAT 1

INTERVIEWER: MUHAMMAD HAIKAL WIJDAN BIN RIZAL (1916771)
CLIENT'S NAME: ZAINAB ZAINON
DATE: 6/12/2023

USER ACCEPTANCE TEST :
SwitchAR (AR Virtual Switch Control For IoT-Based Smart Home Automation)

FEATURE	TEST DATA	TEST CONDITION	EXPECTED RESULT	ACTUAL RESULT (✔)	REMARKS
Launch App	N/A	Launch SwitchAR app.	App initiates and displays the home screen.	✔	
Fan Switch	N/A	Activate fan switch.	Fan turned on.	✔	
Fan Switch	N/A	Deactivate fan switch.	Fan turned off.	✔	
Red Light Bulb Switch	N/A	Activate red light bulb switch.	Red light bulb on.	✔	
White Light Bulb Switch	N/A	Activate white light bulb switch.	White light bulb on.	✔	
Yellow Light Bulb Switch	N/A	Activate yellow light bulb switch.	Yellow light bulb on.	✔	
Light Bulb Switch	N/A	Deactivate each light bulb switch.	All light bulbs are off.	✔	
Automation Temperature Setting	Room Temperature: 32°C	Set room temperature to 32°C.	Fan turns on automatically.	✔	
Automation Temperature Setting	Room Temperature: 32°C	Verify fan's status.	Fan status: On	✔	
AR Camera Activation	N/A	Access AR camera feature.	AR camera activated.	✔	

Image Target Detection	Image Target	Point AR camera towards image target.	Buttons displayed upon target detection.	✔	
AR Virtual Button	Light Bulb Switches	Press light bulb switches.	Light bulbs open.	✔	Change the button to one only instead of two for on and off.
Voice Command	"Jarvis, Turn on all switches"	Issue a voice command to turn on all switches.	All switches turn on.	✔	

Table 4.3.2.1 First User Acceptance Test for Overall functionality of SwitchAR

Additional Remarks:

1. On a scale of 1 to 5, with 5 being the highest, how would you rate the user-friendliness of the app interface?
   Answer: 4

2. Were you able to easily understand and use the AR camera feature?
   Answer: Yes

3. Did you encounter any difficulties while activating the voice command feature?
   Answer: No

4. Did you encounter any unexpected behavior or bugs during testing?
   Answer: The only thing I noticed was that there was a slight delay in the switch status updating, but it seems reasonable since it depends on the Wi-Fi connection.

5. Do you have any suggestions for enhancing the user experience or adding new features?
   Answer: My only suggestion is to combine the two buttons into one for the AR virtual switch. Apart from that, I find the existing features to be adequate for my requirements.

UAT 2

INTERVIEWER: MUHAMMAD HAIKAL WIJDAN BIN RIZAL (1916771)
CLIENT'S NAME: MUADZ AZRI
DATE: 9/12/2023

USER ACCEPTANCE TEST :
SwitchAR (AR Virtual Switch Control For IoT-Based Smart Home Automation)

FEATURE	TEST DATA	TEST CONDITION	EXPECTED RESULT	ACTUAL RESULT (✔)	REMARKS
Launch App	N/A	Launch SwitchAR app.	App initiates and displays the home screen.	✔	
Fan Switch	N/A	Activate fan switch.	Fan turned on.	✔	
Fan Switch	N/A	Deactivate fan switch.	Fan turned off.	✔	
Red Light Bulb Switch	N/A	Activate red light bulb switch.	Red light bulb on.	✔	
White Light Bulb Switch	N/A	Activate white light bulb switch.	White light bulb on.	✔	
Yellow Light Bulb Switch	N/A	Activate yellow light bulb switch.	Yellow light bulb on.	✔	
Light Bulb Switch	N/A	Deactivate each light bulb switch.	All light bulbs are off.	✔	
Automation Temperature Setting	Room Temperature: 32°C	Set room temperature to 32°C.	Fan turns on automatically.	✔	
Automation Temperature Setting	Room Temperature: 32°C	Verify fan's status.	Fan status: On	✔	
AR Camera Activation	N/A	Access AR camera feature.	AR camera activated.	✔	

Image Target Detection	Image Target	Point AR camera towards image target.	Buttons displayed upon target detection.	✔	
AR Virtual Button	Light Bulb Switches	Press light bulb switches.	Light bulbs open.	✔	
Voice Command	"Jarvis, Turn on all switches"	Issue a voice command to turn on all switches.	All switches turn on.	✔	

Table 4.3.2.2 Second User Acceptance Test for Overall functionality of SwitchAR

Additional Remarks:

6. On a scale of 1 to 5, with 5 being the highest, how would you rate the user-friendliness of the app interface?
   Answer: 5

7. Were you able to easily understand and use the AR camera feature?
   Answer: Yes

8. Did you encounter any difficulties while activating the voice command feature?
   Answer: No

9. Did you encounter any unexpected behavior or bugs during testing?
   Answer: None

10. Do you have any suggestions for enhancing the user experience or adding new features?
    Answer: I couldn't come up with any suggestions at the moment; I believe the current features are sufficient for my needs.

UAT 3

INTERVIEWER: MUHAMMAD AMIR HAMZAH BIN ABD AZIZ (2011685)
CLIENT'S NAME: SITI ADAH BINTI KASSIM
DATE: 15/12/2023

USER ACCEPTANCE TEST :
SwitchAR (AR Virtual Switch Control For IoT-Based Smart Home Automation)

FEATURE	TEST DATA	TEST CONDITION	EXPECTED RESULT	ACTUAL RESULT (✔)	REMARKS
Launch App	N/A	Launch SwitchAR app.	App initiates and displays the home screen.	✔	
Fan Switch	N/A	Activate fan switch.	Fan turned on.	✔	
Fan Switch	N/A	Deactivate fan switch.	Fan turned off.	✔	
Red Light Bulb Switch	N/A	Activate red light bulb switch.	Red light bulb on.	✔	
White Light Bulb Switch	N/A	Activate white light bulb switch.	White light bulb on.	✔	
Yellow Light Bulb Switch	N/A	Activate yellow light bulb switch.	Yellow light bulb on.	✔	
Light Bulb Switch	N/A	Deactivate each light bulb switch.	All light bulbs are off.	✔	
Automation Temperature Setting	Room Temperature: 32°C	Set room temperature to 32°C.	Fan turns on automatically.	✔	
Automation Temperature Setting	Room Temperature: 32°C	Verify fan's status.	Fan status: On	✔	
AR Camera Activation	N/A	Access AR camera feature.	AR camera activated.	✔	

Image Target Detection	Image Target	Point AR camera towards image target.	Buttons displayed upon target detection.	✔	
AR Virtual Button	Light Bulb Switches	Press light bulb switches.	Light bulbs open.	✔	
Voice Command	"Jarvis, Turn on all switches"	Issue a voice command to turn on all switches.	All switches turn on.	✔	

Table 4.3.2.3 Third User Acceptance Test for Overall functionality of SwitchAR

Additional Remarks:

11. On a scale of 1 to 5, with 5 being the highest, how would you rate the user-friendliness of the app interface?
    Answer: 4

12. Were you able to easily understand and use the AR camera feature?
    Answer: Yes, but definitely need guidance and help from the developers for the first time.

13. Did you encounter any difficulties while activating the voice command feature?
    Answer: No, very straight forward on how to apply it.

14. Did you encounter any unexpected behavior or bugs during testing?
    Answer: No

15. Do you have any suggestions for enhancing the user experience or adding new features?
    Answer: Probably when using the AR button, developers can make different colors for switches that are already turned on / off. Apart from that, everything else is good enough.

UAT 4

INTERVIEWER: MUHAMMAD AMIR HAMZAH BIN ABD AZIZ (2011685)
CLIENT'S NAME: AMEERUL SHAHMI
DATE: 23/12/2023

USER ACCEPTANCE TEST :
SwitchAR (AR Virtual Switch Control For IoT-Based Smart Home Automation)

FEATURE	TEST DATA	TEST CONDITION	EXPECTED RESULT	ACTUAL RESULT (✔)	REMARKS
Launch App	N/A	Launch SwitchAR app.	App initiates and displays the home screen.	✔	
Fan Switch	N/A	Activate fan switch.	Fan turned on.	✔	
Fan Switch	N/A	Deactivate fan switch.	Fan turned off.	✔	
Red Light Bulb Switch	N/A	Activate red light bulb switch.	Red light bulb on.	✔	
White Light Bulb Switch	N/A	Activate white light bulb switch.	White light bulb on.	✔	
Yellow Light Bulb Switch	N/A	Activate yellow light bulb switch.	Yellow light bulb on.	✔	
Light Bulb Switch	N/A	Deactivate each light bulb switch.	All light bulbs are off.	✔	
Automation Temperature Setting	Room Temperature: 32°C	Set room temperature to 32°C.	Fan turns on automatically.	✔	
Automation Temperature Setting	Room Temperature: 32°C	Verify fan's status.	Fan status: On	✔	
AR Camera Activation	N/A	Access AR camera feature.	AR camera activated.	✔	

Image Target Detection	Image Target	Point AR camera towards image target.	Buttons displayed upon target detection.	✔	
AR Virtual Button	Light Bulb Switches	Press light bulb switches.	Light bulbs open.	✔	
Voice Command	"Jarvis, Turn on all switches"	Issue a voice command to turn on all switches.	All switches turn on.	✔	

Table 4.3.2.4 Forth User Acceptance Test for Overall functionality of SwitchAR

Additional Remarks:

16. On a scale of 1 to 5, with 5 being the highest, how would you rate the user-friendliness of the app interface?
    Answer: 4

17. Were you able to easily understand and use the AR camera feature?
    Answer: Actually yes, I can easily see what i have to do with the mobile application here.

18. Did you encounter any difficulties while activating the voice command feature?
    Answer: No, it works perfectly.

19. Did you encounter any unexpected behavior or bugs during testing?
    Answer: No.

20. Do you have any suggestions for enhancing the user experience or adding new features?
    Answer: For the switchAR mobile application, if the application can have custom layout and colors for different users would be nice.

4.3.3 Enhancement

Based on valuable feedback from user testing, developers are planning some improvements to make SwitchAR even better. First, developers should simplify the AR camera interface by combining the on and off buttons into a single, easy-to-use control. This change will make it more user-friendly and efficient for managing smart devices. Second, developers are considering adding an image target feature for smartwatches. This feature can be especially helpful for people with disabilities, providing them with an alternative method for control. Other than that, developers are working on incorporating a brightness control slider for LED switches. This slider will allow users to adjust the lighting to their preferred level. These enhancements aim to make SwitchAR more user-friendly, visually appealing, and inclusive, in line with our commitment to improving the smart home automation experience. Lastly, switchAR also incorporates the use of Google Assistant to help people to turn on the lamp using their voices. This method is much more convenient for the elderly to interact with home switches than the traditional methods.

CHAPTER 5
CONCLUSION

5.0 PROJECT REQUIREMENT

The SwitchAR project has successfully met all its goals, creating a user-friendly app that combines augmented reality (AR) and the Internet of Things (IoT) to make controlling home devices easier, especially for the elderly and disabled. Although there were challenges along the way, the team worked hard to solve them, ensuring that every part of the project was completed as planned. All switch components have been functioning well throughout the development of SwitchAR. This achievement shows the team's commitment to improving home automation and making daily life simpler for its users.

5.1 PROJECT CONSTRAINT

During the development of the SwitchAR project, several constraints were encountered by the team. First, there was an issue with the compatibility of mobile devices with the Unity AR Camera, attributed to the varying Android API levels. This was primarily because new updates in Android rendered Unity incompatible with the latest versions. Secondly, the project faced financial constraints, which limited the number of switches that could be added. This was due to subscription plan costs and the limitations imposed by Google Home Assistant on the number of switches that could be integrated.

Additionally, an attempt to integrate Unity with Flutter posed significant challenges. The existing documentation for this integration was found to be outdated and incompatible with the current version of Unity. Efforts to resolve this issue through version downgrading were unsuccessful. As a result of this integration challenge, the team had to resort to using two separate applications instead of a single integrated app. This constraint was a direct outcome of the inability to merge Unity with Flutter effectively.

5.2 FUTURE ENHANCEMENT

In the future, the SwitchAR project aims to enhance the user experience by seamlessly integrating Unity and Flutter into a single mobile application, eliminating the need for separate interfaces. Additionally, the project envisions utilizing Firebase to personalize switch configurations and automation based on individual user profiles, making the app adaptable to diverse preferences. Another planned improvement includes the addition of power usage monitoring capabilities, empowering users to monitor and optimize their energy consumption. These enhancements collectively aim to make SwitchAR a more versatile and user-friendly solution for smart home automation, catering to a broader range of user needs and preferences.

5.3 CONCLUSION

In conclusion, the SwitchAR project has achieved its objectives by successfully building an efficient smart home automation device and mobile application. This endeavor involved the seamless integration of augmented reality and the Internet of Things, uniting Unity with AR and Blynk with IoT to create a user-friendly app. The primary goal of SwitchAR is to provide users with a simple and accessible means of controlling switches within their home environment. With the implementation of SwitchAR, elderly and disabled individuals no longer face difficulties in reaching switches, instead, they can enjoy an immersive experience in managing their smart devices. This AR-integrated IoT product utilizes the Blynk API to control switches effectively, enhancing the overall smart home experience. Looking forward, future enhancements are planned, including power usage monitoring and personalization of switch configurations based on individual user profiles, catering to a wide range of preferences. The SwitchAR project values feedback and suggestions from users and fellow developers, aiming to continually improve the system and contribute to the advancement of the home automation industry.

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