SwitchAR: AR Virtual Switch Control For IoT-Based Smart Home Automation

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Abstract—**SwitchAR is an innovative mobile application that seamlessly integrates the principles of Augmented Reality (AR) and the Internet of Things (IoT) to facilitate the effortless and enjoyable control of smart home devices. Primarily designed for homeowners, it is particularly beneficial for elderly and disabled individuals who may find the use of conventional switches challenging. The project is a response to the complexities and management difficulties often associated with existing smart home systems. SwitchAR simplifies this landscape by offering a unified, user-friendly platform that consolidates all home devices. It significantly enhances the quality of life for individuals with mobility issues by providing a straightforward and autonomous method to manage their home environment. Findings suggest that this application has markedly assisted disabled individuals in achieving greater independence and efficiency in managing home devices. Nevertheless, future work is necessary to enhance the user experience, particularly in the integration of Unity and Flutter within a singular mobile application.**

Keywords - Augmented Reality, Internet of Things, Smart Home System, Mobile Application

I. INTRODUCTION

SwitchAR revolutionizes smart home appliance control by blending augmented reality (AR) with Internet of Things (IoT) devices. It is developed specifically to help homeowners, elderly and disabled individuals simplify device interaction for those mobility challenges. This innovative solution eliminates the need for physical coordination, allowing easy and engaging access to smart home devices. Its user-friendly approach may redefine how people interact with these appliances, promising more convenience. Moreover, by facilitating the monitoring and management of IoT-enabled switches and appliances, SwitchAR encourages wider IoT adoption, potentially reducing costs and boosting home energy efficiency.

A. Problem Statements

There aren't many AR-enabled IoT smartphone applications on the market at the moment. Even while smart home automation has had a big impact, there is still a need in the market for a single, user-friendly solution that can cater to the unique demands of homeowners, particularly the elderly and disabled. Moreover, customers find it challenging to properly utilize and regulate smart home gadgets due to a lack of customization and control choices. They may effortlessly operate these gadgets with their smartphones by utilizing SwitchAR, which also boosts augmented reality interaction with smart home equipment.

B. Project Objectives

1. Develop an AR-integrated IoT mobile application (SwitchAR) that allows users to control home switches with ease.
2. Implement an automation feature where users can set conditions to automatically control devices.
3. Simplify setup and customize for users by adding and configuring switches in SwitchAR, ensuring a hassle-free experience.
4. Integrate SwitchAR with Google Home Assistant allowing users to control their home devices through spoken instructions.

C. Restrictions and Limitations

Dealing with different mobile operating systems, commonly Android and iOS is one of the restrictions and limitations of this project as debugging and testing

will require more time due to the different functionality. Other than that, the environment required to use the AR camera functionality in a precise manner. Lastly, the software used to develop this project is free, but some of the features are limited unless subscriptions are involved.

II. LITERATURE REVIEW

A thorough review has been conducted on applications that share the same concept as the proposed application, which combines Augmented Reality with Internet of Things. The reviewed applications include Philips Hue, IKEA Place, Smart AR Home, and SamsungSmartThings.

Starting with the Philips Hue mobile app, which is connected via IoT, allows users to remotely control their smart lighting system using their smartphone or voice assistant. It offers features like scheduling, custom scene creation, and room-wise light control. Its AR feature, Hue Preview, enables users to visualize different lighting setups in their home, enhancing the smart home experience. [13]

Secondly, IKEA Place is an app that combines IoT and augmented reality to help users visualize how IKEA furniture would look in their homes. It uses computer vision to create 3D room models and accurately places virtual furniture. [14] The app connects to IKEA's online product catalog, offering up-to-date information on furniture dimensions, materials, and availability, and allows users to purchase items directly.

Thirdly, Smart AR Home employs augmented reality and 3D technology to map a user's home and interact with devices like Samsung SmartThings and Philips Hue switches and dimmers through a smartphone camera. [15] It uses image recognition to locate anchor points (like paintings or book covers) in the home. Users can then control light switches, dimmers, and shades via the camera view and share these settings between mobile devices.

Lastly, Samsung SmartThings provides a unified interface to control and monitor various smart home devices. Using IoT technology, it connects to devices like lights, thermostats, and security systems, enabling remote control from a smartphone or tablet. [16] The app also incorporates AR to enhance user experience, allowing users to virtually place SmartThings devices in their home before purchasing and installing them.

While all these applications have their unique advantages and drawbacks, they primarily use Augmented Reality for display purposes. In contrast, switchAR innovatively utilizes AR for control features, elevating customization and interaction to a new level. Importantly, switchAR has evolved to use marker-based augmented reality, ensuring greater precision in displaying AR buttons, setting it apart in the realm of smart home technology.

TABLE I.   LITERATURE REVIEW SUMMARY

Application	IoT	Marker-less AR	Marker Based AR	Custo-miz-ation	AR Virtual Button
Philips Hue	✓	✓	-	-	-
IKEA Place	✓	✓	-	-	-
Smart AR Home	✓	✓	-	-	-
Samsung SmartThings	✓	✓	-	-	-
switchAR	✓	-	✓	✓	✓

III. METHODS

A. Requirement Gathering

Several techniques can be done to gather requirements from the users to understand the needs and preferences such as conducting document analysis, observations on the existing work process or doing an interview session with stakeholders. For SwitchAR, online questionnaires were distributed using Google form in order to get the user's requirements.

A collection of 60 respondents from various age groups which consists of homeowners, elderly and disabled individuals. The responses were then further being collected and then further analyzed to get the meaningful insights and meet the customer needs effectively.

The methodology process involved when developing this process is an agile methodology approach due to its ability to mitigate risks through early frequent releases. On the other hand, agile practices play a major part in helping to create more streamlined, efficient, and manageable actions as it offers greater flexibility and responsiveness to changes.

B. Development Requirement

i. Android package - Developed using the Flutter framework, ensuring compatibility with a wide range of devices and providing a seamless user experience.

ii. Unity package - This application was developed with Unity version 2022.3.13f1, targeting a minimum API level of 26 for Android 8.0 'Oreo', ensuring robust performance and compatibility with modern Android devices.

iii. Vuforia License : Integrated with a Vuforia AR camera license, enabling advanced augmented reality features.

C. Functionality Requirement

This section explains the development of the project using diagrams.
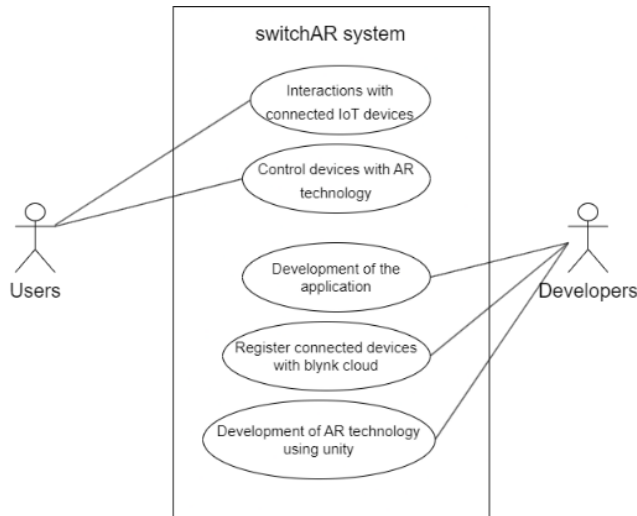
Figure 1. Use Case Diagram

Fig. 1 displays the use case diagram where interactions happened between two actors. For users, they are able to interact with their IoT home devices as well as control and manage them using AR technology using SwitchAR system. For developers, they are involved in the project development, ensuring connection between devices and Blynk cloud and the development of AR technology using unity.
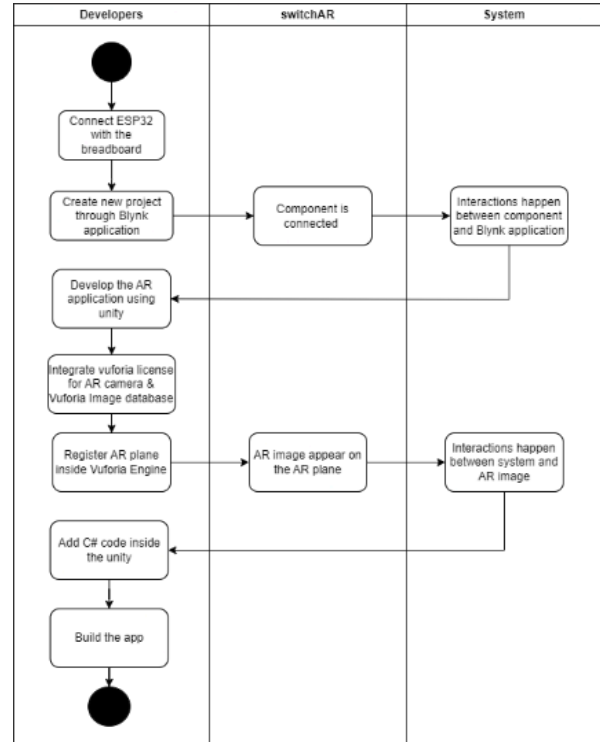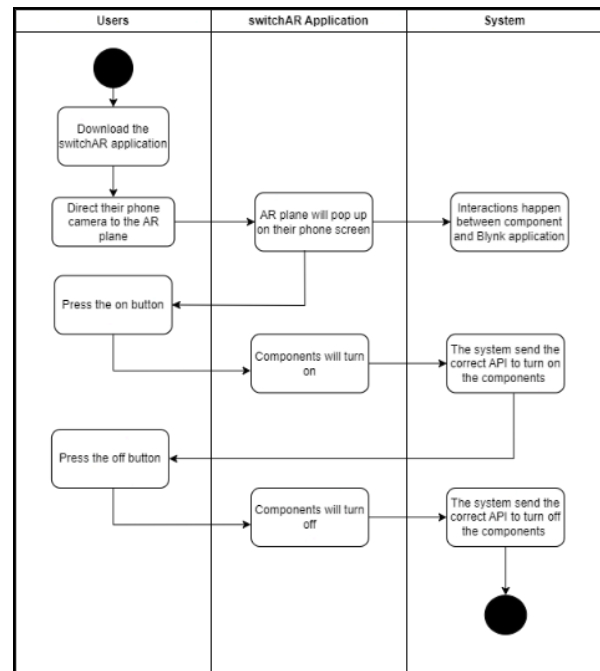

Figure 2. Activity diagram (Developers)

Figure 3. Activity diagram (Users)

Fig. 2 and Fig. 3 displays the activity diagram for both users and developers. This activity diagram acts as flowchart of step-by-step instruction on both actors for the SwitchAR system.
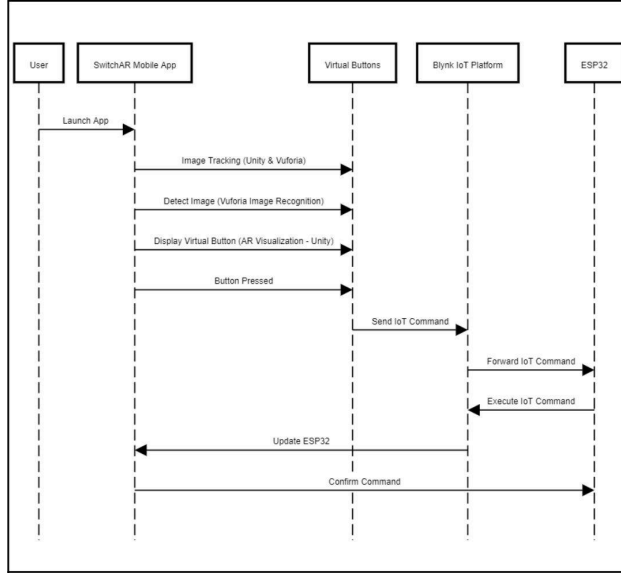
Figure 4. Sequence Diagrams

Fig. 4 shows how the SwitchAR system works in the backend. Users will use their device camera to activate the AR plane and interact with the virtual buttons inside of the SwitchAR mobile application. Then these buttons will send an IoT command to the Blynk IoT platform to interact with the smart home devices through ESP32 devices according to the user's commands.

IV. RESULTS AND DISCUSSION

A. Smart home device

Fig. 5 is the final product of SwitchAR smart home device where it consists of 5 components, 3 on and off lamps, 1 fan and 1 light dimmer light.
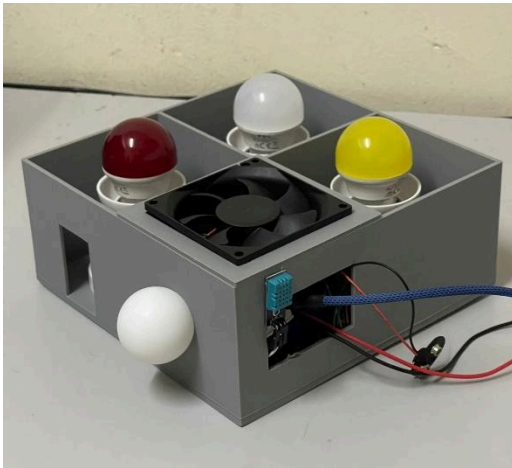

Figure 5. SwitchAR smart home device

B. Mobile and AR interface

Next, in Fig. 6 shows the interface of the SwitchAR mobile application. Users can directly see and interact with the switches that are connected with their home devices. Users can enter the AR Environment by clicking the icon located on the top right of the SwitchAR application. In Fig. 7, visualize how the AR plane works when users project their phone camera towards the image target.
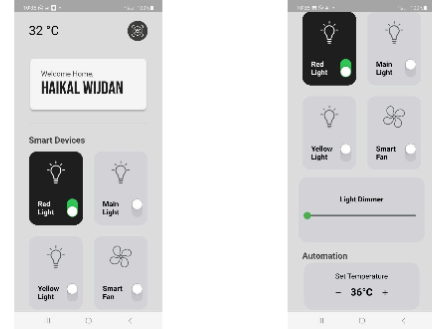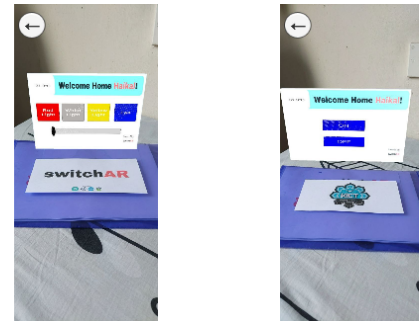

Figure 6. SwitchAR Mobile Interface

Figure 7. SwitchAR AR environment

C. Enhancement

From the previous requirement gathering stage, feedback from users was collected and being used to improve SwitchAR. First, the existing on and off buttons inside of the AR environment are now being combined into a single button to improve user-friendly interface and efficiency when managing smart devices. Furthermore, the addition of an image target feature to smartwatches is suggested as it primarily caters to people with mobility disabilities, offering an alternative method of control for them. Plus, an addition of a brightness controller was added to provide customizations for users to choose their desired brightness. Lastly, addition of voice commands utilizing Google Assistant are included in the switchAR application system to help users turn on and off smart home devices using their voices.

V. Conclusion

The SwitchAR project has successfully achieved its primary objective of developing a user-friendly application that integrates augmented reality (AR) and the Internet of Things (IoT). This innovative app simplifies the control of home devices, specifically designed to assist elderly and disabled individuals. However, the development of the project faced few constraints such as issues with the compatibility of mobile devices with the unity AR camera due to the varying Android API levels. On the other hand, SwitchAR can only incorporate using a few switches as subscription plans are required and the restrictions imposed by the Google Assistant. Additionally, the lack of up-to-date documentation for integrating Unity and Flutter resulted in two separate applications instead of a single integrated one.

Based on the article from Digital Trends, smart home technologies are increasingly being used to support eldercare. These technologies, including IoT platforms, are being recognized for their potential to assist seniors in various ways, particularly in aiding mobility and allowing aging-in-place strategies. [17] The use of robots and smart home sensors in test homes demonstrates how technology can intervene and assist with daily activities. This growing trend addresses the needs of the aging population, emphasizing the significance of technological solutions in enhancing eldercare. This context aligns well with the objectives and achievements of your SwitchAR project, highlighting its relevance and potential impact in the field of smart home technology for elderly.

Looking to the future, the SwitchAR team plans to add features like power usage monitoring and the ability to personalize switch configurations based on individual user profiles. This will cater to a broader range of preferences and needs. The team remains committed to continuous improvement, valuing user feedback and suggestions, and is dedicated to contributing to the evolution of the home automation industry.

VI. Acknowledgement

VII. References

[1] Android/iOS: Launch from within a Unity app another Unity app. (n.d.). Unity Forum.

[2] Hayes, A. (2022, October 29). Augmented Reality (AR) Defined, with Examples and Uses. Investopedia.

[3] Oracle. (2020). What is the Internet of Things (IoT)? Oracle.com.

[4] Syahidi, A. A., Arai, K., Tolle, H., Supianto, A. A., & Kiyokawa, K. (2021). Augmented Reality in the Internet of Things (AR + IoT): A Review. The IJICS (International Journal of Informatics and Computer Science), 5(3), 258.

[5] Zeus Integrated Systems. (2014). A Brief History of Smart Home Automation. Zeusintegrated.com.

[6] Smart Home Works. (2022, November 3). What are the Types of Smart Home Automation Systems? Smart Home Works.

[7] Dobiss. (2022). Advantage of wired home automation system? Dobiss - Domotica Is Logica.
[8] Plume. (2022, June 21). What is wireless home automation? Plume HomePass.

[9] Software Testing App. (2023, March 31). What Is Augmented Reality - Technology, Examples & History.

[10] Žilak, M., Car, Ž., & Čuljak, I. (2022). A Systematic Literature Review of Handheld Augmented Reality Solutions for People with Disabilities. Sensors, 22(20), 7719.
[11] Kaspersky. (2021, June 11). What Are the Security and Privacy Risks of VR and AR. Usa.kaspersky.com.

[12] Modern Smart Home UI • Flutter Tutorial. (n.d.). Www.youtube.com

[13] GearBrain Editorial Team. (2021, June 3). *New Philips Hue app 4.0 lets you preview light scenes right in your home.* Gearbrain; Gearbrain. https://www.gearbrain.com/

[14] *IKEA Place's App Uses AR Technology To Engage Users.*(2024).https://www.designrush.com/best-designs/apps/ikea-place

[15] Binary Banana LLC. (2014). *Smart AR Home.* Google.com.https://play.google.com/store/apps/details?id=com.SmartARHome&hl=ms

[16] *SmartThings | Apps & Services | Samsung Malaysia.* (2023,July24).Samsung.https://www.samsung.com/my/apps/smartthings/

[17]Moore, C. (2019, August 22). *Smart home technology increasingly used to help elderly population.* Digital Trends; DigitalTrends.https://www.digitaltrends.com/home/smart-home-technology-augments-eldercare/