INVENTORY UP-KEEPING WITH AR INTERFACE

BY

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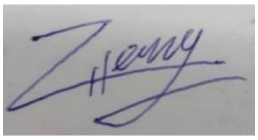

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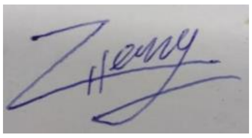

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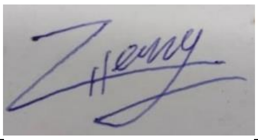

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ABSTRACT

Internet of Things (IoT) devices are being rapidly adopted in homes to provide automation, security, energy savings and convenience. However, the proliferation of heterogeneous devices and platforms poses challenges for effective monitoring and control. Traditional 2D dashboards on desktops/mobiles have limitations in visualizing complex IoT networks and data. This paper proposes an AR-based solution using the Oculus Quest and Home Assistant platform to enhance the management experience. The goal is to develop an intuitive AR interface that overlays 3D visualizations directly onto physical environments for improved visibility. Real-time sensor data will be aggregated from various IoT systems into the Home Assistant and streamed into the AR environment via API integration. The AR dashboard will provide at-a-glance monitoring and controls tailored to IoT tasks. A user-centered iterative design process will be followed incorporating performance benchmarking, usability metrics, and user experience feedback. The Unity game engine will be utilized to render an immersive 3D user interface registered to real-world coordinates. Consolidating insights into a unified AR dashboard aims to simplify smart home management. The project will showcase techniques like natural interactions applied in a practical IoT context, guiding future AR interface and visualization design. Findings will reveal AR's advantages over traditional methods for visualizing complex systems and data, monitoring situational awareness, and enabling intuitive control. This approach of combining AR and IoT provides a model for developing next-generation interfaces to optimize IoT management. Insights gained can inform solutions for managing growing consumer IoT ecosystems spanning diverse devices, standards, and vendors.

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LIST OF ABBREVIATIONS

AR	Augmented Reality
IoT	Internet of Things
HMD	Head Mounted Display
MR	Mixed Reality
API	Application Programming Interface
UI	User Interface
UX	User Experience
GPS	Global Positioning System
BI&A	Business Intelligence and Analytics
SDK	Software Development Kit
XR	Extended Reality

CHAPTER 1: Introduction

1.1 Problem Statement and Motivation

The rapid growth of Internet of Things (IoT) devices in smart homes has brought many conveniences through increased connectivity and automation [8]. However, this proliferation of devices has also created significant challenges in managing, monitoring, and maintaining them effectively.

One of the key challenges is the **fragmentation of control and limited visibility**. With the proliferation of IoT devices from various manufacturers, users often have to juggle multiple apps and dashboards to control their devices [4]. This fragmentation results in limited visibility and requires manual effort to inspect each system, hindering the seamless interaction that a truly “smart” home should provide [4].

Another challenge is the **unintuitive user interfaces**. The control of IoT devices through basic applications and dashboards is often unintuitive, making it challenging for average users to change configurations or activate features. This lack of user-friendliness hinders the user experience and adoption of home.

Lastly, there is a **lack of immersive and interactive control**. Traditional control interfaces do not leverage the potential of immersive technologies like XR, which can provide a more intuitive, immersive, and interactive way of interacting with smart home devices[10].

The proposed solution is to develop an XR application for the Meta Quest 2 platform that integrates with the Home Assistant API. This application will provide a unified, immersive interface for controlling and monitoring smart home devices, thereby addressing the problems outlined above.

The motivation behind the development of an Extended Reality (XR) application for integrated smart home control on Meta Quest 2 is driven by multiple factors. The management of settings, updates, connectivity, and usage of the vast array of consumer IoT devices available in the market can be quite challenging [9]. This complexity necessitates a solution that simplifies the management of devices by using intuitive visualisation and controls specifically designed for home environments.

Consumer XR headsets, such as Meta Quest 2, have made significant progress in recent times, allowing for room-scale tracking and interaction without the need for external infrastructure [11]. This feature allows for a more engaging and easy-to-use management experience that cannot be achieved with traditional desktop or mobile applications. In XR, natural controls such as gestures, and gaze interactions are used to effortlessly manipulate virtual objects. This helps to minimise the reliance on hardware for control purposes. The natural inputs mentioned are well-suited for the purpose of controlling connected devices and creating visual representations.

This project aims to greatly enhance the user experience by utilising XR capabilities to address the challenges associated with managing smart home Internet of Things (IoT) devices. By developing an XR application for the Meta Quest 2 platform that integrates with the Home Assistant API, this approach is expected to be more effective than traditional dashboard methods, providing a unified, immersive interface for controlling and monitoring smart home devices.

1.2 Objectives

The main objective of this project is to develop an augmented reality (AR) based interface for managing Internet of Things (IoT) devices in smart homes. The sub objectives of the project include:

a) **To retrieve real time device data using Home Assistant**

Seamlessly integrate real-time data from IoT sensors, such as temperature and humidity sensors, retrieved from Home Assistant, into the Unity application. This will provide users with insightful information about their home environment while leveraging the capabilities of Home Assistant to efficiently manage and control IoT devices within the AR interface, enhancing user convenience and engagement.

b) **To develop an AR based IoT interface using Unity and Meta Quest2**

Develop an intuitive interface within the Unity environment on the Meta Quest 2 headset to enable users to effortlessly control IoT devices, particularly a smart lightbulb, by utilizing the controllers. This includes functionalities such as adjusting light colours and toggling the light on or off.

By achieving these objectives, the project aims to showcase the practical advantages of AR technology in simplifying the management and interaction with IoT devices in smart home settings, ultimately enhancing user convenience and engagement.

1.3Project Scope and Direction

The central focus of this project is the development of an Extended Reality (XR) application tailored for the Meta Quest 2 headset. The aim is to provide an immersive environment that empowers users to seamlessly visualize, interact with, and centrally control their smart home devices. The project entails the thorough design and implementation of the core XR environment using Unity on the Meta Quest 2.

Key components of the project scope include the creation of a real-time visualization for IoT device data, including device information and status. Utilizing the Home Assistant platform, we will retrieve the device data and display it into the AR interface, offering users a centralized hub for monitoring and controlling their diverse smart home ecosystem.

The XR application serves as a centralized hub for monitoring and controlling diverse smart home devices, consolidating control and management into a single, immersive interface. By showcasing the practicality and potential of augmented reality in smart home management, the project aims to demonstrate the benefits of a unified interface in streamlining the user experience and enhancing efficiency.

In conclusion, the project endeavours to harness the power of augmented reality to revolutionize smart home management. By providing users with an immersive and intuitive interface on the Meta Quest 2 headset, the project aims to empower users to seamlessly visualize, interact with, and centrally control their smart home devices.

1.4 Contributions

In this project, we're pioneering a **novel approach to smart home device interaction** by leveraging the immersive capabilities of the Meta Quest 2 headset. Our primary focus lies in developing a seamless user experience that empowers individuals to control their smart home devices directly through the headset's controllers.

Our primary goal is to empower users with a **unified interface** that utilizes Home Assistant APIs to seamlessly monitor and control their smart home devices. By tapping into live sensor streams and device statuses, users can effortlessly oversee and manage their IoT systems from a single, cohesive platform.

Moreover, we're pushing the boundaries by integrating an AR interface into the Meta headset. This immersive experience offers users a **spatial and intuitive visualization of their smart home device information**, overlaying a 3D representation directly onto their physical environment. This innovative approach enhances user interaction and understanding of their IoT network, providing a seamless blend of virtual and real-world elements.

In essence, our project aims to revolutionize smart home device management by offering a cutting-edge AR-based solution. By **centralizing monitoring and control**, we not only consolidate data from different vendors and protocols but also provide users with a powerful tool for managing their diverse smart home ecosystem directly through their Meta headset.

1.5 Report Organization

This report is organised into 7 chapters: Chapter 1 Introduction, Chapter 2 Literature Review, Chapter 3 System Methodology, Chapter 4 System Design, Chapter 5 System Implementation, Chapter 6 System Evaluation and Discussion, Chapter 7 Conclusion and Recommendation. The first chapter is the introduction of this project which includes problem statement, project background and motivation, project scope, project objectives, project contribution, and report organisation. The second chapter is the literature review carried out on several existing AR interfaces in the market to evaluate the strengths and weaknesses of each paper. The third chapter is discussing the overall system design of this project. The fourth chapter is regarding the details on how to implement the design of the system. Furthermore, the fifth chapter reports the system implementations. The sixth chapter discuss the system evaluation results. Lastly, the seventh chapter concludes the project and give recommendation for future work.

CHAPTER 2: Literature Reviews

2.1 Previous works on Augmented reality interfaces

2.1.1 IDIAR: Augmented Reality Dashboards to Supervise Mobile Intervention Studies

This paper explores the use of augmented reality (AR) dashboards for supervising mobile health intervention studies [12]. This provides valuable insights for the design and development of AR dashboards for Internet of Things (IoT) devices in smart homes which is the main objective of our project. The key contribution of this paper is the user-centered design and evaluation of interactive dashboards visualized in AR for monitoring data streams from mobile health studies [12]. The Interactive dashboards in augmented reality (IDIAR) prototype combines an optical head-mounted display with smartphone-based touch, voice, and gaze input. Four dashboards provide overviews and details on study metrics, rules, notes, and communication channels. The familiar smartphone touch input of the IDIAR was preferred for writing notes or messages. The study also revealed high user experience scores for IDIAR's novelty and aesthetics.

Figure 2.1: IDIAR, four different dashboards provide users with both general and detailed information.

Strengths

This work provides several useful implications for designing AR dashboards for IoT devices. First, it shows that interactive dashboards with different views and granularity levels facilitate monitoring. Second, it tells us that multimodal input such as such as speech, touch, and hand gestures allow flexible interactions tailored to each task. Third, we can see that combining AR head mounted displays (HMDs) with mobile touch devices will enable immersive analytics [12].

Limitations

The IDIAR prototype lacks collaboration capabilities and integration with existing workflows. This can hinder its usability, efficiency, and overall effectiveness in supporting mobile intervention studies. Researchers and professionals in this field typically require tools that facilitate teamwork, data management, and workflow integration to conduct their work effectively and efficiently [12]. The hardware constraints of current HMDs also affect prolonged use. These limitations can impact the user experience and potentially discourage or even harm users in certain situations. The weight of the HMDs can strain the neck and shoulders leading to discomfort. The relatively low resolution of 720 pixels per eye according to [13] will also cause strain on the users eyes when used for a long time.

2.1.2 Augmented Reality for Industry 4.0: Architecture and User Experience

This paper by [14] provides valuable insights for the development of augmented reality (AR) interfaces for visualizing real-time data from IoT devices. The authors present two AR prototype systems. The first is, Real-Time Machine Data Overlay, which visualizes industrial machine data on holographic dashboards, and the second one is Web-Based AR Remote Support, which enables remote collaboration via AR annotations [14]. For our project we will mainly look at the first prototype. The Real-Time Machine Data Overlay prototype demonstrates how AR can effectively display real-time sensor data by overlaying it directly onto physical devices. The paper provides recommendations on architecting such a system, including using industry standard protocols like OPC UA for sensor data transmission, certified hardware like the HoloLens for the AR device, and optimizations for tracking real-world objects. These learnings can be applied to our AR based IoT dashboard.

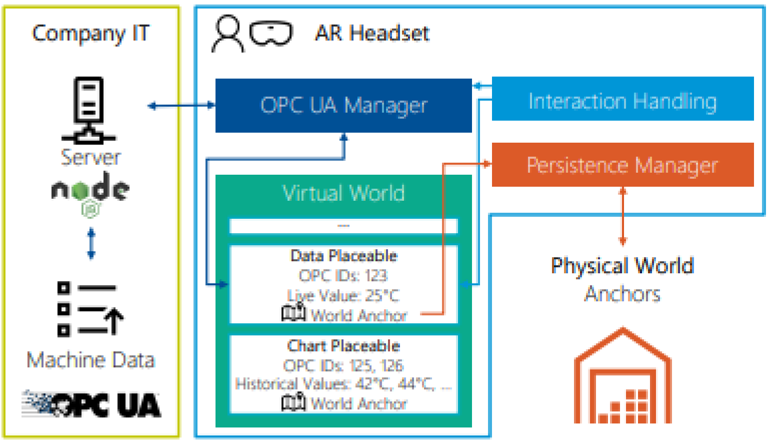


Figure 2.2: Possible architecture of an Augmented Reality app, overlaying real-time machine data.

Strengths

A key strength of this paper is the analysis of the usability considerations for industrial users. As the authors point out, AR interfaces should be designed keeping in mind ease of use and minimal training requirements. The recommendations on UI/UX design, such as using metaphors familiar to users, and intuitive hand gestures will help us get a general idea of the UI design for the smart home AR dashboard in our project.

Figure 2. 3: Example of UI/UX design of AR dashboard.

Limitations

One limitation of the work is that the prototypes have only been evaluated at a low level with informal expert reviews. As the authors suggest, more rigorous user studies are required to evaluate the usability of the proposed architecture and visualizations [14]. For our project, user testing and refinement will be critical to validate the dashboard interface and user experience.

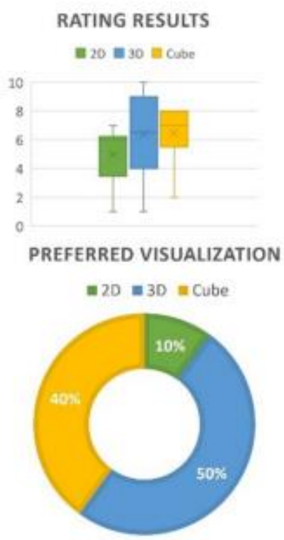
2.1.3 Exploring the usage of Mixed Reality Dashboards in Business Intelligence and Analytics

This paper by [15] explores the usage of mixed reality (MR) dashboards in business intelligence and analytics (BI&A). The paper takes a design science research approach to understand user perspectives on MR dashboards through the development and evaluation of HoloDash, an MR dashboard prototype. In terms of design principles, the paper suggests the need for intuitive and ergonomic interaction techniques. For example, gesture-based interactions may be tiring over prolonged use, so it will be important to consider ergonomics. The paper also highlights the value of 3D data visualization for understanding complexity and enabling collaboration. This suggests including 3D visualizations in our AR IoT dashboard. For example, visualizing 3D geometry of the smart home device and positioning sensor data near it could aid understanding.

Figure 2. 4: Example of 3D data visualization.

Strengths

The rigorous design science research approach and the collection of end user opinions are two of this paper's primary qualities. The authors used a methodical approach to create an MR dashboard, collect feedback from real BI&A users via semi-structured interviews, and develop design principles [15]. This gives a solid empirical foundation for understanding user demands and developing design recommendations. Obtaining feedback from end users is crucial for an user-centered design approach. The paper surveyed users to determine which form of AR visualisation method they prefer and their thoughts on each method.



2D	Pros	- It is familiar to participants and easy to use - Can be supportive for collaboration
	Cons	- Using MR for this type does not deliver added value - Lack of deeper interaction with visualized data
Cube	Pros	- Innovative way to provide access to the dashboard - Easy to navigate among dashboard pages
	Cons	- Usability concerns in working with cube - Lack of added value in case users have access to the desktop-based dashboards in parallel - Lack of deeper interaction with visualized data
3D	Pros	- Support exploring and understanding complex data easier - Closer to reality as augmented information is presented in the real environment - Facilitate collaboration and discussions
	Cons	- Not proper for all types of visualizations. - Need to provide and learn new types of visualizations - Sometimes complicated to work and can lead to the wrong impression of data based on the point of view - Lack of deeper interaction with visualized data

Figure 2. 5: User opinion on preferred visualization methods

Limitations

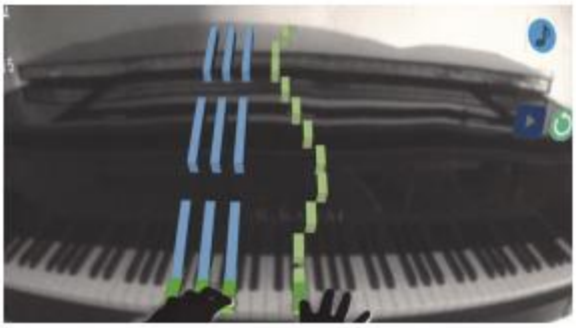
The first limitation is that users could not experience the HoloDash prototype in person due to pandemic restrictions. They had to view videos of it instead of directly interacting with the augmented reality system [15]. This means the findings may not accurately reflect how users would actually behave when physically present with the technology compared to just observing it remotely.

The second limitation is that the dashboard prototype was static and did not support real-time data analytics. Many augmented reality applications, like visualizing IoT data, involve live, dynamic updates. A static prototype fails to realistically demonstrate how the system might perform with changing data in real-time. Allowing users to interact with live, updating information could provide additional useful insights into their behavior and decision-making compared to a static demo.

2.1.4 Passthrough Mixed Reality with Oculus Quest 2: A Case Study on Learning Piano

This paper by [16] presents a mixed reality (MR) application using the Oculus Quest 2 Passthrough API to assist with learning piano. The application shows virtual notes overlaid on top of a real piano captured through the Quest 2's cameras, guiding the user on which keys to press to play a song. The paper demonstrates the potential of using MR and AR to overlay virtual information and interactions onto real-world objects and environments. The paper also highlights techniques for hand tracking and natural gesture-based interactions using the VR controllers and finger tracking [16]. This information can provide valuable insights that can be applied to developing hand tracking and gesture-based interactions for selecting and manipulating virtual devices in our project.

(a)



(b)

Figure 2. 6: (a) shows the user playing the piano with overlay. (b) shows user's point of view in the headset.

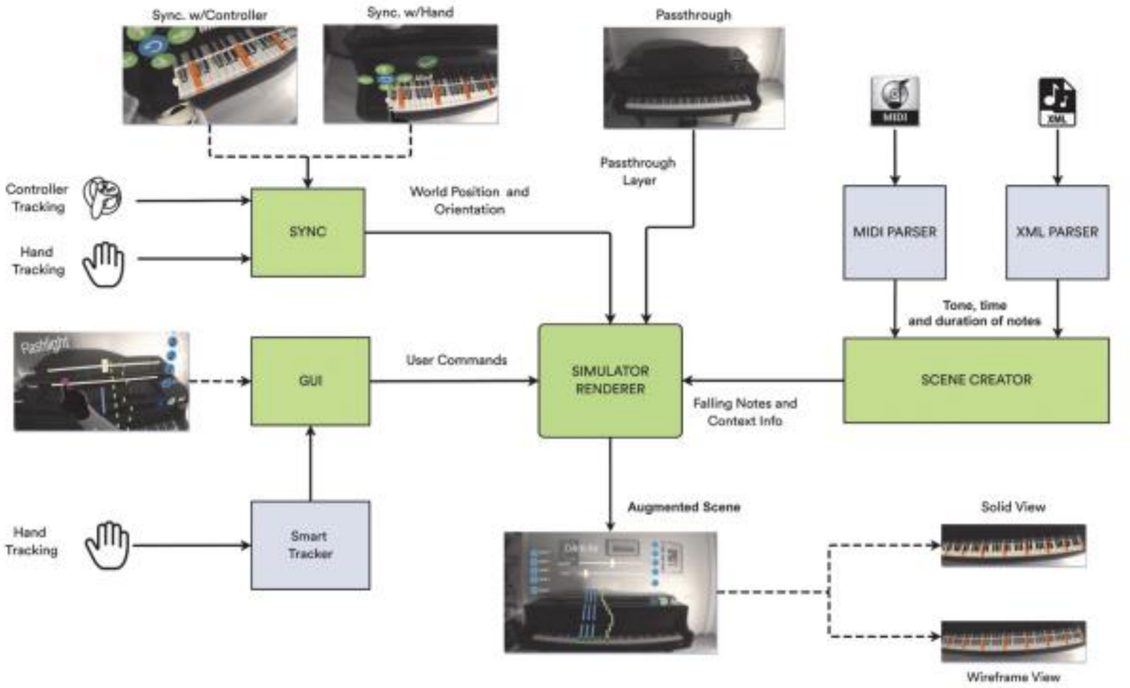


Figure 2. 7: Architecture of the mixed reality application.

Strengths

A key strength of the paper is that it provides a detailed report on a full user study evaluating the MR piano learning application. The study compares two different visualization modes and collects both subjective questionnaire data and objective playing accuracy metrics [16]. This provides a basis for making informed decisions about which features or modes are more suitable for specific use cases, which can be particularly valuable in the design and development process. This provides a methodology template for conducting rigorous evaluations of AR/MR interfaces. The statistically significant preference for the solid visualization mode despite no difference in playing accuracy highlights the importance of subjective user feedback in addition to performance data.

Limitations

Here are some limitations of the current mixed reality functionality and how they could potentially impact the user experience. The image quality captured from the real-world lacks clarity, has instability, and is only displayed in grayscale rather than colour [16]. This low visual quality could cause discomfort or motion sickness for users. It also makes precise interactions and visualizations more difficult. High quality, stable imagery in full colour is important for creating truly immersive and realistic mixed reality. The Passthrough API currently has restrictions that prevent the use of computer vision techniques like object detection [16]. Without computer vision capabilities, MR applications may be limited to simpler forms of interaction. This could potentially limit their functionality and engagement for users. Additionally, the technology does not enable rendering with depth perception. Being able to perceive depth is key for realistic and immersive AR/MR experiences. Without depth rendering, applications may struggle to accurately convey spatial relationships between virtual objects and the real-world environment.

2.1.5 Visual Assembling Guidance Using Augmented Reality

[17] presents a study on using AR to provide visual guidance for assembly line workers to enhance the efficiency and effectiveness of the workers. The paper presents an AR system using the Oculus Rift headset with mounted cameras to view the real world, and Unity software to overlay the virtual objects [17]. It was evaluated by having users assemble a 3D puzzle with either the AR system or paper instructions. The AR system provided animated guidelines on which piece to select and where to place it. This is relevant to my project, as both involve overlaying virtual information onto the real environment to guide the user.

Strengths

One of the key strengths of this paper is that it focuses on user acceptance rather than just task performance. Many previous AR assembly studies focused only on quantitative performance metrics like time and errors [17]. Evaluating subjective acceptance is critical for successful adoption in industry. Another strength is that they used low-cost, consumer AR hardware (Oculus Rift). This demonstrates the feasibility of implementing AR without expensive custom hardware. Using off-the-shelf consumer hardware makes the system more accessible and easier to integrate into existing environments, potentially lowering the barrier for adoption in industry.

Figure 2. 8: Oculus rift prototype with cameras attached to front.

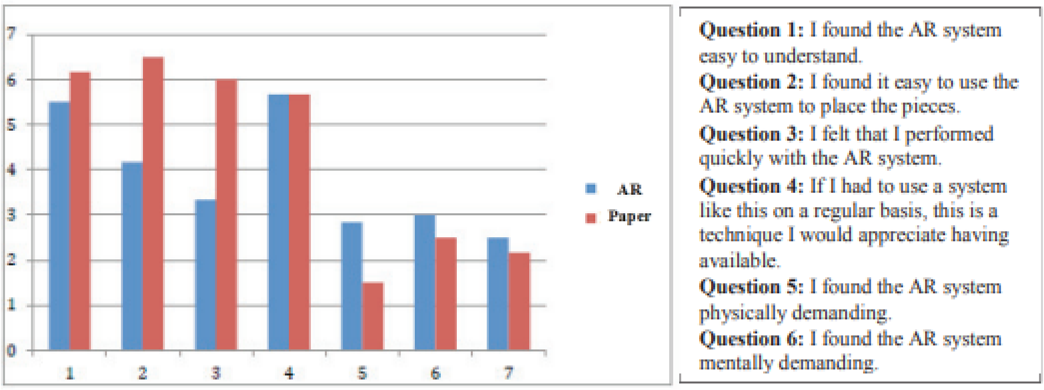


Figure 2. 9: User opinion on AR system (1 = totally agree, 7 = totally disagree)

Limitations

The assembly task is very simple, unlike real industrial tasks. The study involves a 3D puzzle with only nine pieces, which may not accurately reflect the complexity and variety of tasks encountered on industrial shop floors. Assembling a simple puzzle may not fully capture the challenges and intricacies of real-world industrial tasks, which can be much more demanding and multifaceted. The second limitation is the small number of participants (6 per condition). With only 12 total users, the subjective ratings and performance metrics have low statistical power. The third limitation is the low-resolution display which has only a 640 x 800 pixels display [17]. The low display resolution caused eye fatigue, which could hinder adoption.

2.2 Summary of previous works

Table 2. 1: Summarization all the previous works in terms of strengths and limitations.

Paper Title	Strength	Limitations
IDIAR: Augmented Reality Dashboards	- User-centered design - Multimodal input - Combining AR with mobile devices - High user experience scores	- Lack of collaboration and workflow integration - Hardware constraints of AR HMDs
Augmented Reality for Industry 4.0	- Usability considerations - UI/UX design recommendations	- Informal expert reviews instead of rigorous user studies
Exploring the Usage of Mixed Reality Dashboards	- Design science research approach - End-user feedback - 3D data visualization	- Users couldn't experience the MR prototype in person - Static prototype without real-time data support
Passthrough Mixed Reality with Oculus Quest 2	- Detailed user study - Comparison of visualization modes - Insights into hand tracking and gestures	- Low visual quality, grayscale imagery - Restrictions on computer vision and depth rendering
Visual Assembling Guidance Using Augmented Reality	- Focus on user acceptance - Use of low-cost consumer AR hardware	- Simple assembly task - Small number of participants - Low display resolution causing eye fatigue

2.3 Solution for limitations of previous works.

2.3.1 Solution for limitations of IDIAR: Augmented Reality Dashboards

To address the lack of collaboration and workflow integration, our system could incorporate collaborative features like allowing multiple users to view and interact with the AR dashboard simultaneously. Integration with existing dashboard platforms like Home Assistant through APIs can also enable better workflow integration. This allows users to seamlessly import, analyze, and view data from various sources directly within the AR environment. To mitigate hardware constraints of AR HMDs, we can optimize the dashboard interface and visualizations for current consumer hardware like Oculus Quest. Features like gaze-based interactions can reduce physical fatigue. To improve the overall user experience on lower-end hardware, we can adjust render resolutions based on the user's interaction and the complexity of the visualizations. For example, only fully rendering objects in the user's view while blurring the rest.

2.3.2 Solution for limitations of Augmented Reality for Industry 4.0

Conduct rigorous user studies with representative users performing realistic tasks to formally evaluate the usability and effectiveness of the AR dashboard design. Realistic tasks should be carefully designed to mimic actual scenarios that users will encounter in their daily lives. Also conduct comprehensive user studies with a larger and more diverse user base. Implement controlled experiments and gather quantitative data alongside qualitative feedback. Involve industry professionals and end-users to ensure real-world relevance. They can provide insights into the practical requirements, challenges, and nuances that the AR system should address. End user feedback helps identify areas where the AR system may need further simplification or guidance.

2.3.3 Solution for limitations of Exploring the Usage of Mixed Reality Dashboards

Providing direct hands-on experience with the AR system allows users to interact with it in an immersive and engaging way [18]. This interactive approach simulates real-world use scenarios, giving users a realistic sense of how the AR dashboard would function. Through physical manipulation, they can provide natural and authentic feedback on ease of use, preferences, and frustrations. Hands-on interaction is valuable as it enables users to identify any issues or errors they encounter firsthand. This helps ensure the AR system meets expectations for reliability and usability. It also allows users to evaluate how responsive the interface feels when handling live data streams. Visualizing real-time IoT data feeds during evaluations offers a dynamically responsive demonstration of the AR system's capabilities. Users can observe how it performs under changing conditions in close to real-time. This level of engagement tends to facilitate more detailed and insightful feedback. It gives users confidence that the system can adequately manage incoming data updates as they occur.

2.3.4 Solution for limitations of Passthrough Mixed Reality with Oculus Quest 2

Investigate more advanced AR hardware options. While the current setup allows for prototyping and iterative design, stepping up to equipment with superior technical capabilities could significantly enhance certain aspects of the experience. For example, switching to an AR headset with better color reproduction, such as the Meta Quest Pro, may improve color accuracy when visualizing user backgrounds. Its full-color passthrough provides users with a more perceptually comfortable, high-fidelity, real-time representation of the physical world around them [19]. Leveraging built-in depth sensing may also augment usability. Depth sensors like the LiDAR scanner and True Depth camera found in Apple's Vision Pro enable sensible spatial anchoring of virtual objects within real environments [20]. Integrating this kind of hardware could offer a more seamless mixed reality experience when overlaying analytics onto live camera views.

2.3.5 Solution for limitations of Visual Assembling Guidance Using Augmented Reality

To properly assess the AR dashboard's utility, it is crucial to design simulated IoT management tasks that authentically mimic real-world use cases. This allows a rigorous evaluation of how effectively the solution would support technicians in their day-to-day work. For a smart home application, examples may involve overseeing multiple devices simultaneously, checking equipment statuses at a glance, or remotely troubleshooting connectivity issues. It is also imperative to recruit larger, more diverse user samples for evaluation studies. Broadening the participant pool enhances statistical validity and ensures findings are representative rather than isolated occurrences. More robust conclusions regarding ease of use, efficiency and satisfaction levels can then be established. Using higher-resolution AR headsets, such as Oculus Quest 3, can significantly advance the quality and immersion of the visualized overlays. Their vivid, high-definition displays help maintain engagement and focus throughout lengthy sessions. Less eye strain contributes to richer, more nuanced feedback.

CHAPTER 3: System Methodology/Approach

3.1 System Architecture

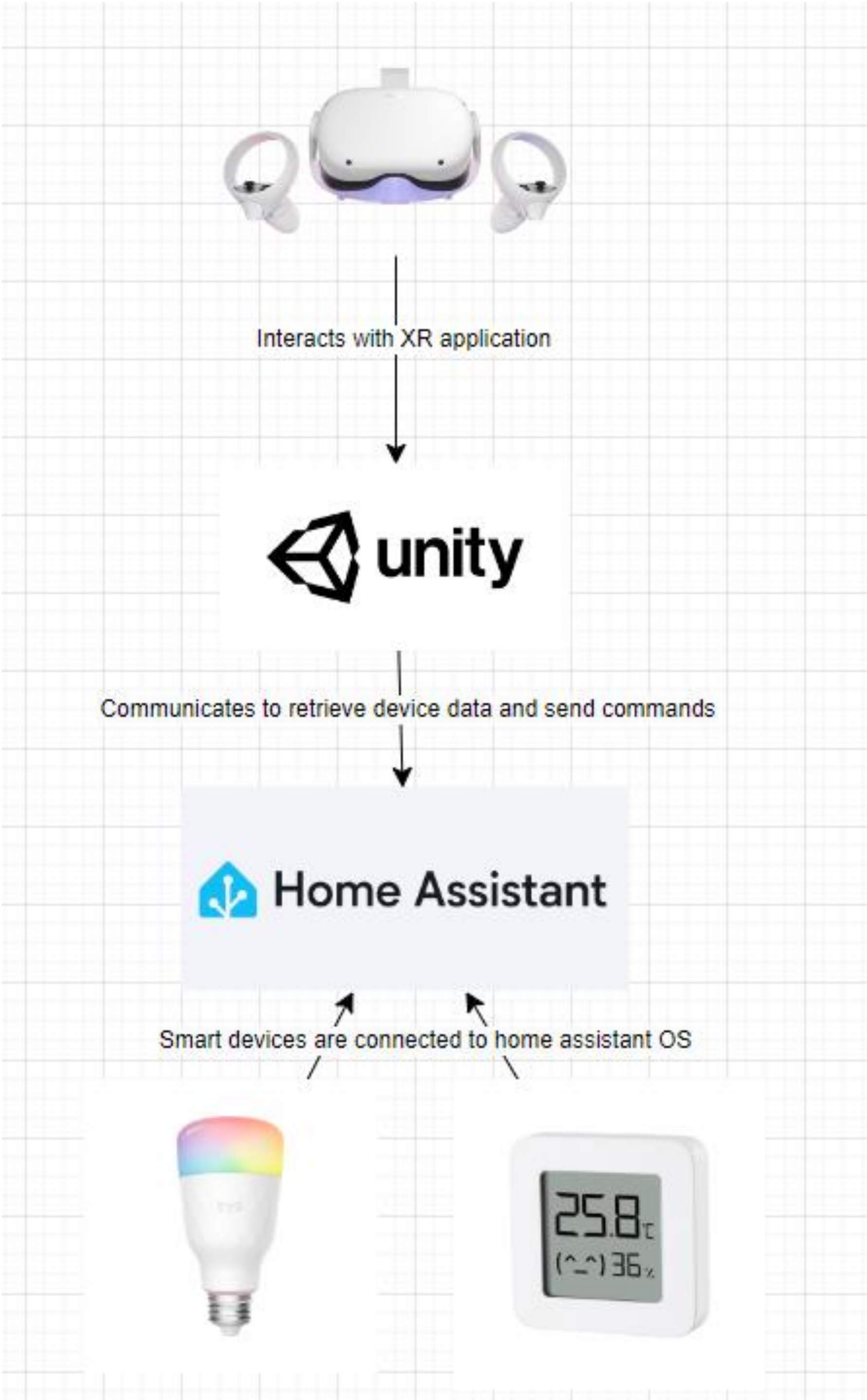


Figure 3. 1 System Architecture

3.2 Use Case Diagram

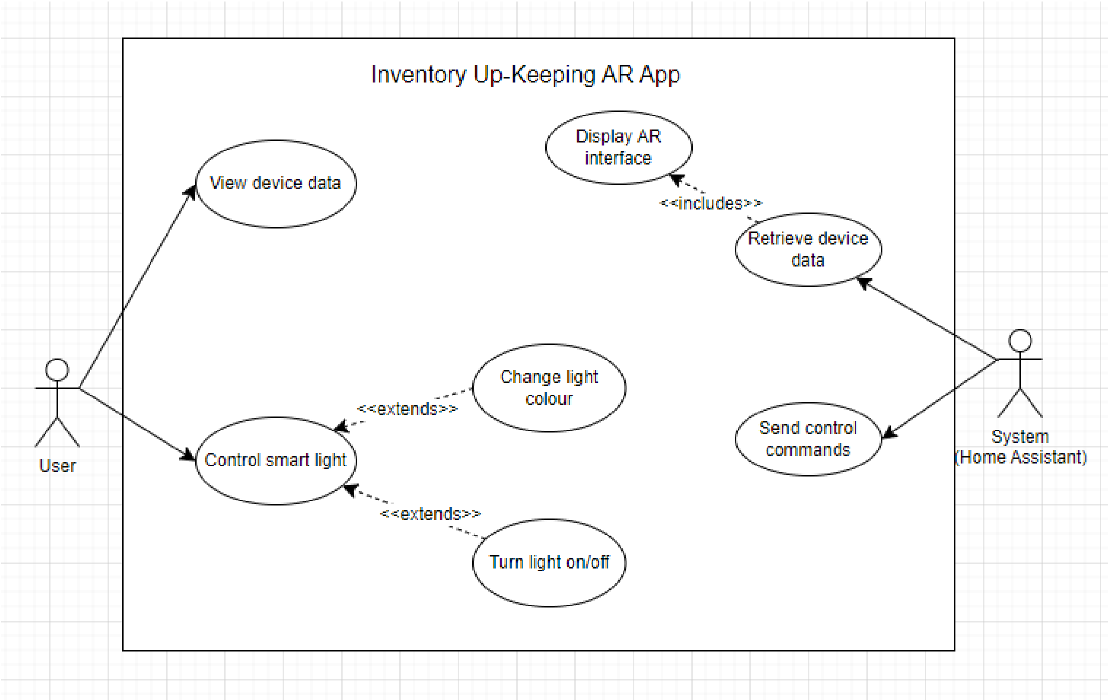


Figure 3. 2 Use Case Diagram

There are two actors in the system. The first is the user the second is the system which home assistant. The first use case for the user is to be able to view the device data in the AR app. The second use case for the user is to be able to control the smart light. The user can choose to turn the light on or off. They can also choose to change the colour of the light.

The first use case of the system is to retrieve the device data from various devices and sensors within the smart home environment then display it on the AR interface for the user to view them. The second use case is to send the user’s control commands to the light. Upon receiving these commands, the system processes them and communicates with the smart light device to execute the desired actions.

3.3 Activity Diagram

View device data activity

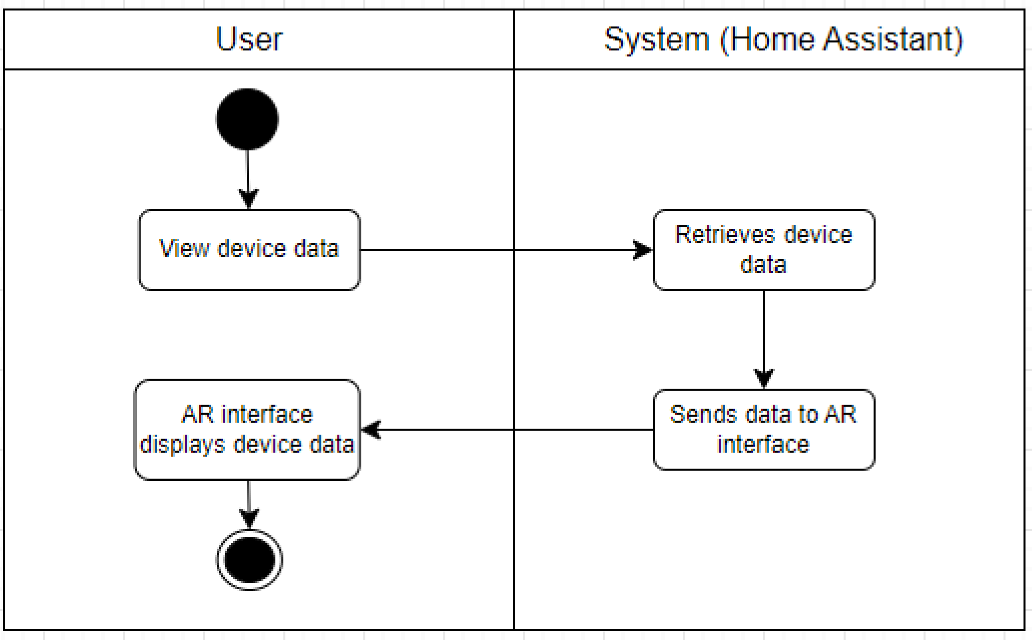


Figure 3. 3 View device data activity diagram.

Figure 3.3 shows the activity to view device data. After the user opens the app the device data will be retrieved from home assistant will retrieve the data and send it to the app. It will then be displayed on the AR interface for the users to see.

Turn lights on/off activity

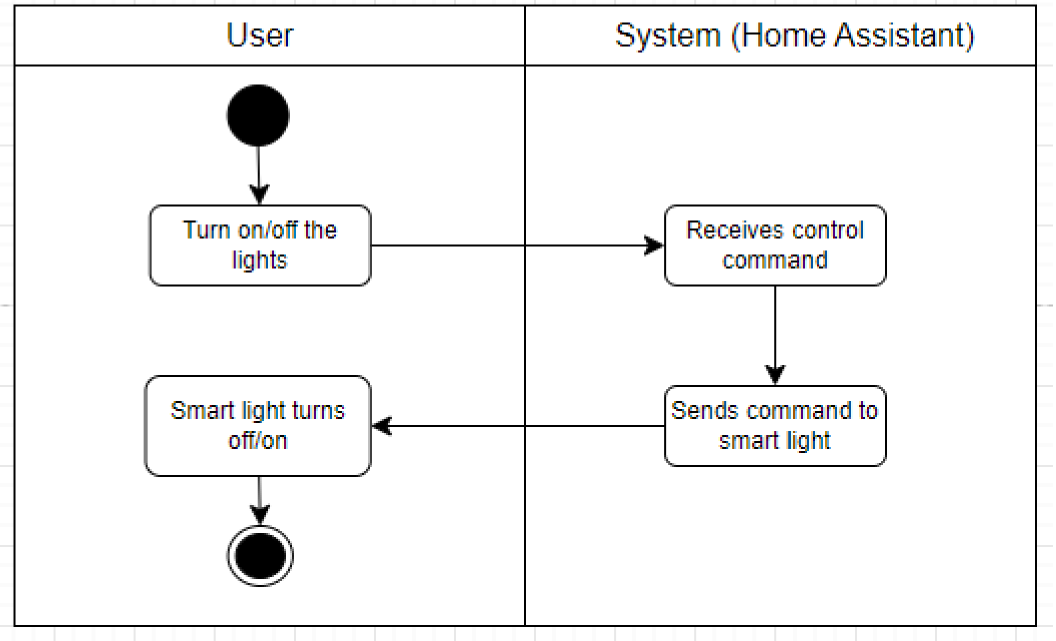


Figure 3. 4 Turn lights on/off activity diagram.

Figure 3.4 shows the activity to turn the lights on or off. When the user clicks on the lightbulb in the AR app it will toggle the lights to be on or off. Then home assistant will receive the toggle command and send it to the smart light. The smart light will then toggle on or off according to the user commands.

Change light colour activity

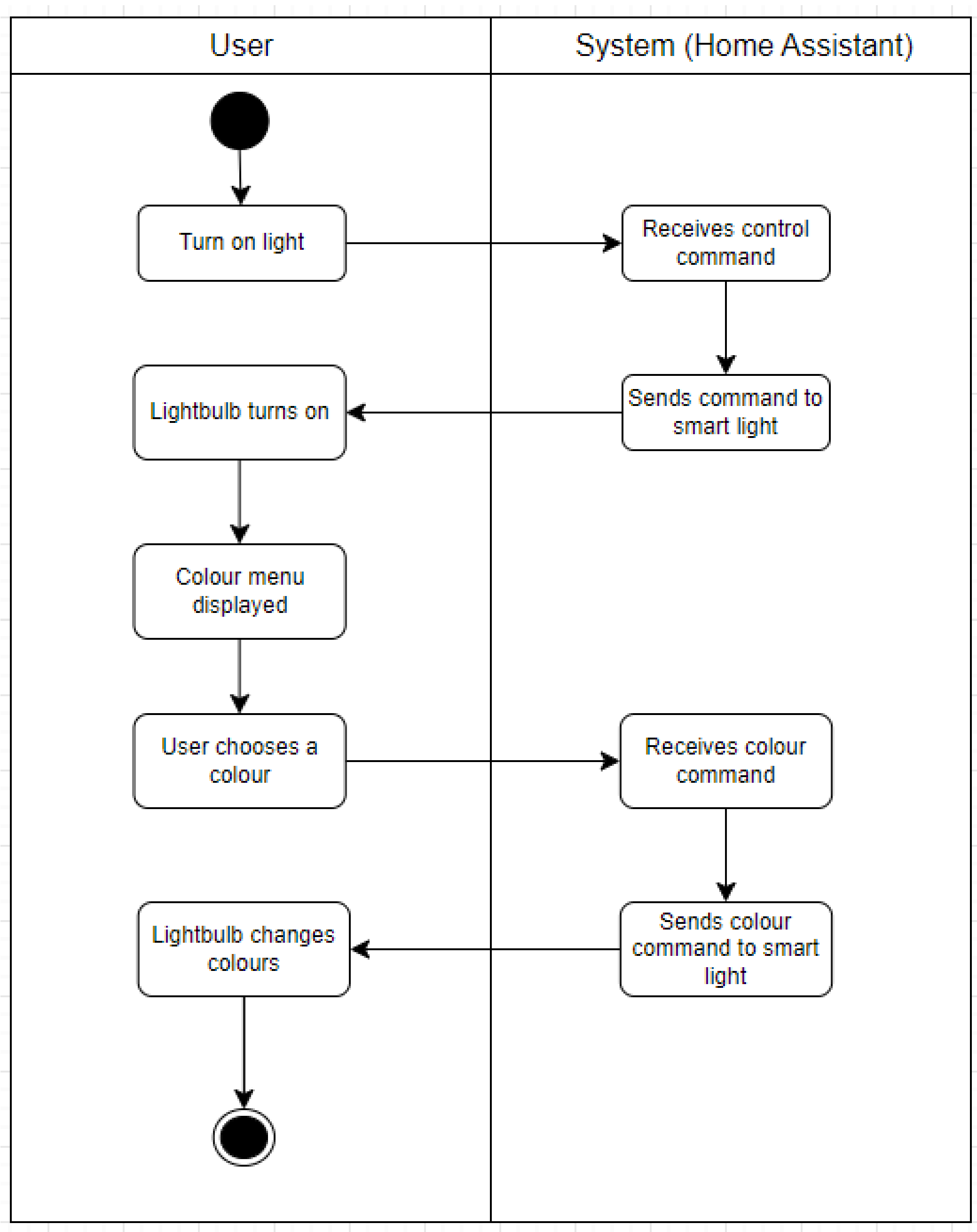


Figure 3. 5 Change light colour activity diagram

Figure 3.5 shows the activity to change the lightbulb colour. When the light is on the colour menu will be displayed. The user can then choose any colour on the menu. Home assistant will receive the colour command and send it to the lightbulb. The lightbulb will then change to the desired colour.

Chapter 4: System Design

4.1 System Flow Chart

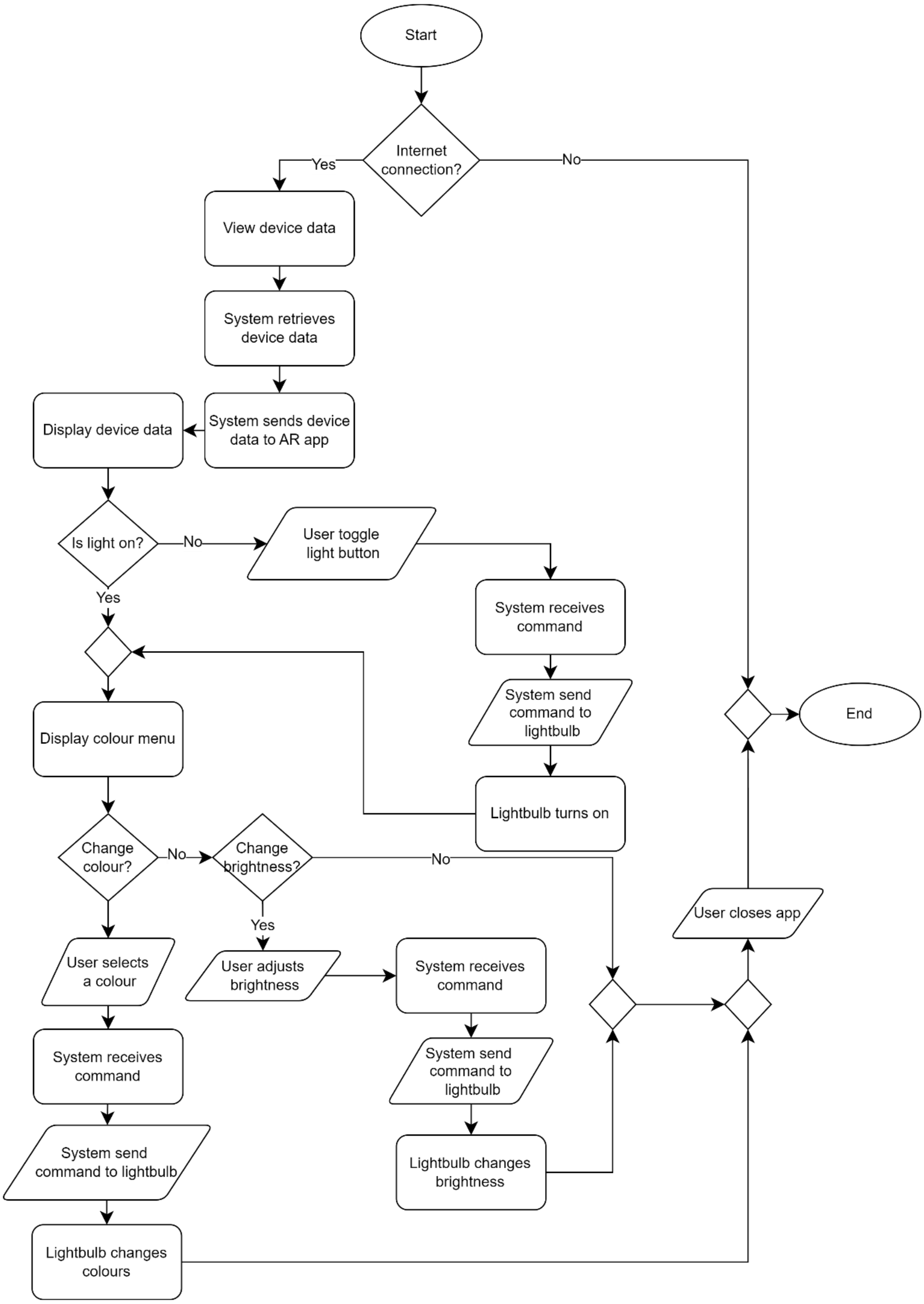


Figure 4. 1 Flowchart of Inventory Upkeeping AR App

When the user launches the app and has an internet connection the app will retrieve data from home assistant and display it for the user to see. If there is no internet connection the app will not work. After looking at the device information, the user will be able to control the light bulb. If the light is already on at the start of the app then the lightbulb game object will light up and the colour menu will be displayed. If the light is off at the start then the lightbulb object will be off and the colour menu will be hidden. Once the user clicks on the lightbulb to toggle it on the colour menu will be displayed. In the colour menu there are 16 different colour options that are available for the user to pick. Once a user chooses a colour and clicks on it the app will send a command to home assistant which will send a command to the light bulb to change its rgb value. If the user wants to change the brightness they can adjust it with the slider in the colour menu. Once the user adjusts the brightness the app will send a command to the lightbulb to change its brightness. After that the user can choose to close the app which will end the system.

4.2 Gantt Chart

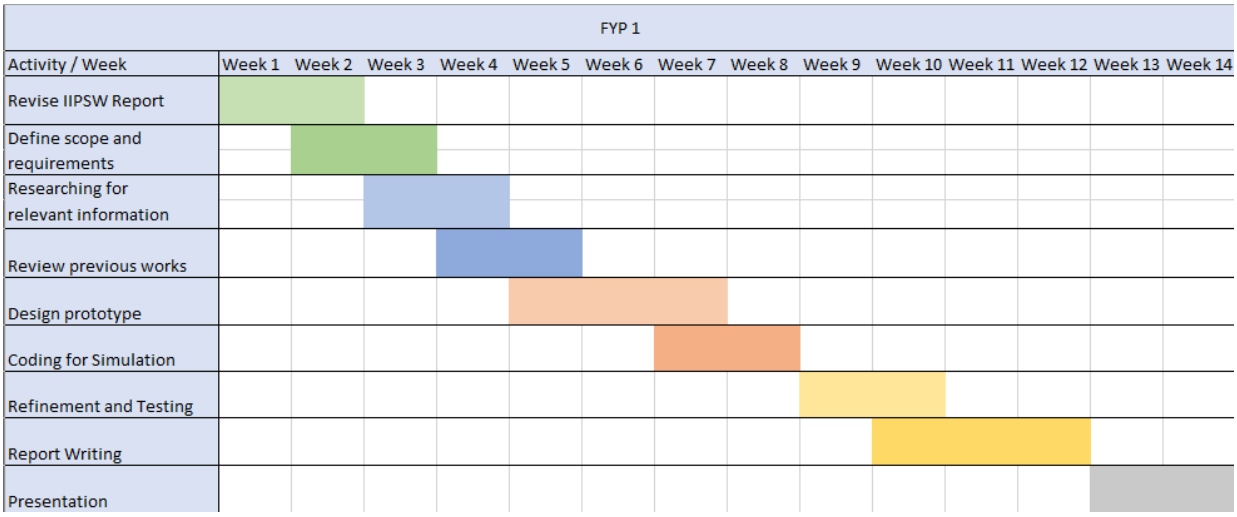


Figure 4. 2 FYP 1 Timeline

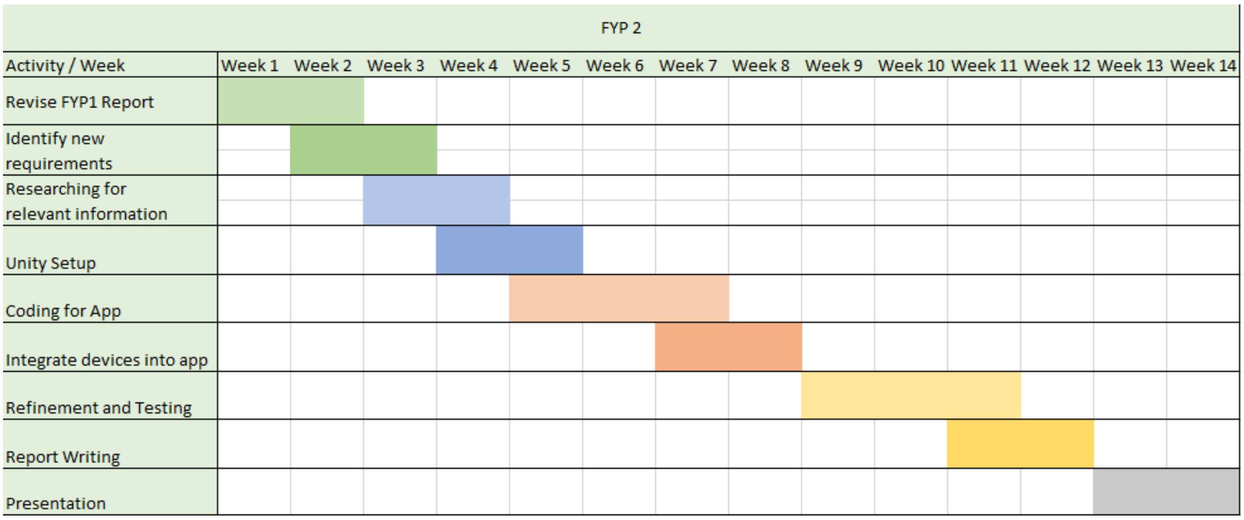


Figure 4. 3 FYP 2 Timeline

4.3 System Component Interaction Operations

When users first open the app they will be able to see a lightbulb object this object will light up depending on if the smart lightbulb is currently on. Fig 4.4 shows the lightbulb object when the smart light is off

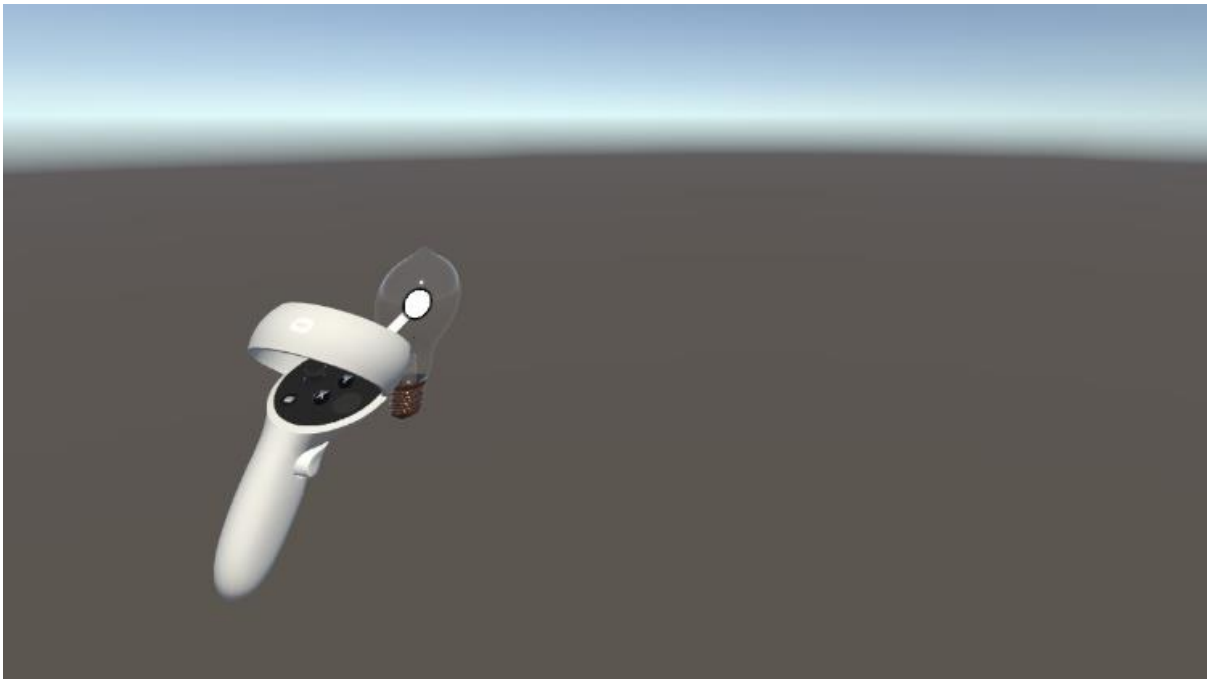


Figure 4. 4 App view when light is off

Fig 4.5 shows the lightbulb and colour menu which will only show up when the lightbulb is on. When users toggle the light off the colour menu will be hidden. When user toggle it on the menu will pop up.

Figure 4. 5 App view when light is on

Fig 4.6 shows the grab function which allows the colour menu to be grabbed positioned anywhere the user wants.

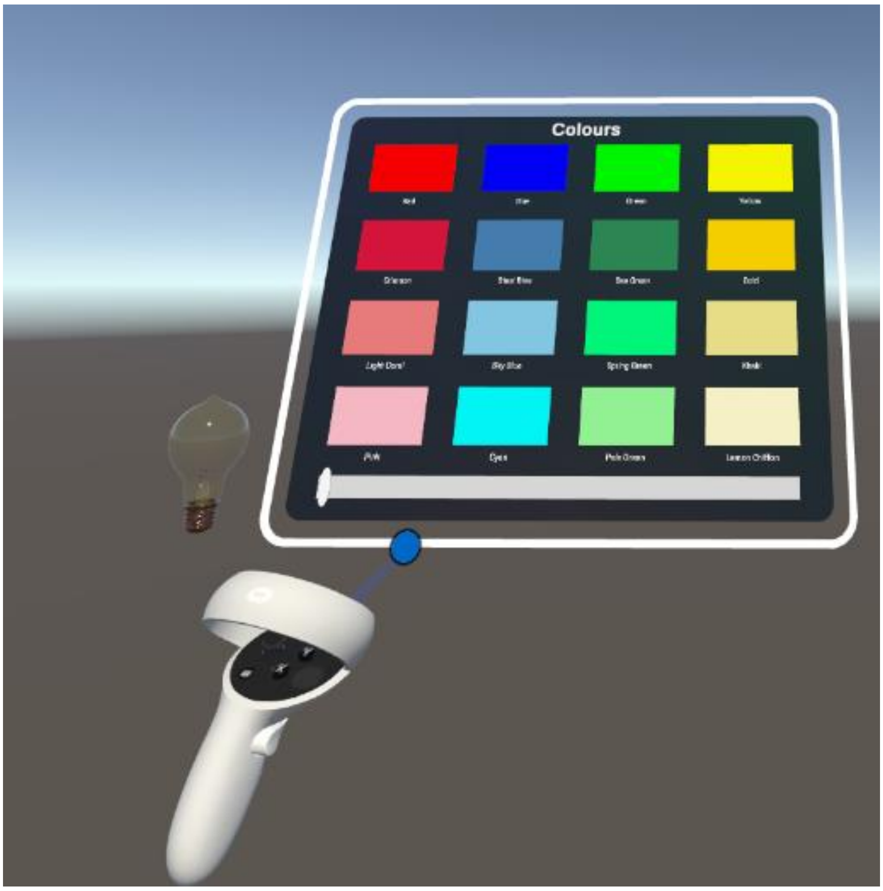


Figure 4. 6 Colour menu positioning

Fig 4.7 shows the rotating function for the colour menu. Users can rotate the menu vertically to better fit their screen.

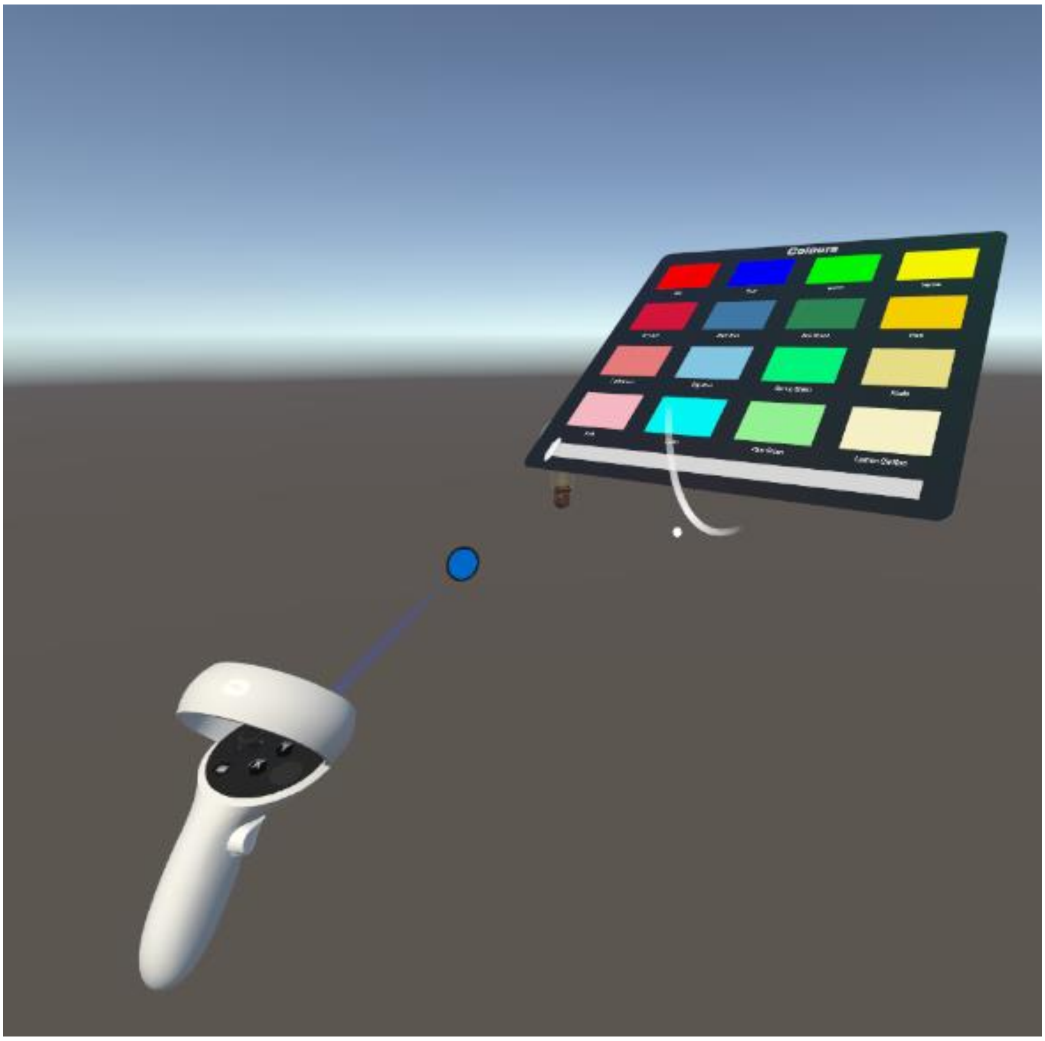


Figure 4. 7 Colour menu rotation

Fig 4.8 shows the user clicking on one of the colour buttons.

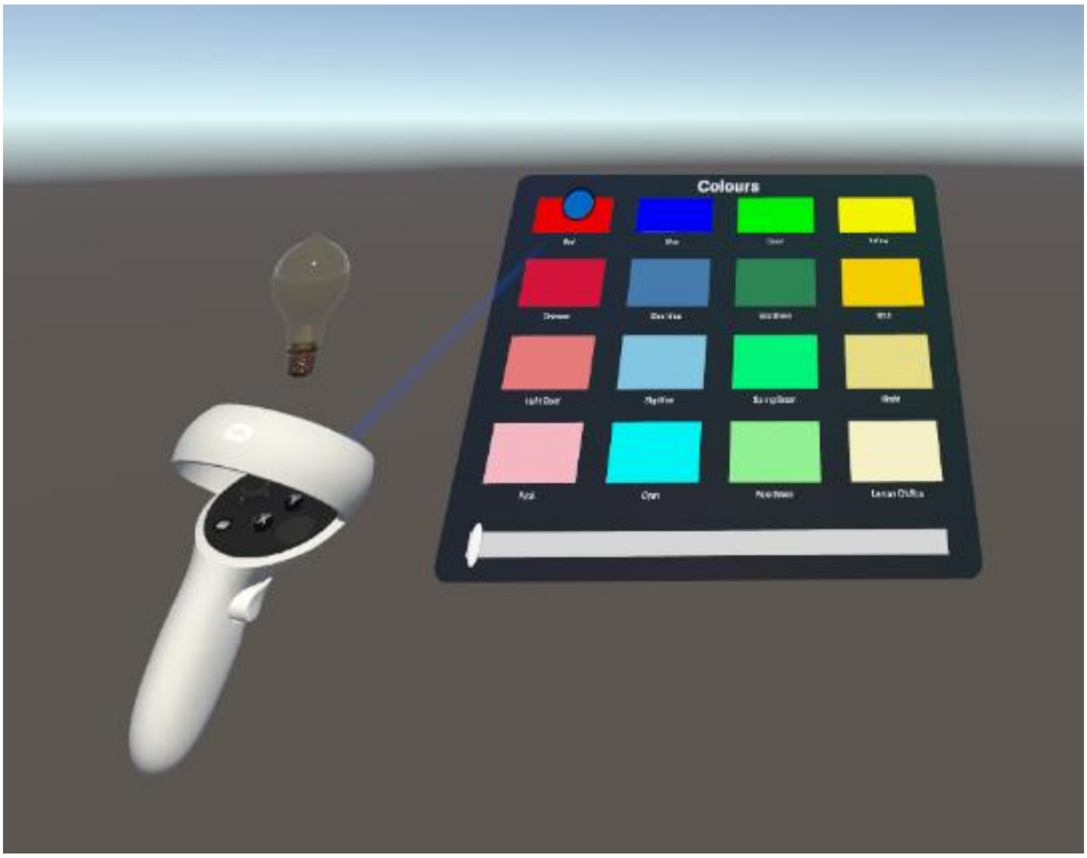


Figure 4. 8 Colour selection

Fig 4.9 shows the smart lightbulb which changes to the selected colour.

Figure 4. 9 Smart lightbulb changes colour

Fig 4.10 shows the user adjusting the brightness of the lightbulb using a slider on the colour menu.

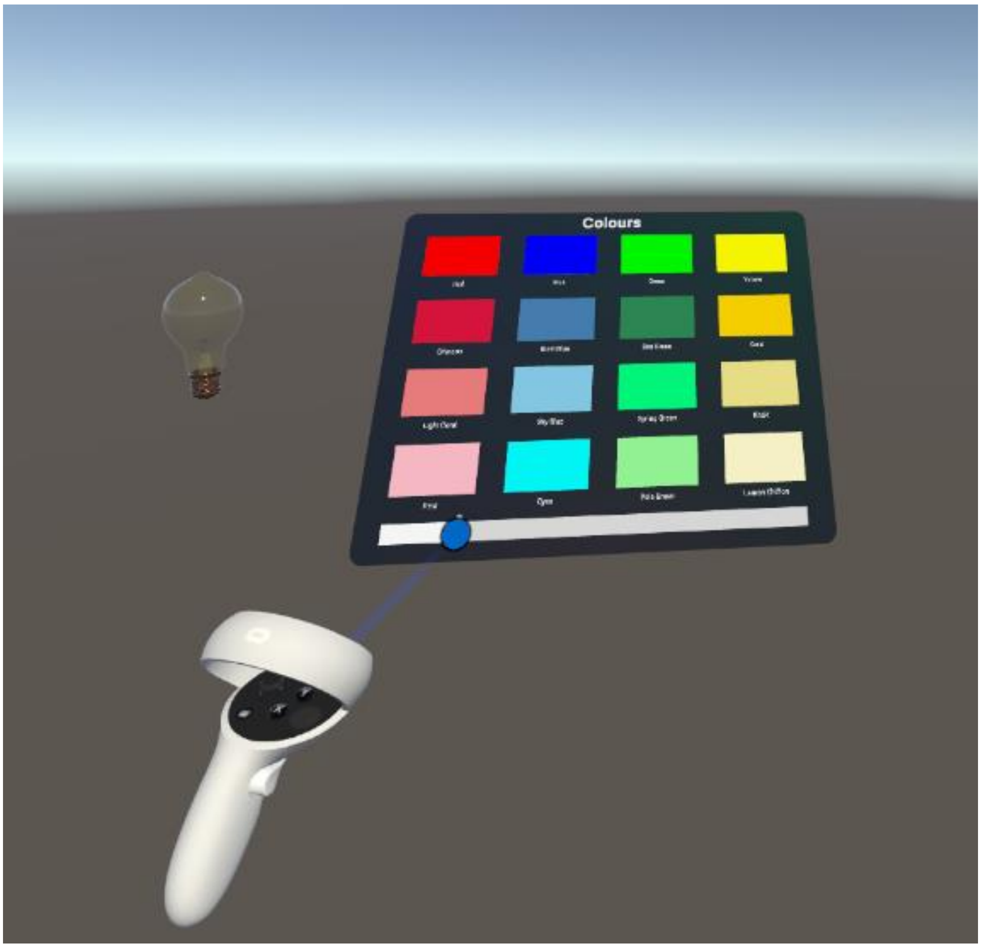


Figure 4. 10 Colour menu brightness slider

Fig 4.11 shows the actual lightbulb which changes to lower brightness.

Figure 4. 11 Lightbulb changes brightness

Fig 4.12 shows the temperature and humidity sensor data displayed in a UI canvas.

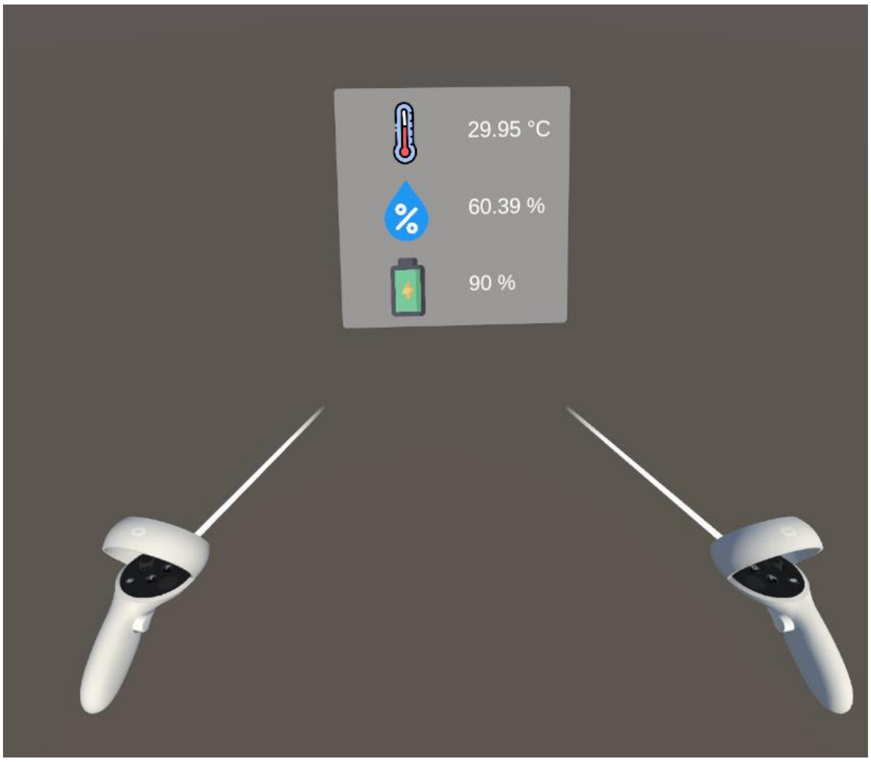


Figure 4. 12 Sensor UI

Fig 4.13 shows the temperature and humidity sensor which has the accurate data sent to our UI.

Figure 4. 13 Temperature and Humidity sensor

Fig 4.14 shows the sensor ui when there is no wifi to connect to home assistant api.

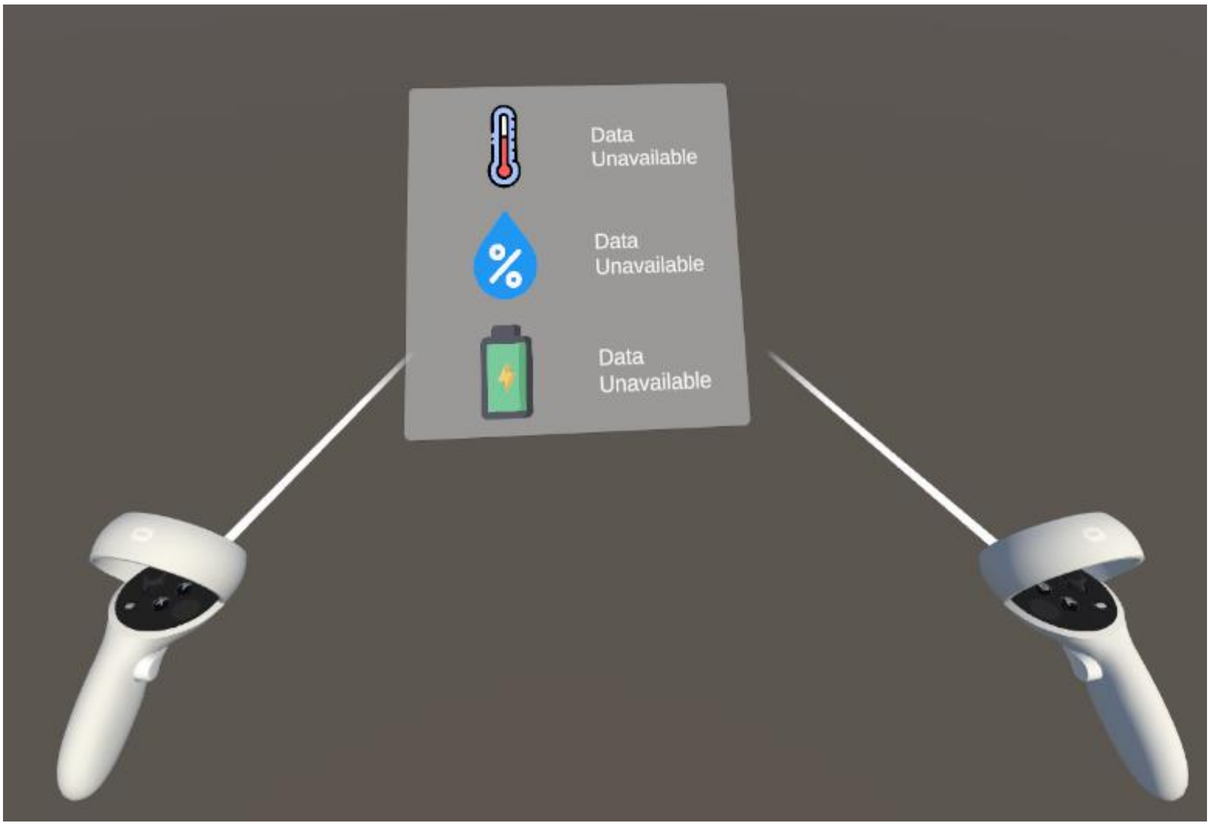


Figure 4. 14 Sensor UI without WiFi

CHAPTER 5: System Implementation

5.1 Hardware Setup

The hardware involved in this project is a laptop, 2 Yeelight Smart LED Light Bulbs, a Xiaomi temperature and humidity sensor and an Oculus quest 3 headset. The laptop will be used to run the virtual machine for Home Assistant OS and The Oculus quest headset will be used to display the AR environment and application. Table 4.1 shows the specifications of the laptop and Table 4.2 shows the specifications of the Oculus Quest 3 headset.

Table 5. 1: Specifications of laptop

Description	**Specification**
Motherboard model	Gigabyte B450M DS3H-CF
Processor	AMD Ryzen 5 3500U
Operating system	Windows 10 Pro
Graphics	Radeon Vega Mobile Gfx
Memory	12GB DDR4 Ram @2400 MHz
Storage	237GB SSD, 931GB HDD

Table 5. 2: Specifications of Oculus Quest 2

Description	**Specification**
Display	IPS LCD, 1832x1920px per eye resolution, 90Hz native refresh rate
Processor	Qualcomm Snapdragon XR2 (7 nm): Octa-core
Graphics	Adreno 650
Tracking	Supports 6 degrees of freedom (6DoF) head and hand tracking through integrated Oculus Insight technology. 4 front-facing cameras for visual controller

	tracking, plus gyroscopes and accelerometers in headset and controllers; Hand tracking (beta).
Memory	128GB Storage 6GB RAM
Operating system	Oculus Mobile, based on Android 10

Table 5. 3: Specifications of Smart Light Bulb

Description	**Specification**
Name	Yeelight Smart LED Bulb 1S (color)
Model	YLDP13YL-COLOR
Lamp Holder	E26/E27
Luminous Flux	800lm
Connectivity	Wi-Fi IEEE 802.11 b/g/n 2.4GHz
Rated Power	8.5W
Color Temperature	1700K-6500K

Table 5. 4: Specifications of Temperature and Humidity Sensor

Description	**Specification**
Name	Mi Temperature and Humidity Monitor 2
Model	LYWSD03MMC
Battery Model	CR2032 (installed)
Temperature measurement range	From 0℃ to 60℃
Humidity measurement range	From 0% RH to 99% RH
Connectivity	Bluetooth 4.2 BLE

5.2 Software Setup

a) Programming Languages

C# is the primary scripting language used in Unity. Most of the application logic, controls, algorithms etc. will be programmed in C#.

b) Unity

Unity is a game engine that will be used to develop the augmented reality interface and environment. Meta all in one sdk package can be used to create augmented reality experiences and develop the AR application for Oculus, and many other platforms.

c) Oracle VirtualBox

Oracle VM VirtualBox is a type-2 hypervisor for x86 virtualization developed by Oracle Corporation. It is used in this project to host a virtual machine containing the Home Assistant OS. This is where all the IoT devices will be connected to and the AR interface will retrieve the data from here.

5.3 Settings and configurations

5.3.1 Home assistant installation

Oracle VirtualBox is used to host the Home Assistant OS. To set up the virtual machine we have to follow these steps:

Step 1: Install home assistant .vdi file. (Fig 5.1)

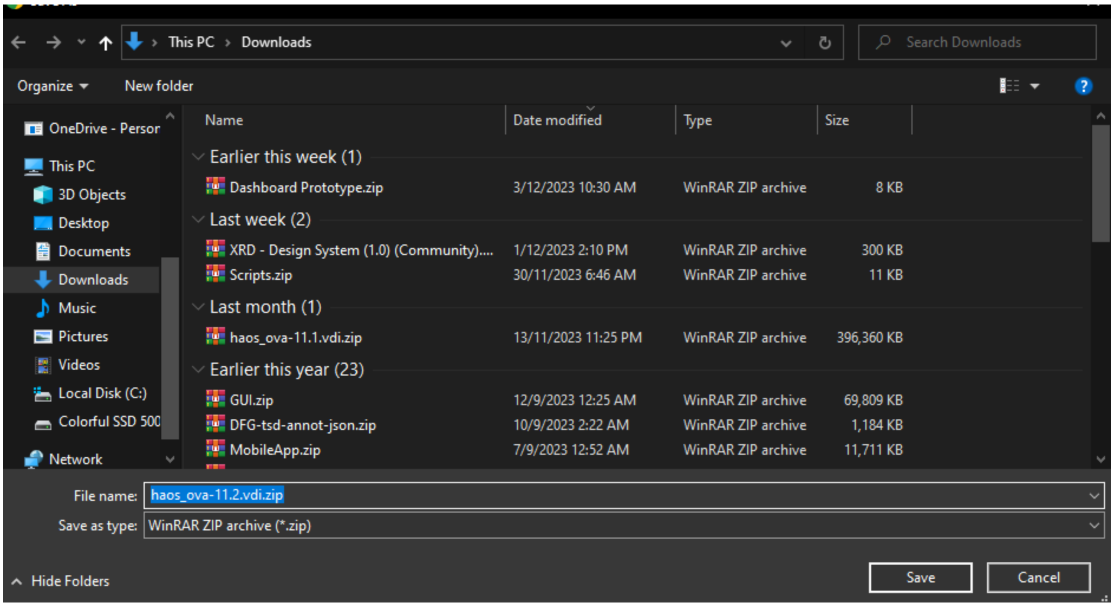


Figure 5. 1: Installing Home Assistant OS VDI

Step 2: Create a virtual machine in VirtualBox. (Fig 5.2)

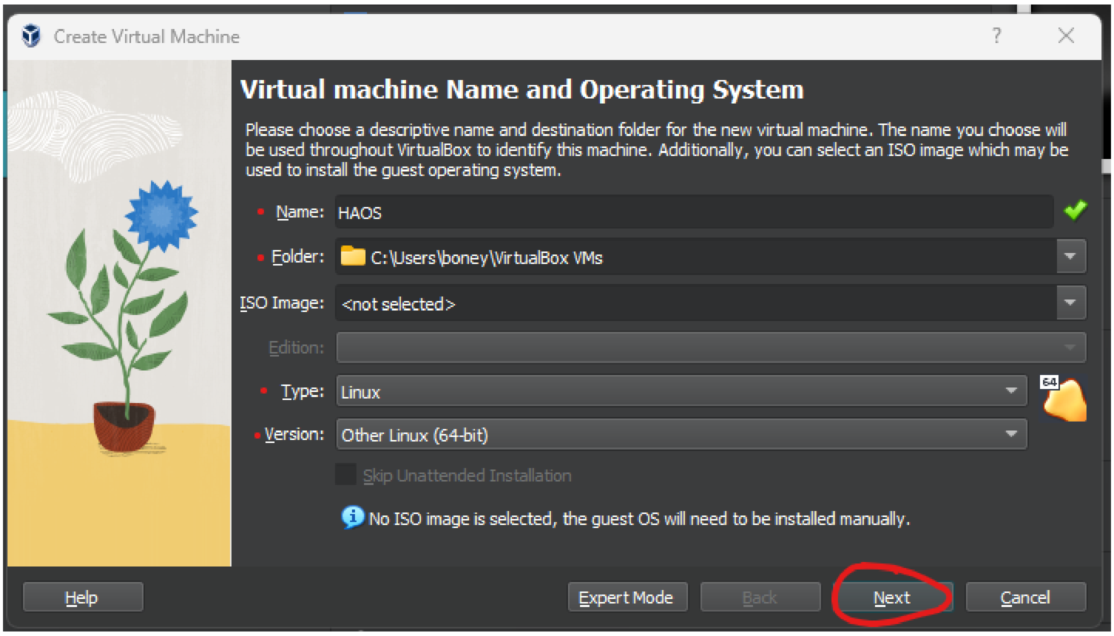


Figure 5. 2: Create a virtual machine with Linux 64bit

Step 3: Configure the virtual machine. (Fig 5.3)

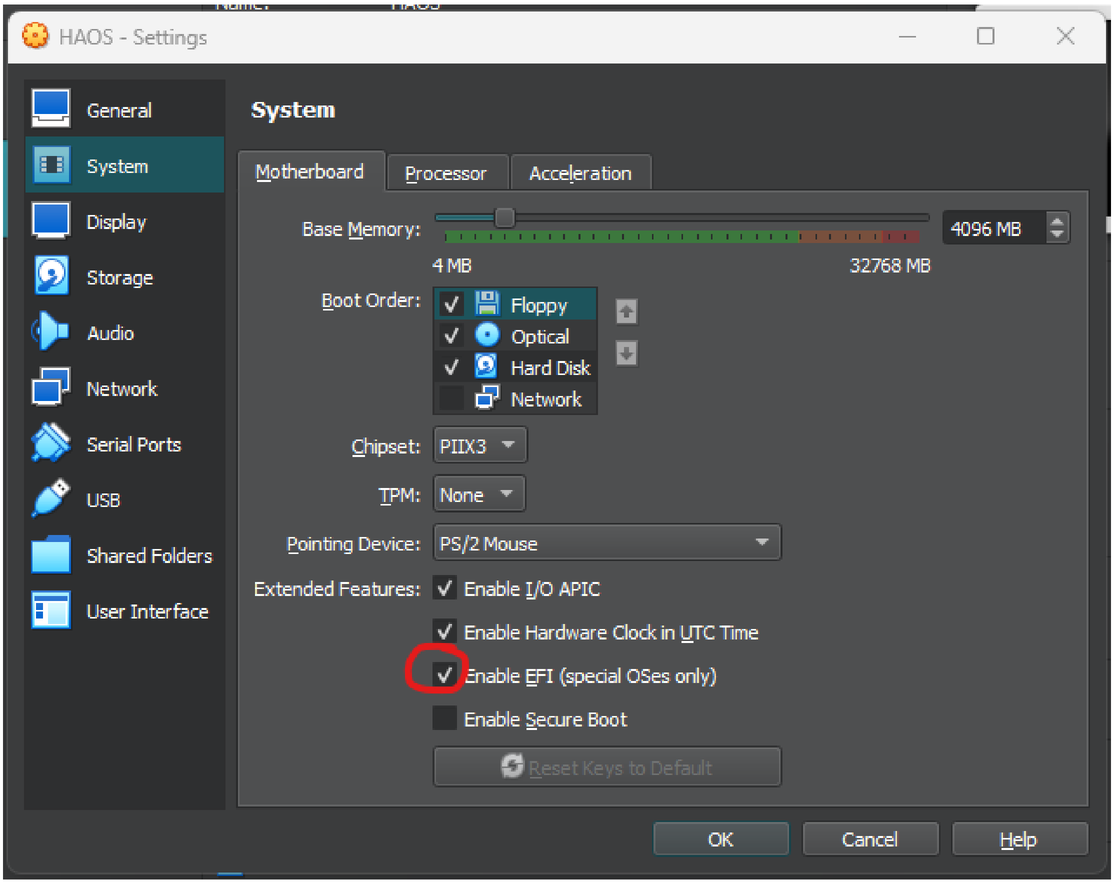


Figure 5. 3: Enable the EFI feature for special OS

Allocate CPU (Fig 5.4)

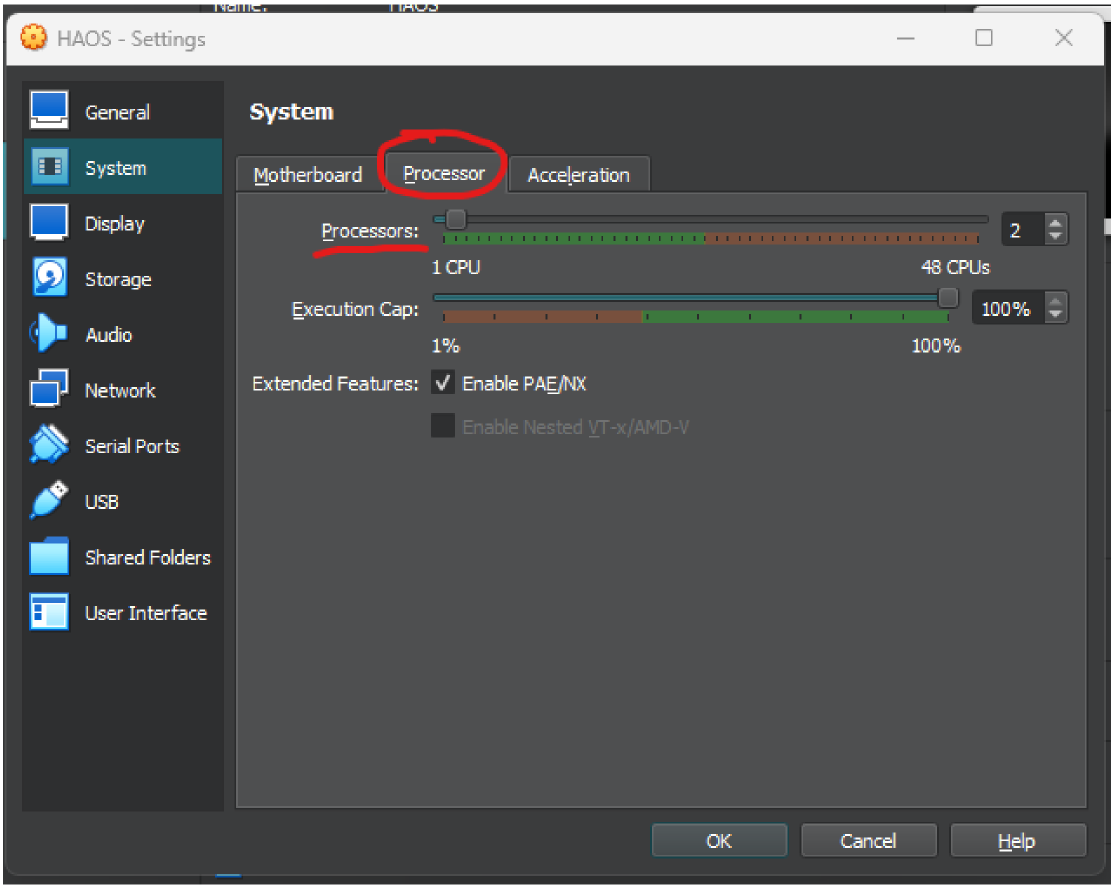


Figure 5. 4: Allocate CPUs to the virtual machine

Enable bridged adapter (Fig 5.5)

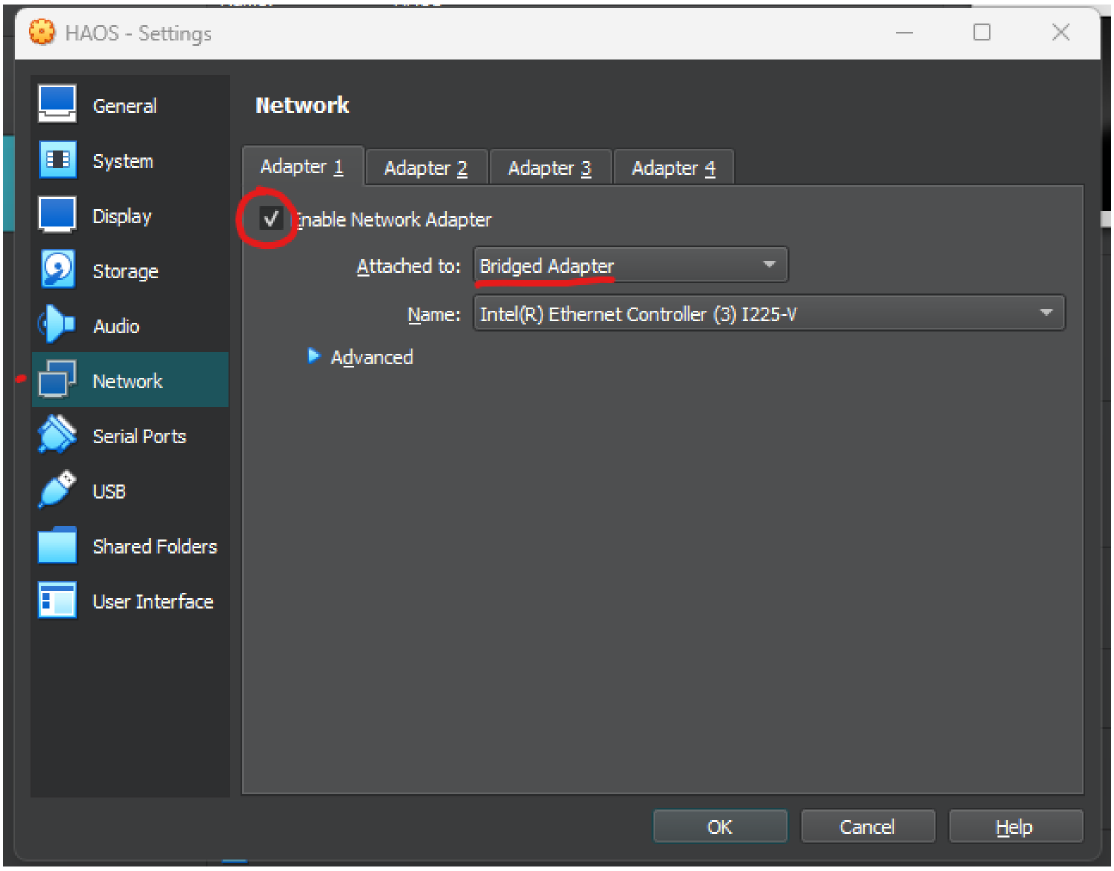


Figure 5. 5: Change network adapter to bridged

Step 4: Run Home Assistant OS (Fig 5.6)

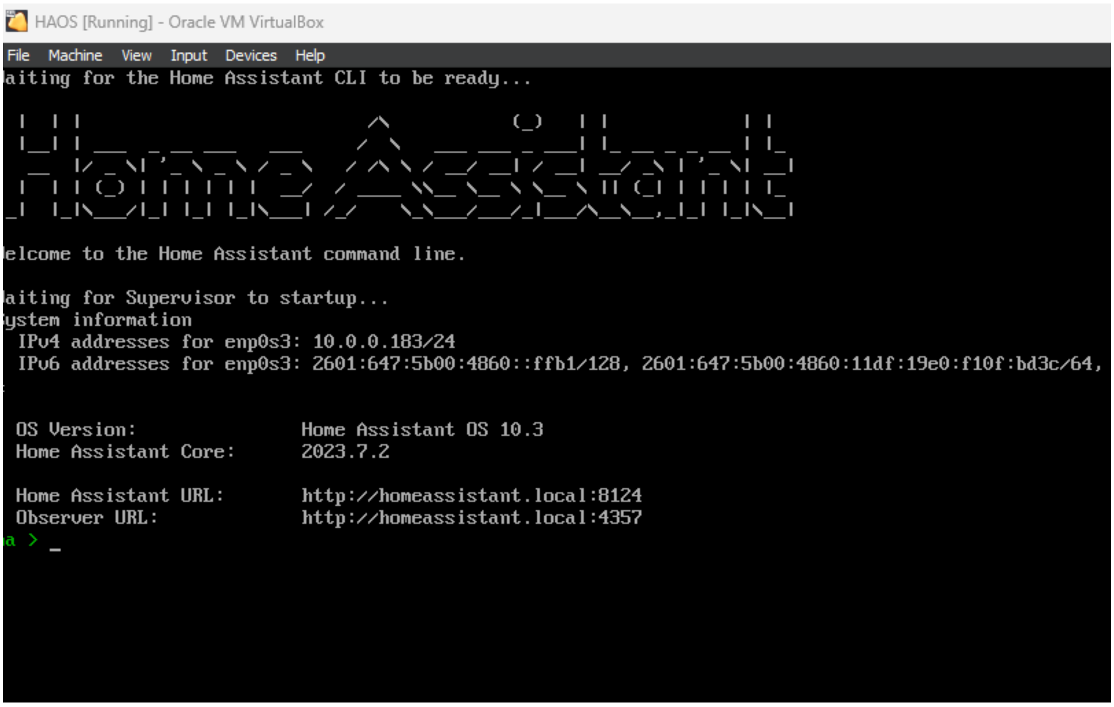


Figure 5. 6: Image of home assistant OS when run.

5.3.2 Xiaomi Temperature and Humidity Sensor Setup

Step 1: Connect the device to ATC_MiThermometer flasher. (Fig 5.7)

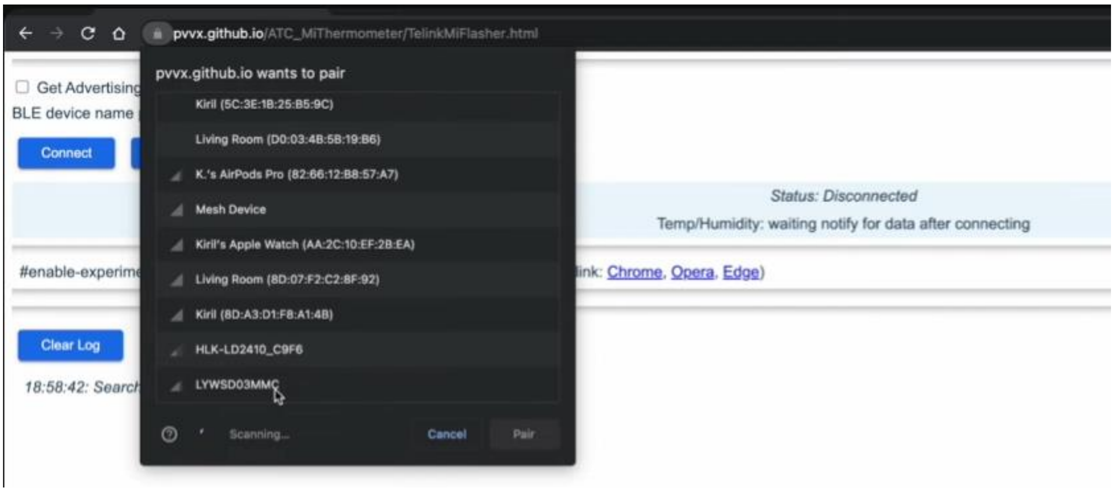


Figure 5. 7: Connecting the device to the flasher.

Step 2: Select custom firmware version and click start flashing. (Fig 5.8)

Figure 5. 8: Selecting firmware version.

Step 3: Select BTHome as the advertising type. (Fig 5.9)

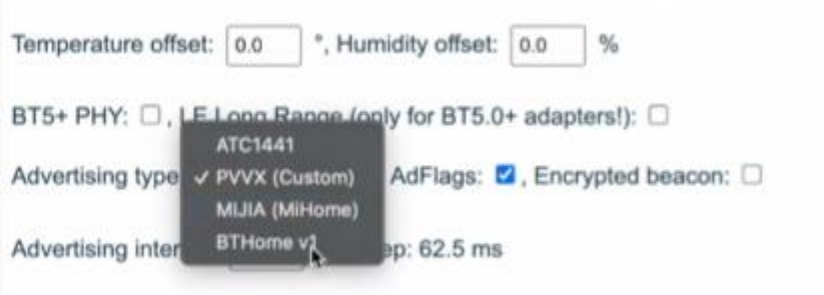


Figure 5. 9: Selecting advertising type

Step 4: Connect the sensor to home assistant. (Fig 5.10)

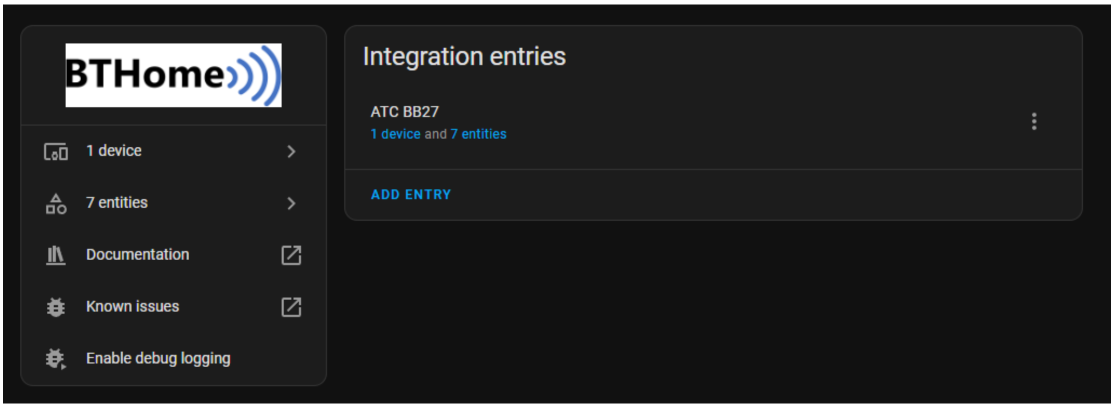


Figure 5. 10: Image of successful integration to home assistant

5.3.3 Yeelight Smart LED Bulb 1S (colour) Setup

Step 1: Reset the light bulb. (Fig 5.11)

Figure 5. 11: Image describes how to reset the light bulb

Step 2: Connect to the light bulb and turn on LAN control. (Fig 5.12)

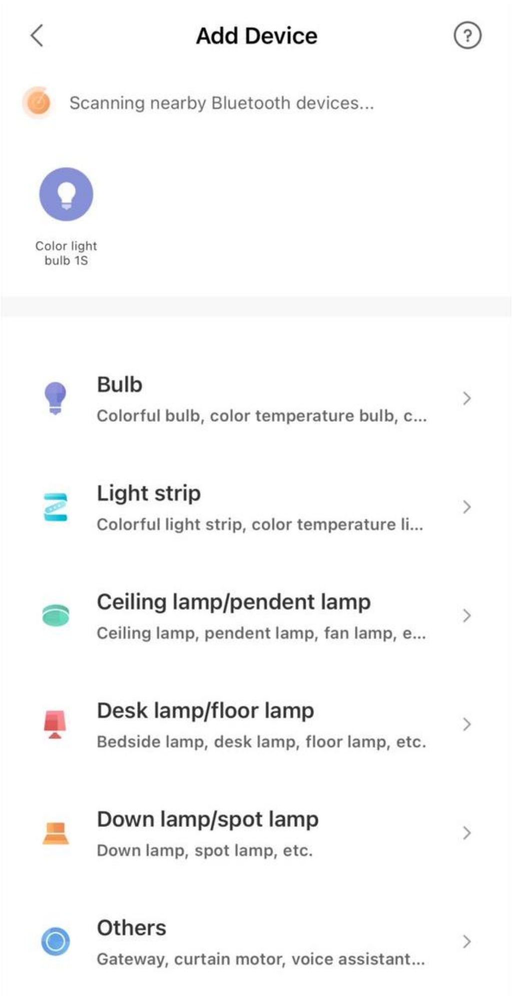


Figure 5. 12: Yeelight app detects the device

Enable lan control (Fig 5.13)

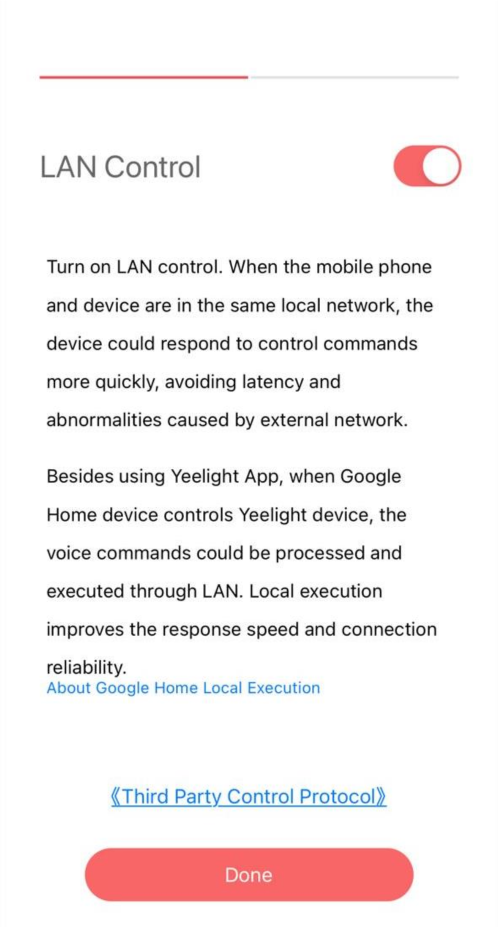


Figure 5. 13: Turn on LAN control in Yeelight app

Step 3: Connect the lightbulb to Home Assistant (Fig 5.14)

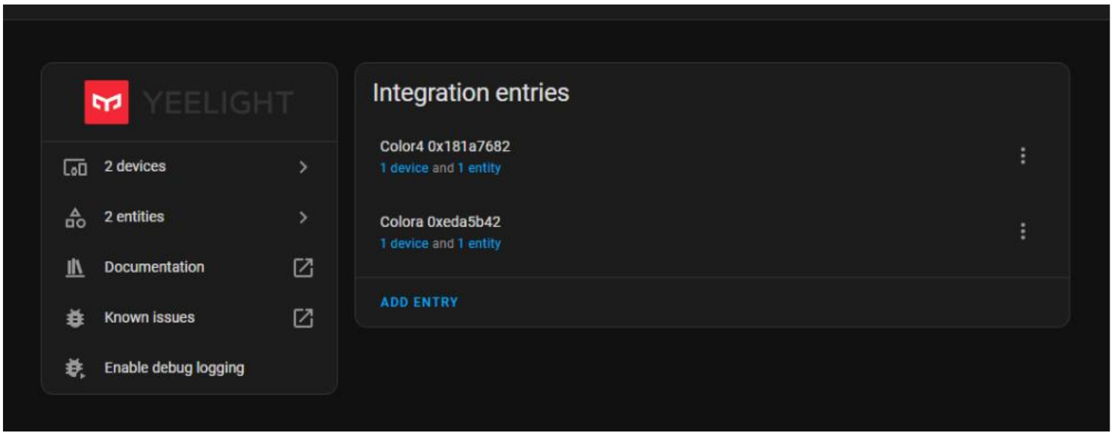


Figure 5. 14: Successful integration of lightbulbs to home assistant

5.3.4 Unity setup

Step 1: Install unity version 2022.3.14.f1 (Fig 5.15)

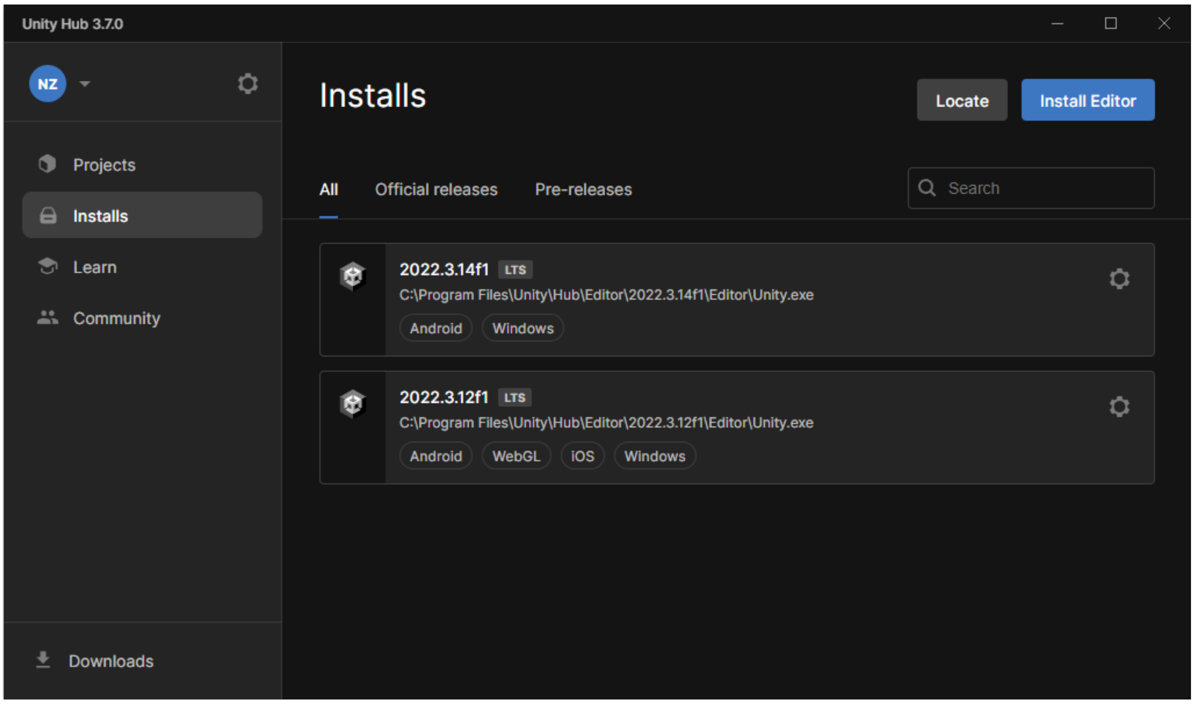


Figure 5. 15 Install unity version 2022.3.14.f1

Step 2: Add android modules (Fig 5.16)

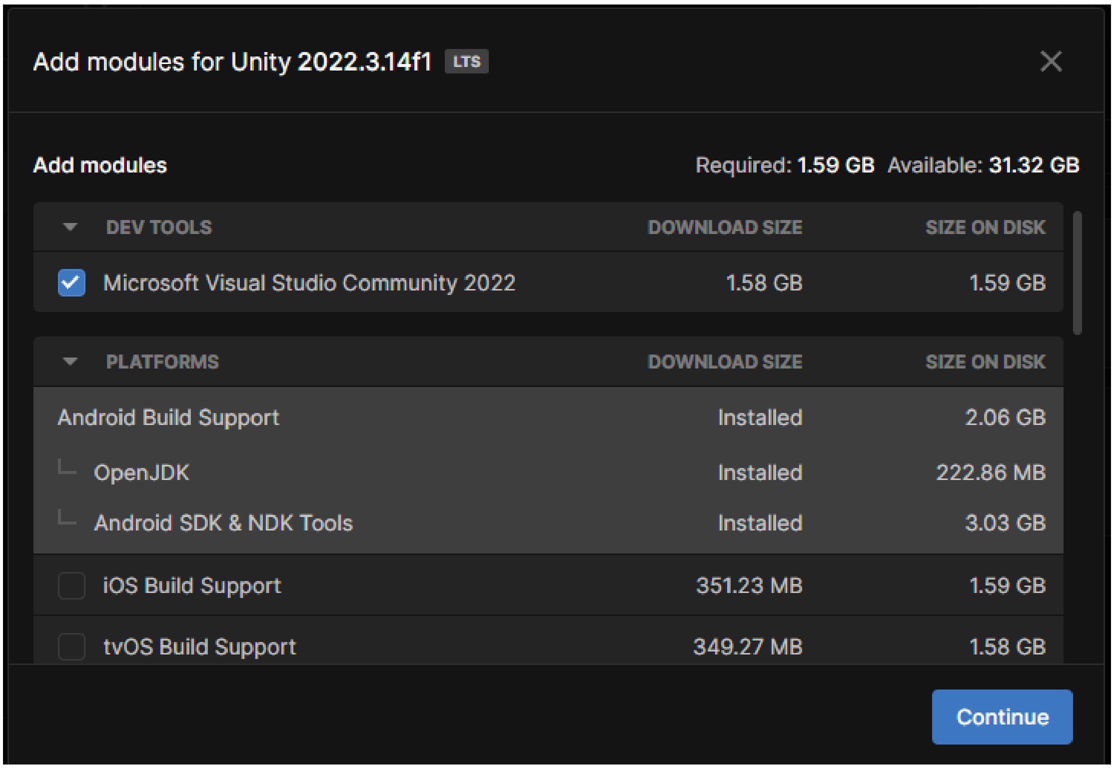


Figure 5. 16 Add android modules

Step 3: Create 3D core project (Fig 5.17)

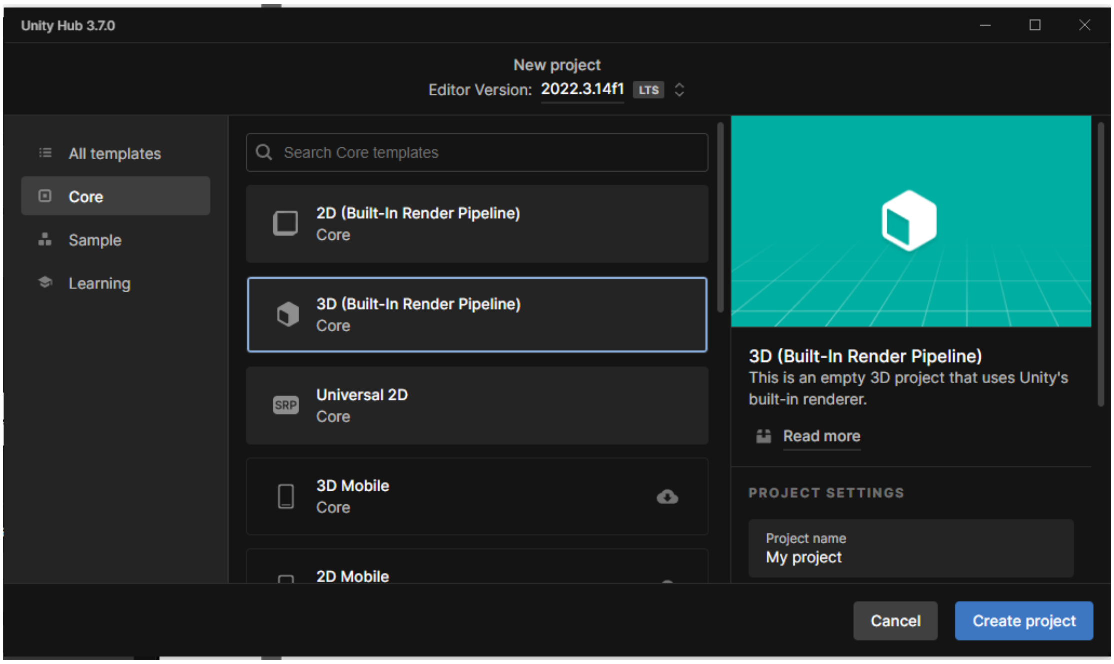


Figure 5. 17: Create 3D core project

Step 4: Install Meta XR all in one sdk (Fig 5.18)

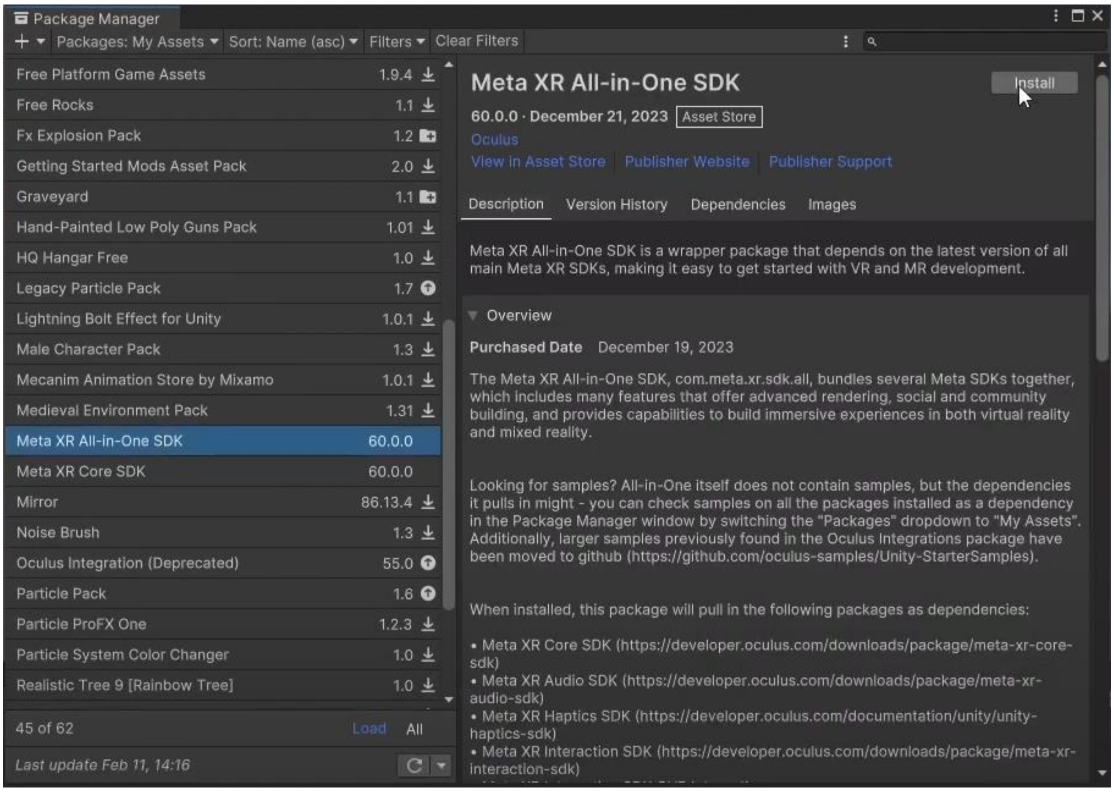


Figure 5. 18 Get Meta XR all in one sdk

Step 5: Enable oculus xr plugin management (Fig 5.19)

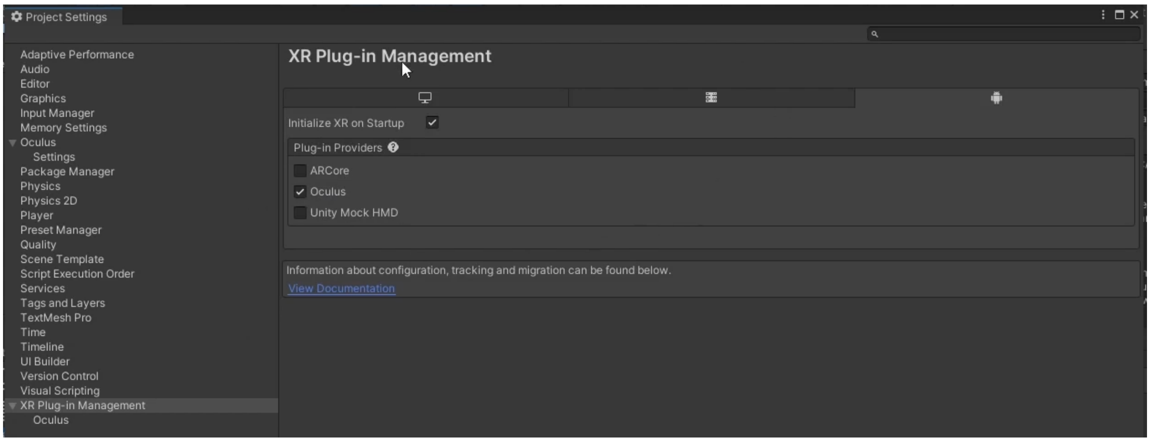


Figure 5. 19: Enable oculus xr plugin management

Step 6: Set api level to 29 or above (Fig 5.20)

Figure 5. 20: Set minimum api level to 29

Step 7: Add OVRCameraRigInteraction prefab (Fig 5.21)

Figure 5. 21 Setup OVRCameraRigInteraction

Step 8: Enable passthrough (Fig 5.22)

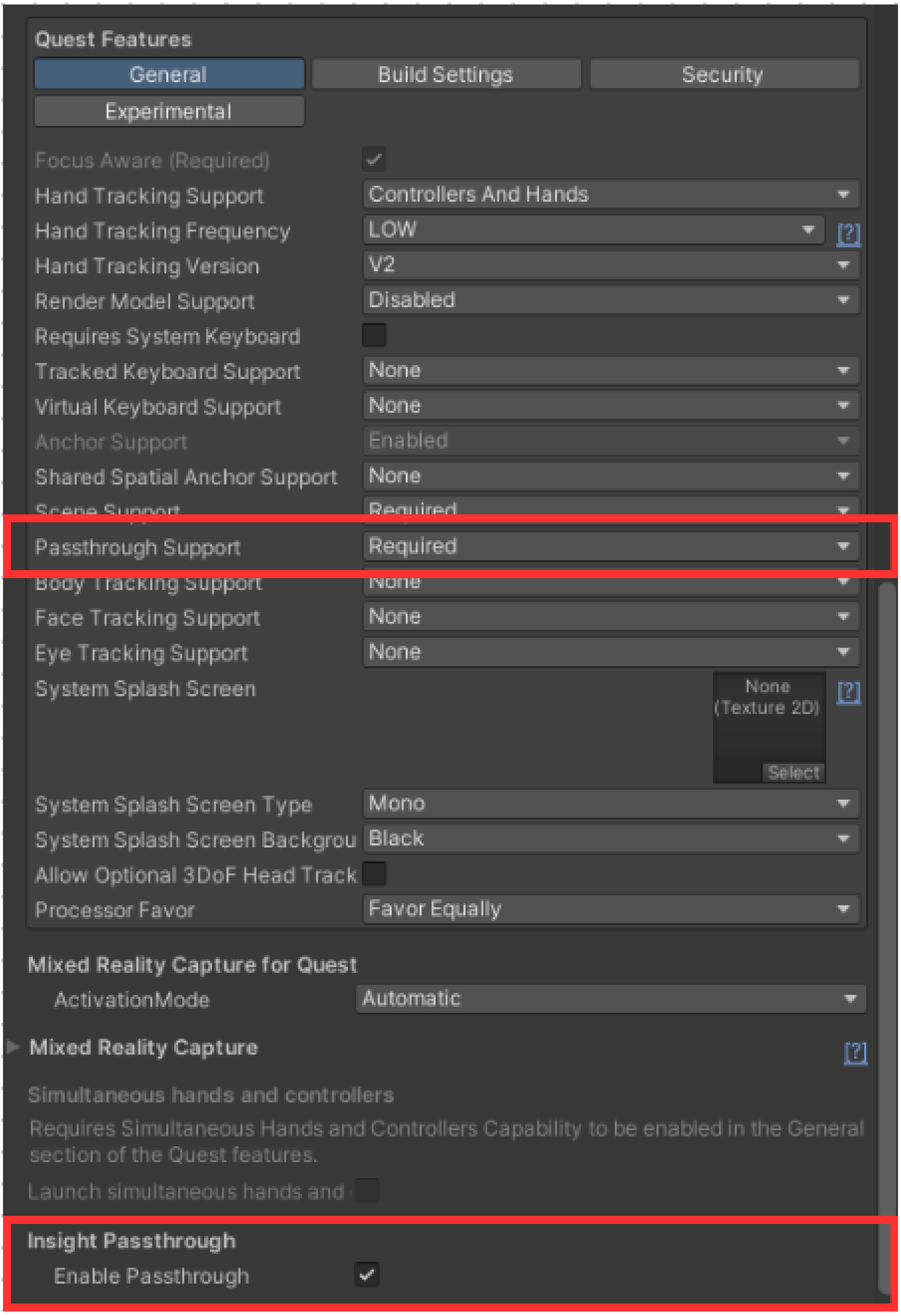


Figure 5. 22: Enable passthrough

Step 9: Add passthrough script to empty game object (Fig 5.23)

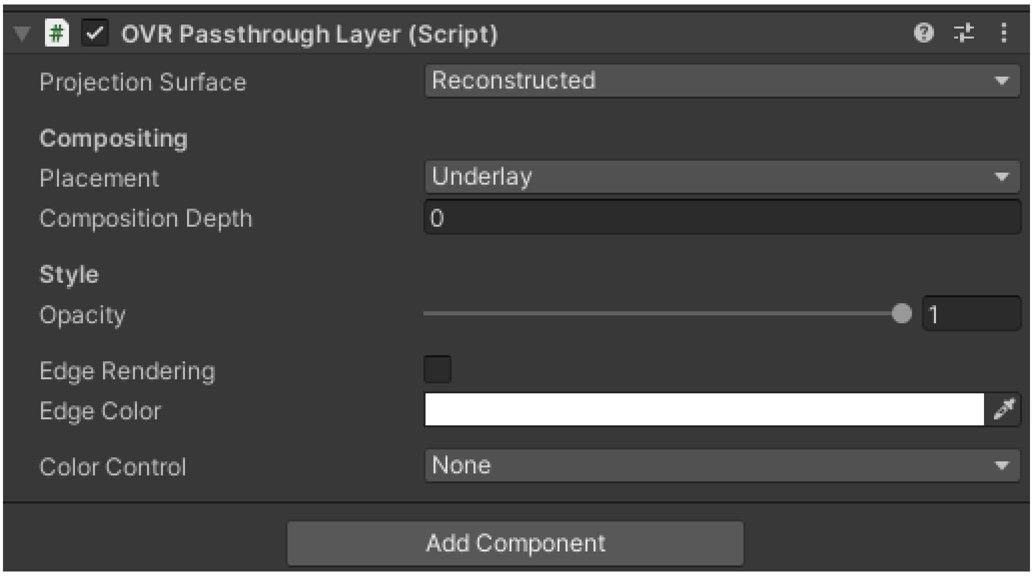


Figure 5. 23 Add passthrough script to empty game object

Step 10: Add collider and ray interaction scripts to lightbulb game object (Fig 5.24)

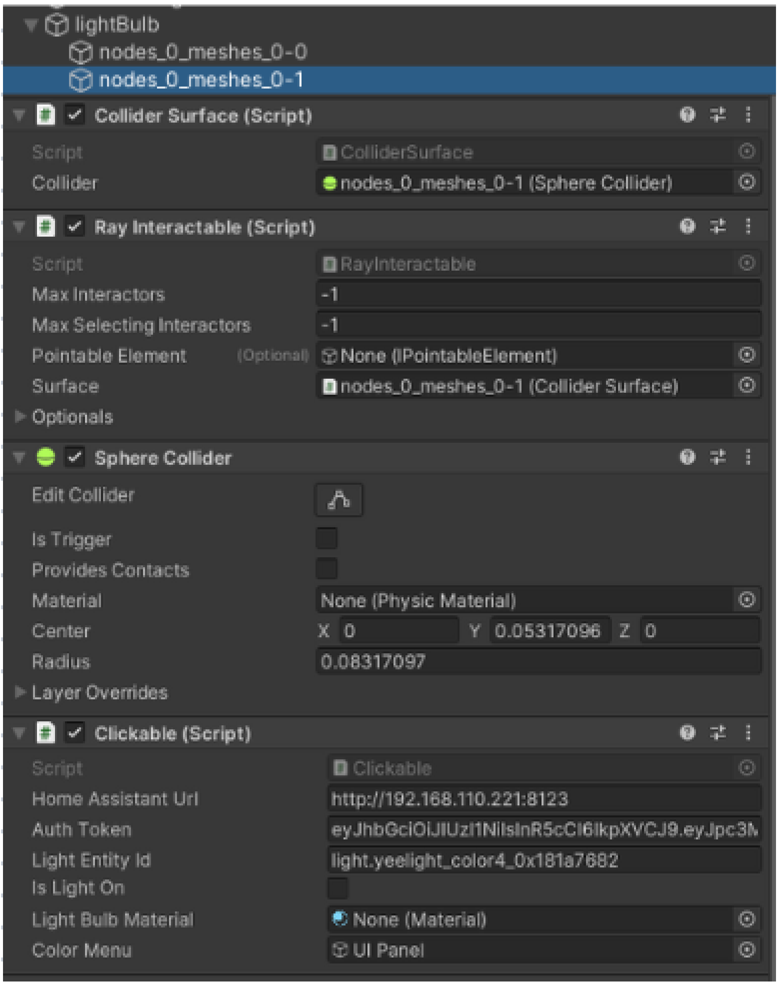


Figure 5. 24 Add scripts to lightbulb game object

Step 11: Add UI canvas for colour menu (Fig 5.25)

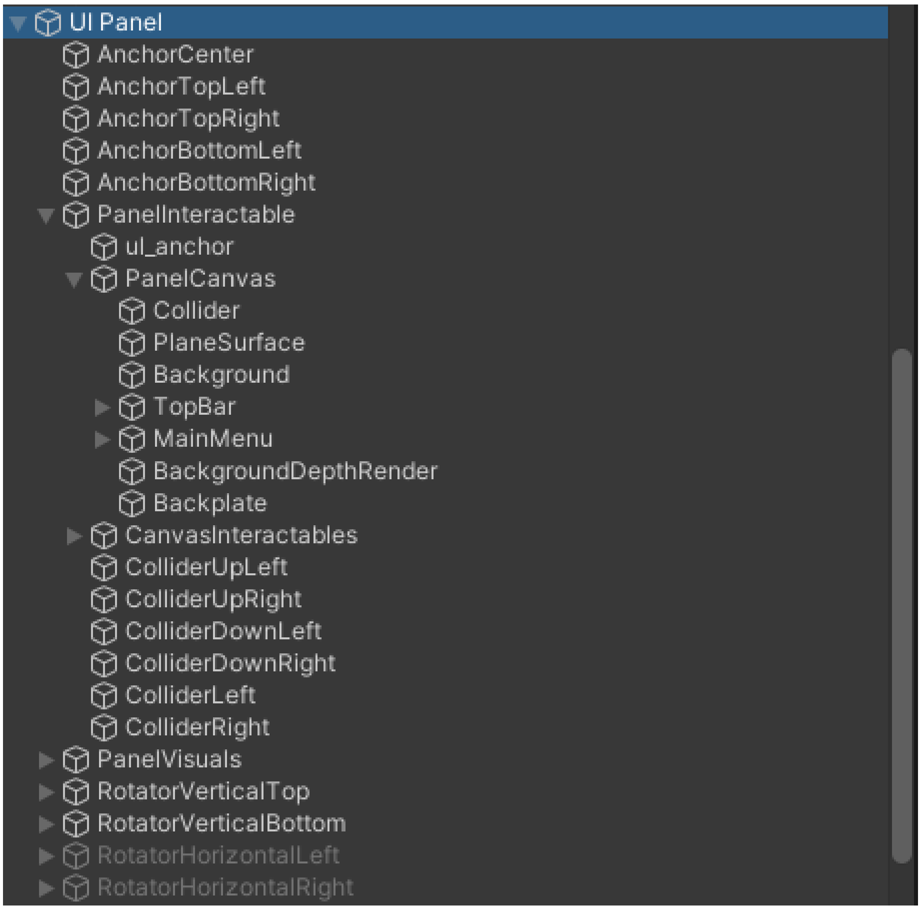


Figure 5. 25 Colour menu UI canvas

Step 12: Add Sensor UI canvas to display sensor info (Fig 5.26)

Figure 5. 26 Sensor UI canvas

5.4 System Operations

Initial screen when user opens the app (Fig 5.27). The grey would be the passthrough when wearing the quest 2 headset. The UI on the right displays the sensor data from the temperature and humidity sensor. The lightbulb to the right is used to toggle the light on and off. If the light is off when app is open the colour menu will not be displayed.

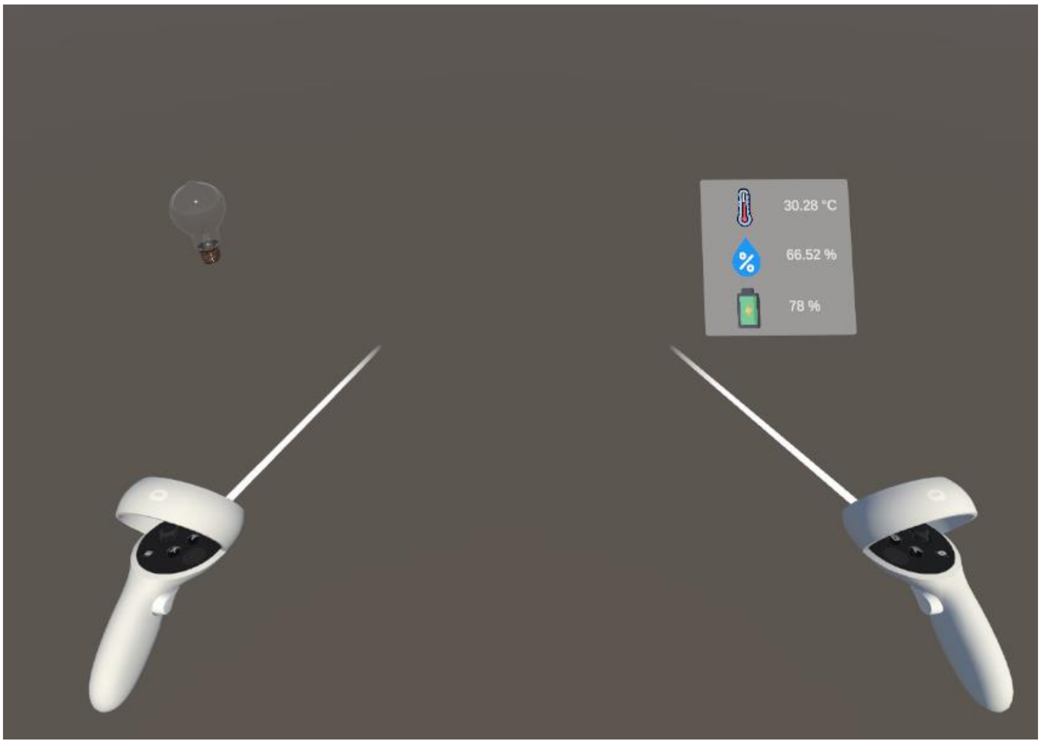


Figure 5. 27: Initial open application (If light is off)

Colour menu (Fig 5.28) it pops up when the light is on or when the user toggles the light on. There are 16 set colours that can be selected by the user. There is also a brightness slider at the bottom to allow users to adjust the brightness.

Figure 5. 28: Colour menu

(Fig 5.29) Shows the colour changing to green when the user selects green in the colour menu. In this picture the passthrough is working.

Figure 5. 29: Colour changing example

5.5 Implementation Issues and Challenges

During the implementation phase of the project, a significant challenge arose due to **outdated Oculus integrations**. With the transition of Oculus to Meta, the existing assets and resources associated with Oculus became deprecated, and the introduction of new assets under the Meta brand presented its own set of challenges. These new assets, although intended to improve functionality and user experience, were plagued by numerous bugs and inconsistencies.

One of the primary issues stemmed from the discontinuation of support for older Oculus assets. This meant that any **existing code or integrations relying on these deprecated assets had to be reworked or replaced** entirely to accommodate the new Meta assets. This not only consumed additional development time and resources but also introduced a level of uncertainty regarding the compatibility and stability of the new assets.

Additionally, the influx of bugs associated with the new Meta assets posed significant hurdles during the implementation phase. These bugs ranged from minor glitches affecting user interface elements to critical errors impacting core functionalities of the application. **Addressing these issues required thorough testing, meticulous debugging**, and sometimes creative workarounds to mitigate their impact on the overall user experience.

5.6 Concluding Remarks

In conclusion, the Inventory Upkeeping AR app is designed to provide users with the ability to easily view and control their smart home devices with intuitive controls using the quest 2 headset. By leveraging two major hardware platforms, including Meta Quest 2 headsets and various smart home devices, along with essential software components such as Home Assistant APIs, this application ensures compatibility and performance across different devices and platforms. The use of Unity for development facilitates the creation of immersive augmented reality experiences, enhancing user engagement and interaction with their smart home environment. Looking ahead, there is great potential for the continued expansion and development of the Inventory Upkeeping AR app. There are posibilities of adding more functionalities and support for a wider range of devices.

Chapter 6: System Evaluation and Discussion

6.1 System Testing and Performance Metrics

In this chapter, black box testing is applied to each module of the AR app, ensuring comprehensive validation of its functionality and adherance to the functional requirements.

The first module to be tested is the light control module. This module enables users to control their smart lights through the AR app. In this module we test the functionalities like the on/off control, the colour changing, and the brightness adjustment.

The second module is the sensor data display. In this module we test the retrieving and presenting of sensor data into the AR app. We will also test the precision of the data retrieval to ensure users have accurate data displayed.

6.2 Testing Setup and Result

6.2.1 Light Control Module

Table 6. 1: Light Control Module Testing Table

Test Action	Expected Result	Meet Expectation (✓/X)
User toggle on the light with controller	The lightbulb will turn on	✓
User toggle off the light with controller	The lightbulb will turn off	✓
Display colour menu	Only display when light is on	✓
User selects a colour from the colour menu	The light will change colour to desired colour	✓
User changes the brightness slider	The light brightness will change according to the slider	✓
Test light indicator	Light indicator should light up when light is on	✓

6.2.2 Sensor Display Module

Table 6. 2: Sensor Display Module Testing Table

Test Action	Expected Result	Meet Expectation (✓/X)
Data retrieval	Retrieve real time sensor data from home assistant	✓
Data display	The retrieved data should be displayed in the sensor UI	✓
Real time updates	When sensor data changes it will update the UI in real time	✓
Data accuracy	The sensor data should be accurate and same as the sensor itself	✓

6.3 User Surveys

6.3.1 Sample Size and Test Users

Sample size: 5 participants

Table 6. 3 Test user demographics

	Demographic
Gender	Male (40%), Female (60%)
Age	18-21 (40%), 22-25 (40%), 26-29 (20%)
Education	High school (20%), Bachelor's (60%), Master's or higher (20%)
Occupation	Students

6.3.2 Survey Questions and Answers

Fig 6.1 shows the first part of the survey questions

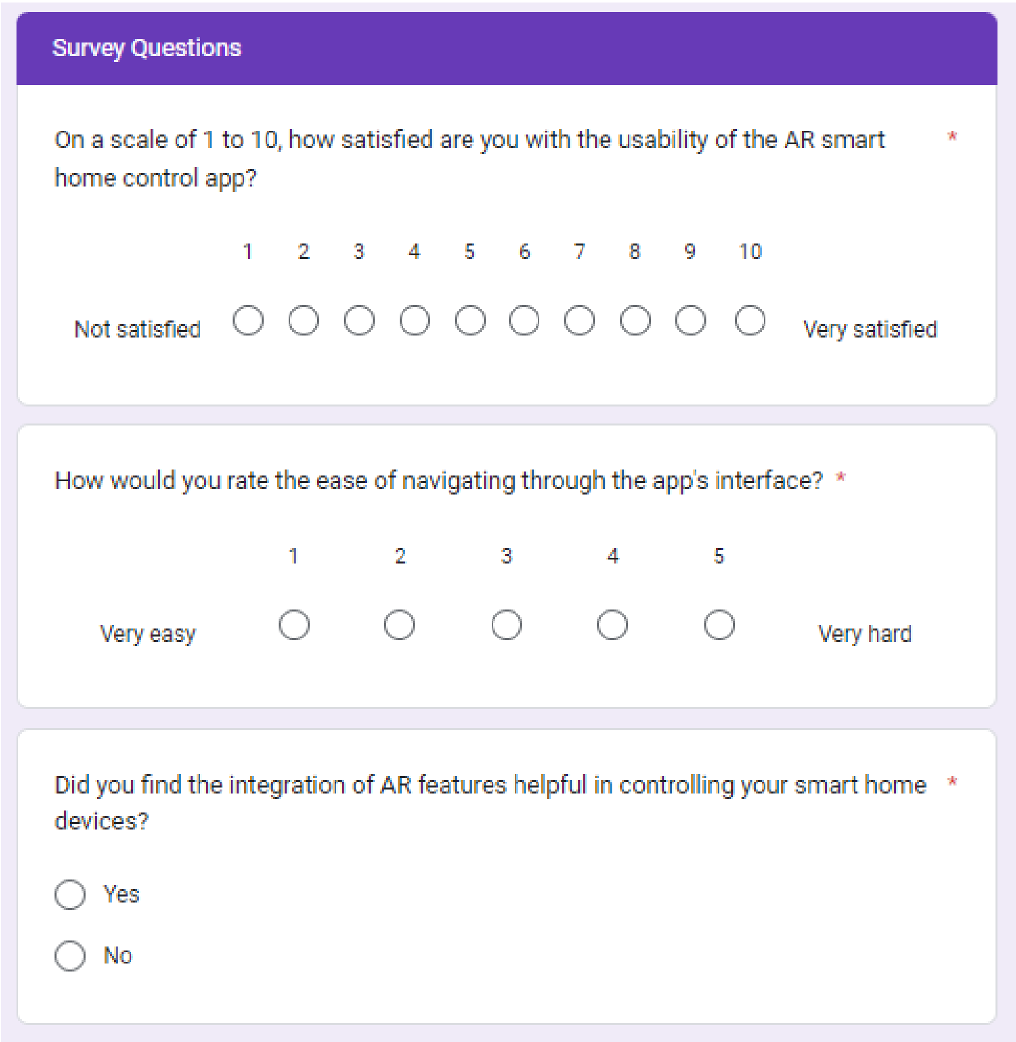


Figure 6. 1 Survey questions part 1

Fig 6.2 shows the second part of the survey questions

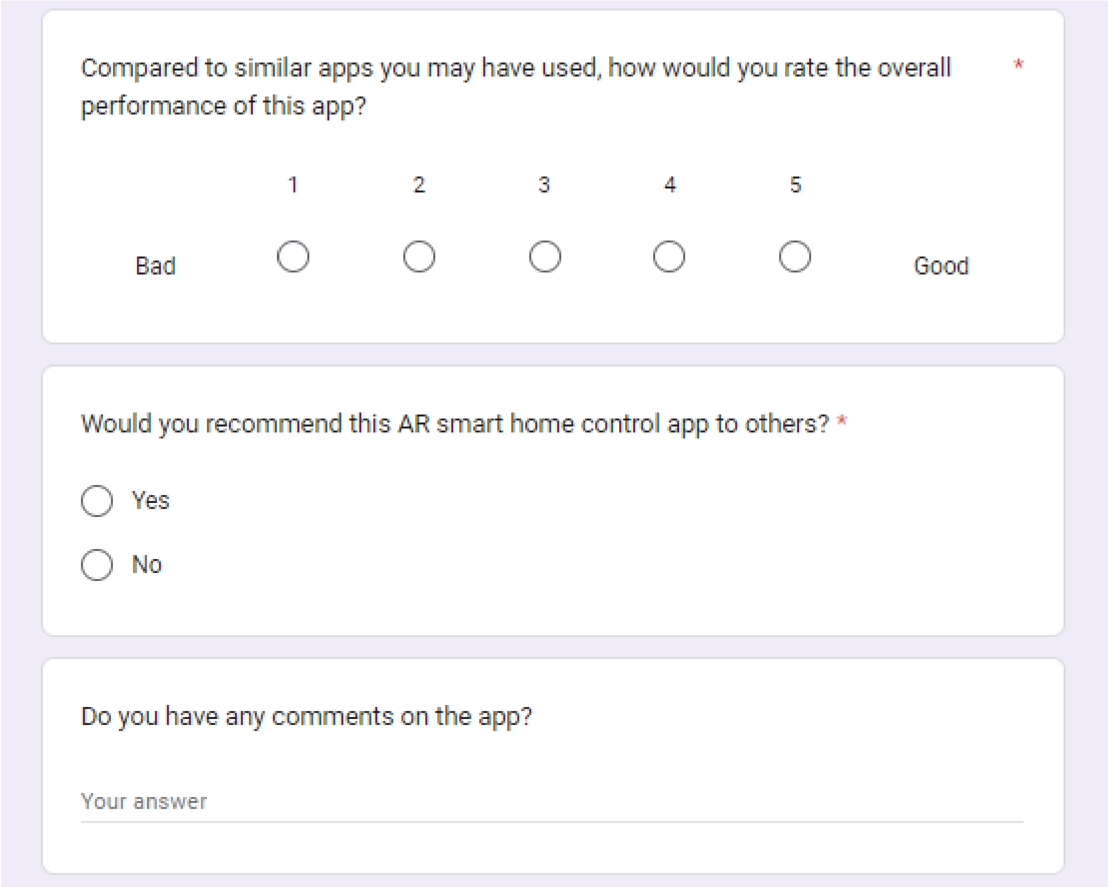


Figure 6. 2 Survey questions part 2

Fig 6.3 shows a competitor's smart home ar control app that the users tested. The app is build on android platform and allows users to control lights using their phone.

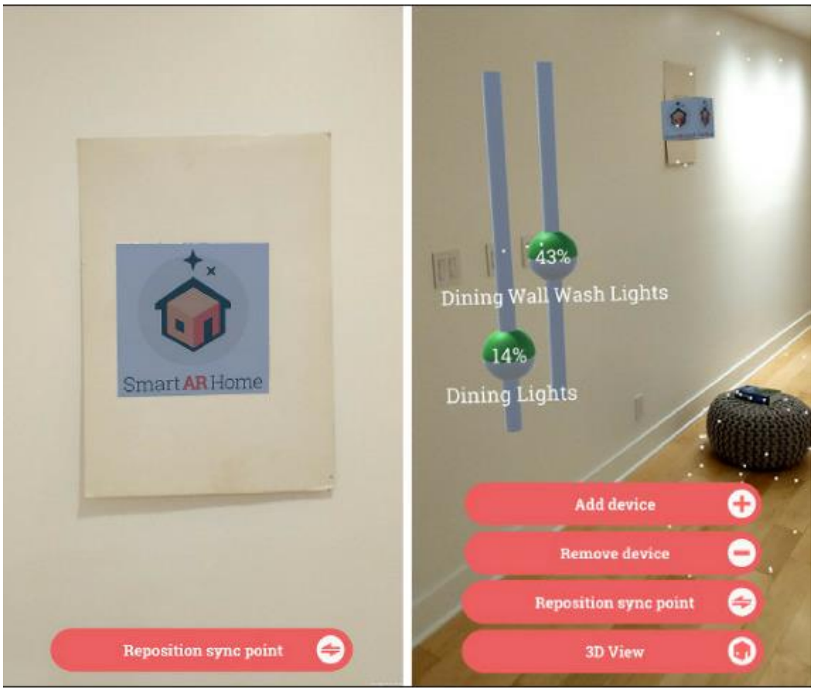


Figure 6. 3 Competitor's app Smart AR Home

Table 6. 4 Survey question average answers

Question	Average answer
Usability satisfaction	8/10
Navigation ease	4/5
AR features usefulness	80% (Yes), 20%(No)
Performance compared to similar apps	4/5
Likelihood of recommendation to others	80% (Yes), 20% (No)

Based on the survey results, it's evident that our Inventory Up-Keeping AR app for the Quest 2 garnered higher preference among users compared to the competitor's Android app. Many users expressed that the Quest 2 provided a significantly more immersive experience than the Android alternative. They appreciated the seamless integration with the Oculus Quest 2 headset, which transported them into a futuristic realm of smart home control. Users found our app's utilization of AR technology to be futuristic and innovative. Overall, the consensus among users was that our app on the Quest 2 offered a level of immersion and futurism that surpassed the experience of using an Android app for smart home control.

6.4 Project Challenges

Throughout the development of the Inventory Upkeeping AR app, several significant challenges arose, hindering the project's progress and requiring innovative solutions to overcome. Initially, the project was intended to be developed on the Meta Quest 3 headset, promising advanced mixed reality support and functionalities.

However, due to logistical constraints, access was limited to the Meta Quest 2 headset instead. This posed a significant hurdle as the Quest 2's passthrough feature only provided a black and white feed, making it challenging to discern colors accurately, particularly when changing the light colors within the app.

Additionally, a critical setback emerged as the Meta Quest 2 headset did not grant developers access to the camera feed, thwarting plans for implementing an AR interface alongside smart devices. The absence of object detection capabilities using the headset further complicated the development process, necessitating a reevaluation of the project's design and functionality.

Furthermore, the Meta Interaction SDK, while promising, presented its own set of challenges. Numerous bugs, including ray interactors disappearing, inability to interact with UI elements, and issues with hand tracking functionality, plagued the development process. Resolving these bugs consumed valuable time and resources, slowing down progress and delaying project milestones.

Lastly, hardware issues with my laptop increased the challenges faced during development. Performance issues and lag caused by hardware limitations hindered the testing and refinement phase, prolonging the development cycle and impacting overall project timelines.

6.5 Objective Evaluation

The objectives of the project, aimed at developing an augmented reality (AR) based interface for managing Internet of Things (IoT) devices in smart homes, have been meticulously pursued and successfully achieved. The project entailed two primary objectives:

Firstly, the integration of real-time data from IoT sensors retrieved from Home Assistant into the Unity application was seamlessly accomplished. This aspect of the project aimed to provide users with insightful information about their home environment while leveraging the capabilities of Home Assistant for efficient management and control of IoT devices within the AR interface. Through meticulous implementation, the system effectively retrieved data from sensors such as the temperature and humidity sensor, displaying this information within the AR interface in real-time. This integration not only enhanced users' understanding of their home environment but also streamlined the management of IoT devices, fulfilling the objective of enhancing user convenience and engagement.

Secondly, the development of an intuitive AR-based interface within the Unity environment on the Meta Quest 2 headset was successfully realized. This interface allowed users to effortlessly control IoT devices, particularly a smart lightbulb, using the Meta Quest 2 controllers. Users could perform actions such as adjusting light colors and toggling the light on or off with ease, thereby enhancing their interaction with IoT devices within the AR environment. The design and functionality of the interface were meticulously crafted to align with the project objectives of simplifying the management and interaction with IoT devices in smart home settings. Through the implementation of these objectives, the project effectively showcased the practical advantages of AR technology in enhancing user convenience and engagement in smart home environments.

6.6 Concluding Remarks

In conclusion, the AR app has undergone thorough black box testing across its modules, ensuring the functionality. Despite encountering multiple challenges during the development such as black and white passthrough, not having camera feed access, and an outdated Oculus SDK, the project has successfully achieved its objectives. The application provides the users with an intuitive way to interact with their smart home devices through seamless integration from sensors to home assistant and unity. With all tests passing and functionality thoroughly validated, the project not only meets but exceeds expectations, setting a new standard for AR-based smart home management. Moving forward, the lessons learned and experiences gained from this project will undoubtedly help my future endeavors.

CHAPTER 7: Conclusion and Recommendations

7.1 Conclusion

In conclusion, the project has successfully addressed the challenges associated with managing and interacting with smart home devices by leveraging the immersive capabilities of the Meta Quest 2 headset. By developing an XR application integrated with the Home Assistant API, we have created a unified interface that allows users to seamlessly visualize, interact with, and centrally control their IoT devices.

The project's objectives were achieved through the implementation of real-time data retrieval from Home Assistant, enabling users to monitor their home environment while efficiently managing IoT devices within the AR interface. Additionally, an intuitive interface was developed within Unity on the Meta Quest 2 headset, allowing users to control devices such as smart lightbulbs with ease.

By showcasing the practical advantages of AR technology in simplifying smart home management, the project has contributed to enhancing user convenience and engagement. The XR application serves as a centralized hub for monitoring and controlling diverse smart home devices, consolidating control and management into a single, immersive platform.

Furthermore, the project has pioneered a novel approach to smart home device interaction by integrating an AR interface into the Meta headset. This innovative experience offers users a spatial and intuitive visualization of their smart home device information, enhancing their understanding and interaction with their IoT network.

In essence, the project has revolutionized smart home device management by offering a cutting-edge AR-based solution. By centralizing monitoring and control, we have provided users with a powerful tool for managing their diverse smart home ecosystem directly through their Meta headset, ultimately enhancing their overall experience and efficiency.

7.2 Recommendations

While the Meta Quest 2 serves as a solid foundation for AR application development, its limited mixed reality capabilities may impose constraints on achieving desired levels of interactivity and immersion. Therefore, it's advisable to explore alternative platforms like HoloLens or Magic Leap, renowned for their advanced mixed reality features. These platforms offer enhanced flexibility and functionality, thereby unlocking new possibilities for immersive AR experiences.

Expanding the application's compatibility to encompass a broader range of smart home devices and protocols is crucial for enhancing its utility. By ensuring compatibility with various IoT ecosystems, the application can cater to a more diverse user base. Integrating support for popular devices and protocols not only increases versatility but also augments appeal to a larger audience.

Voice recognition capabilities represent a natural and convenient method for controlling smart home devices. Integrating voice commands empowers users to interact with the application using natural language, thereby enhancing accessibility and usability. By enabling users to issue commands verbally, the application becomes more intuitive and efficient, particularly in scenarios where manual interaction may prove challenging or impractical.

REFERENCES

[1] P. Brown, "Smart home shipments to surpass 1.4 billion in 2025 - globalspec," Smart home shipments to surpass 1.4 billion in 2025, https://electronics360.globalspec.com/article/16543/smart-home-shipments-to-surpass-1-4-billion-in-2025 (accessed Sep. 6, 2023).

[2] A. S. Gillis, "What is augmented reality (AR)?," WhatIs.com, https://www.techtarget.com/whatis/definition/augmented-reality-AR (accessed Sep. 11, 2023).

[3] Victor, "Oculus quest 2 review," GSMArena.com, https://www.gsmarena.com/oculus_quest_2_review-news-46255.php (accessed Sep. 11, 2023).

[4] K. Rose, S. Eldridge, and L. Chapin, "The Internet of Things: An Overview Understanding the Issues and Challenges of a More Connected World," 2015.

[5] Y. Bin Zikria, R. Ali, M. K. Afzal, and S. W. Kim, "Next-generation internet of things (IoT): Opportunities, challenges, and solutions," *Sensors (Switzerland)*, vol. 21, no. 4. MDPI AG, pp. 1–7, Feb. 02, 2021. doi: 10.3390/s21041174.

[6] J. Carmigniani and B. Furht, *Augmented Reality: An Overview*. Springer New York, 2011. doi: 10.1007/978-1-4614-0064-6.

[7] "Types of AR," Digital Promise, https://digitalpromise.org/initiative/360-story-lab/360-production-guide/investigate/augmented-reality/getting-started-with-ar/types-of-ar/ (accessed Sep. 6, 2023).

[8] L. Y. Rock, F. P. Tajudeen, and Y. W. Chung, "Usage and impact of the internet-of-things-based smart home technology: a quality-of-life perspective," *Univers Access Inf Soc*, 2022, doi: 10.1007/s10209-022-00937-0.

[9] I. S. S.Sujin, *A Review of Connectivity Challenges in IoT-Smart Home*. IEEE, 2016.

[10] J. Fromm, K. Eyilmez, M. Baßfeld, T. A. Majchrzak, and S. Stieglitz, "Social Media Data in an Augmented Reality System for Situation Awareness Support in Emergency Control Rooms," *Information Systems Frontiers*, vol. 25, no. 1, pp. 303–326, Feb. 2023, doi: 10.1007/s10796-020-10101-9.

[11] T. A. Syed *et al.*, "In-Depth Review of Augmented Reality: Tracking Technologies, Development Tools, AR Displays, Collaborative AR, and Security Concerns," *Sensors*, vol. 23, no. 1. MDPI, Jan. 01, 2023. doi: 10.3390/s23010146.

[12] K. Vock, S. Hubenschmid, J. Zagermann, S. Butscher, and H. Reiterer, "IDIAR: Augmented reality dashboards to supervise mobile intervention studies," in Mensch und Computer 2021 (MuC '21), Sep. 2021, pp. 247-263. doi: 10.1145/3473856.3473876.

[13] “Microsoft hololens,” Microsoft HoloLens - Review - Full specification - Where to buy?, https://www.niora.net/en/p/microsoft_hololens (accessed Sep. 11, 2023).

[14] A. Jakl, L. Schöffer, M. Husinsky, and M. Wagner, "Augmented Reality for Industry 4.0: Architecture and User Experience," in 2020 IEEE International Symposium on Mixed and Augmented Reality (ISMAR), 2020, pp. 38-42. doi: 10.1109/ISMAR50242.2020.00020.

[15] P. Toreini and S. M. Jahromi, “Association for Information Systems Exploring the usage of Mixed Reality Dashboards in Business Intelligence and Analytics” [Online]. Available: https://aisel.aisnet.org/ecis2023_rip

[16] M. Banquiero, G. Valdeolivas, S. Trincado, N. Garcia, and M. C. Juan, “Passthrough Mixed Reality With Oculus Quest 2: A Case Study on Learning Piano,” *IEEE Multimedia*, Apr. 2023, doi: 10.1109/MMUL.2022.3232892.

[17] A. Syberfeldt, O. Danielsson, M. Holm, and L. Wang, “Visual Assembling Guidance Using Augmented Reality,” in *Procedia Manufacturing*, Elsevier B.V., 2015, pp. 98–109. doi: 10.1016/j.promfg.2015.09.068.

[18] G. Papanastasiou, A. Drigas, C. Skianis, M. Lytras, and E. Papanastasiou, “Virtual and augmented reality effects on K-12, higher and tertiary education students’

[19] “Full-color passthrough on meta quest pro,” Meta, https://www.meta.com/help/quest/articles/getting-started/getting-started-with-quest-pro/pro-color-passthrough/ (accessed Sep. 11, 2023).

[20] C. Rinaldi, “Apple Vision Pro: Features, Specs, price, and more!,” nextpit, https://www.nextpit.com/apple-vision-pro (accessed Sep. 11, 2023).

twenty-first century skills,” *Virtual Real*, vol. 23, no. 4, pp. 425–436, Dec. 2019, doi: 10.1007/s10055-018-0363-2

Appendix

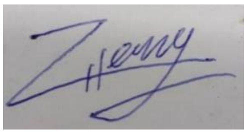
FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3S3	**Study week no.: 2**
Student Name & ID: Ng Zheng 20ACB03448	
Supervisor: Dr. Aun Yichiet	
Project Title: Inventory Up-Keeping with AR Interface	

1. WORK DONE - Documentation: Update problem statement, Objective, and Contributions - Unity: Finished setting up 3D core scene
2. WORK TO BE DONE - Documentation: Chapter 3 system methodology - Coding: Create script for lightbulb interaction - Unity: Create lightbulb object
3. PROBLEMS ENCOUNTERED - Meta quest headsets doesn’t give developers access to camera feed
4. SELF EVALUATION OF THE PROGRESS - Busy with CNY

Supervisor’s signature



Student’s signature

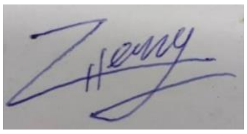
FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3S3	Study week no.: 4
Student Name & ID: Ng Zheng 20ACB03448	
Supervisor: Dr. Aun Yichiet	
Project Title: Inventory Up-Keeping with AR Interface	

1. WORK DONE
- Documentation: Finished Chapter 3, System Methodology - Unity: Created lightbulb object - Coding: Created script for lightbulb interaction
2. WORK TO BE DONE
- Coding: Send lightbulb commands to home assistant API - Unity: Create ray interactors for quest 2 controllers - Documentation: Chapter 4, System Design
3. PROBLEMS ENCOUNTERED
- Meta quest 2 only supports black and white passthrough.
4. SELF EVALUATION OF THE PROGRESS
- So far so good

Supervisor's signature



Student's signature

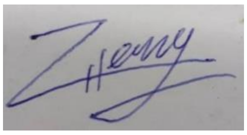
FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3S3	Study week no.: 6
Student Name & ID: Ng Zheng 20ACB03448	
Supervisor: Dr. Aun Yichiet	
Project Title: Inventory Up-Keeping with AR Interface	

1. WORK DONE
- Documentation: Finished Chapter 4, System Design - Unity: Created ray interactors for controllers and added ray interaction to lightbulb - Coding: Modified lightbulb script to send command to lightbulb through home assistant API
2. WORK TO BE DONE
- Unity: Create colour menu UI - Coding: Create script to calculate RGB value of each assigned button
3. PROBLEMS ENCOUNTERED
4. SELF EVALUATION OF THE PROGRESS
- So far so good

Supervisor's signature



Student's signature

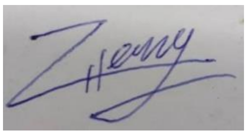
FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3S3	**Study week no.: 8**
Student Name & ID: Ng Zheng 20ACB03448	
Supervisor: Dr. Aun Yichiet	
Project Title: Inventory Up-Keeping with AR Interface	

1. WORK DONE - Unity: Created colour menu UI, added 16 buttons each with specific colour codes - Coding: Created script to calculate RGB based on HEX colour code from buttons
2. WORK TO BE DONE - Unity: Add brightness controllers - Coding: Create script to send colour command to home assistant API
3. PROBLEMS ENCOUNTERED - Controller ray interactors couldn't interact with 2D canvas
4. SELF EVALUATION OF THE PROGRESS - Busy with midterms but on track

Supervisor's signature



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FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3S3	**Study week no.: 10**
Student Name & ID: Ng Zheng 20ACB03448	
Supervisor: Dr. Aun Yichiet	
Project Title: Inventory Up-Keeping with AR Interface	

1. WORK DONE

- Unity: Added brightness slider into colour menu

- Coding: Created script to send colour command to home assistant API, Created script to adjust brightness with slider.

- Fixed ray interaction problem

2. WORK TO BE DONE

- Unity: Add UI to display temperature and humidity sensor data

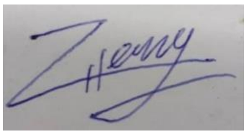
- Coding: Create script to hide colour menu when light is off. Create script to retrieve sensor data and display to UI.

3. PROBLEMS ENCOUNTERED

4. SELF EVALUATION OF THE PROGRESS

- Busy with assignments but on track

Supervisor's signature



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FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3S3	**Study week no.: 12**
Student Name & ID: Ng Zheng 20ACB03448	
Supervisor: Dr. Aun Yichiet	
Project Title: Inventory Up-Keeping with AR Interface	

1. WORK DONE

- Unity: Added UI to display temperature and humidity sensor data

- Coding: Created script to retrieve sensor data from home assistant and display in sensor UI. Created script to hide colour menu when light is off and display when light is on.

2. WORK TO BE DONE

- Documentation: Chapter 5, System Implementation. Chapter 6, System Evaluation and Discussions,

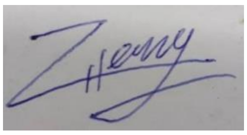
-Testing and Refinement: Perform testing on functions

3. PROBLEMS ENCOUNTERED

4. SELF EVALUATION OF THE PROGRESS

- So far so good

Supervisor's signature



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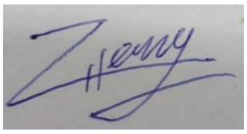
FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3S3	**Study week no.: 13**
Student Name & ID: Ng Zheng 20ACB03448	
Supervisor: Dr. Aun Yichiet	
Project Title: Inventory Up-Keeping with AR Interface	

1. WORK DONE - Documentation: Completed FYP2 Report documentations - Done testing and refinement
2. WORK TO BE DONE
3. PROBLEMS ENCOUNTERED
4. SELF EVALUATION OF THE PROGRESS - So far so good

Supervisor's signature



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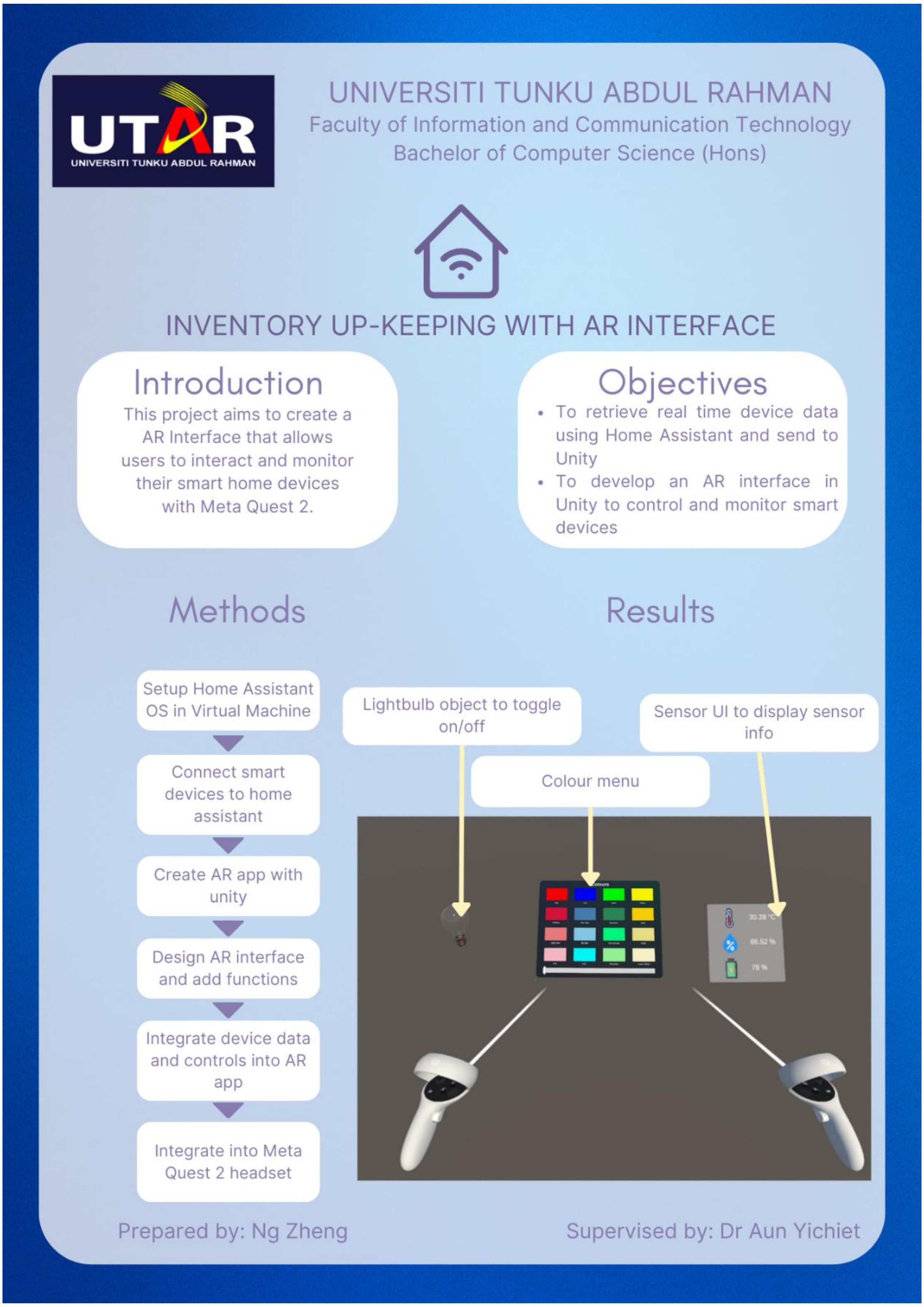
UNIVERSITI TUNKU ABDUL RAHMAN
Faculty of Information and Communication Technology
Bachelor of Computer Science (Hons)
INVENTORY UP-KEEPING WITH AR INTERFACE
Introduction
This project aims to create a AR Interface that allows users to interact and monitor their smart home devices with Meta Quest 2.
Objectives
• To retrieve real time device data using Home Assistant and send to Unity
• To develop an AR interface in Unity to control and monitor smart devices
Methods
Setup Home Assistant OS in Virtual Machine
Connect smart devices to home assistant
Create AR app with unity
Design AR interface and add functions
Integrate device data and controls into AR app
Integrate into Meta Quest 2 headset
Results
Lightbulb object to toggle on/off
Colour menu
Sensor UI to display sensor info
Prepared by: Ng Zheng
Supervised by: Dr Aun Yichiet

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FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY

Full Name(s) of Candidate(s)	Ng Zheng
ID Number(s)	20ACB03448
Programme / Course	Bachelor of Computer Science
Title of Final Year Project	Inventory Up-Keeping with AR Interface

Similarity	**Supervisor's Comments (Compulsory if parameters of originality exceed the limits approved by UTAR)**
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Based on the above results, I hereby declare that I am satisfied with the originality of the Final Year Project Report submitted by my student(s) as named above.

Signature of Supervisor	Signature of Co-Supervisor
Name: Aun Yichiet	Name:
Date: 26/04/2024	Date:

UNIVERSITI TUNKU ABDUL RAHMAN

FACULTY OF INFORMATION & COMMUNICATION TECHNOLOGY (KAMPAR CAMPUS)

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Student Name	Ng Zheng
Supervisor Name	Dr Aun Yichiet

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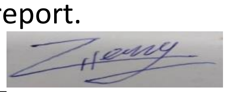

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(Signature of Student)

Date: 24th April 2024