Asia-Pacific Journal of Information Technology and Multimedia 13(1) 2024: 21 –32
https://doi.org/10.17576/apjitm-2024-1301-02

Smart Mirror Enhancement with RFID

Penambahbaikan Cermin Pintar dengan RFID

Muhammad Faris Mohd Isham[1], Azana Hafizah Mohd Aman[1], Zainab S. Attarbashi[2], Mohamad Sirajuddin Jalil[3], Abdulazeez E. Altaleb[4]*

[1]*Faculty of Information Science and Technology, University Kebangsaan Malaysia, Malaysia*

[2]*Kulliyyah of Information and Communication Technology, International Islamic University Malaysia, Malaysia*

[3]*Malaysia Cyber Consumer Association*

[4]*Softtech Software Technologies, Reşitpaşa Mah. Katar Cad. İTÜ Teknokent ARI-3, Istanbul, Turkey*

**Corresponding author: azana@ukm.edu.my*

Received 25 September 2023
Accepted 29 January 2024, Available online 1 June 2024

ABSTRACT

Since it was first presented a few years ago, smart mirrors have gained popularity as an indoor convenience. When the idea of smart homes started to be raised by different parties in earlier years, a variety of smart devices were released and distributed worldwide. The introduction of smart devices into several outdoor industries shows that their application is not limited to the indoors. Therefore, this project focuses on solving problems for industries, i.e. the clothing sales industry. Smart Mirror is an innovative device that combines information technology with traditional mirrors, giving users access to important information in an interactive way. The project was developed using the Raspberry Pi 4 as the main controller and MagicMirror2 software as an interface platform. This Smart Mirror displays information such as weather, news, and notifications on a digital display hidden behind a mirrored glass. The project also uses an RFID scanner for displaying clothing information with RFID tags, as well as voice control via a microphone for easy user interaction. Users can access information through a digital display, view clothing information with RFID tags, and interact with the system via voice. Future enhancements to the project are possible, including integrating artificial intelligence and new functional modules. This Smart Mirror can significantly improve daily life and information monitoring using technology and creativity.

Keywords**:** RFID function, raspberry pi smart mirror, smart mirror RFID, raspberry application, smart application

ABSTRAK

Sejak pertama kali diperkenalkan beberapa tahun yang lalu, cermin pintar telah mendapat populariti sebagai salah satu kemudahan di rumah. Apabila idea rumah pintar mula dibangkitkan oleh pelbagai pihak pada tahun-tahun sebelumnya, pelbagai peranti pintar telah direka dan digunakan di seluruh dunia. Pengenalan peranti pintar di beberapa industri luar menunjukkan bahawa aplikasi tersebut tidak terhad kepada kemudahan di rumah. Oleh itu, projek ini memberi tumpuan kepada menyelesaikan masalah di luar rumah, iaitu dalam industri pakaian. Cermin Pintar adalah peranti inovatif yang menggabungkan teknologi maklumat dengan cermin tradisional, memberikan pengguna akses kepada maklumat penting dengan cara yang interaktif. Projek ini dibangunkan menggunakan Raspberry Pi 4 sebagai pengawal utama dan perisian MagicMirror2 sebagai platform antara muka. Cermin Pintar ini memaparkan maklumat seperti cuaca, berita dan pemberitahuan pada paparan digital yang tersembunyi di belakang kaca cermin. Projek ini juga melibatkan pengimbas RFID untuk memaparkan maklumat pakaian dengan tag RFID, serta kawalan suara melalui mikrofon untuk interaksi pengguna yang mudah. Pengguna boleh mengakses maklumat melalui paparan digital, melihat maklumat pakaian dengan tag RFID, dan berinteraksi dengan sistem melalui suara. Peningkatan masa depan untuk projek ini adalah mungkin, termasuk integrasi kecerdasan buatan dan modul berfungsi baru. Cermin Pintar ini dapat meningkatkan kehidupan seharian dan pemantauan maklumat dengan ketara dengan penggunaan teknologi dan kreativiti.

Kata kunci**:** fungsi RFID, cermin pintar raspberry pi, cermin pintar RFID, aplikasi raspberry, aplikasi pintar

INTRODUCTION

Although many technologies have become smart in the age of modernization, the mirror, one of the tools used daily, still needs to be properly converted into a smart appliance. The Internet of Things (IoT) (Alboaneen, 2020) makes it possible to upgrade different appliances or devices to keep up with modern technological advancements (Gorkem et al., 2018; Praveena et al., 2021). Many appliances, including fans, air conditioners, and even lights, have been made smarter so consumers can control them using their voice or smart devices (Shaikh et al, 2021). However, although several researchers have successfully developed smart mirrors in the past, almost all users' objectives are for daily use at home (Bianco, 2021; Chaparro et al, 2021, Shakir et al, 2022). Because of this, a smart mirror should be developed to suit the need for use not only in homes but also in other industries (Ogunjimi et al, 2021; Yu et al, 2021), such as the clothing industry (also known as the garment industry or apparel industry) and most importantly according to functionality demand (Yang, 2022).

Most clothing stores also often need to correct their display of the prices of ongoing promotions. This causes many customers to be dissatisfied when the price displayed during the payment process differs from the tag on the clothes. Based on the problems identified, this smart mirror can detect price, existing color, and even size through radio frequency recognition tags or RFID (Gus, 2022). Through the data that has been stored in the tag, the smart mirror will read the data and display information on the choice of clothing that has been selected. In addition to maintaining the main function of the mirror for viewing self-reflection (Garcia et al, 2017), it can now help users choose clothes that suit their taste while providing information through a real-time database.

The project's objectives include creating a smart mirror with the Raspberry Pi (Jin et al, 2018;

Sun, 2018; Gus, 2022) as a critical component, building one with an RFID detector and internet access for increased functionality, and creating a smart mirror that is both affordable and successful at providing users' feedback. The scope of this smart mirror is that it has a Raspberry Pi will be connected to a network of servers to access stored data. The RFID detector will find the tags and then put them onto a computer screen hidden behind a one-way mirror so that users can view the data the computer is displaying. However, there are some limitations, such as the need for more equipment, such as mirrors and sensors, to optimize the production of this project.

This smart mirror project focuses on the opportunities that can be given to the buying and selling of products, especially in the sale and purchase of clothing. Customers frequently experience the proposed problem, which can be resolved through this project while also giving IoT technology additional chances to stand out in resolving issues that we encounter on a regular basis. This study is significant in demonstrating how a straightforward device may alter people's perceptions as it develops into smart technology.

METHODOLOGY

In the implementation of this project, the methodology used is IoT Methodology. It is a generic method and is easily built on repeated prototypes and Lean Startups. This methodology focuses on the production of prototypes to solve the problems that have been identified. The improvement process will recur when new problems appear in the production of this prototype. Six phases are carried out before the study results can be released, as shown in Figure 1.

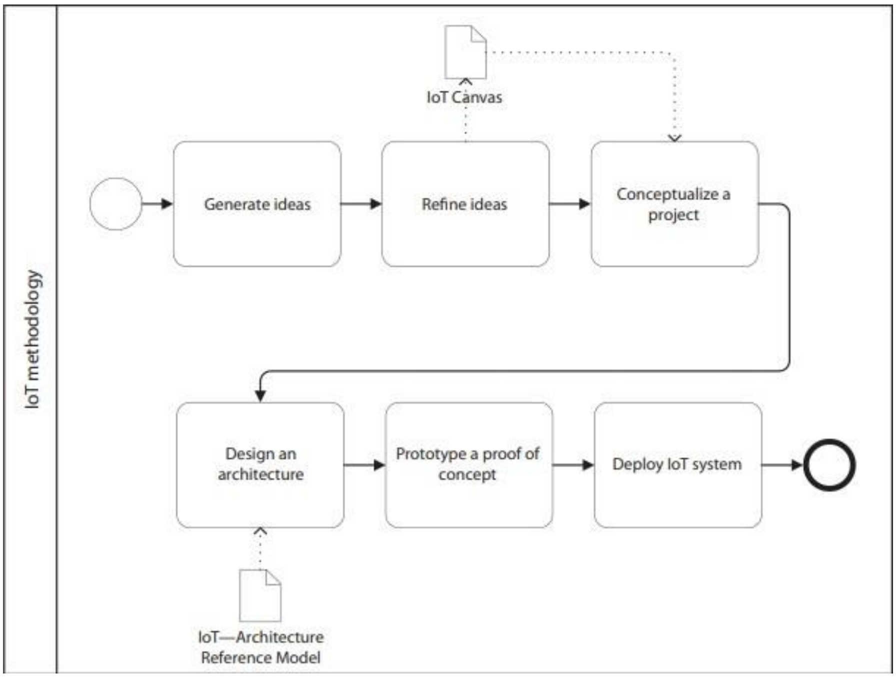

FIGURE 1. Methodology flows 'The methodology involves the following phases:

1. Generate Ideas: In this phase, ideas are issued based on the problems that have been identified, the objectives of the study, and the scope of the study. Literacy studies will also be conducted to compare differences between models, ideas, andObjectives of other studies. This can bring out ideas that meet the objectives and solve

the problem statement of this study.

2. Refining Ideas: The second phase requires information from the idea creation phase to provide all the project needs. The two requirements of this project are the needs of the user and the specification of the system requirements, which consist of functional and non-functional requirements. The user's requirement is the function provided by the user to use this smart mirror. The non-functional requirement, on the other hand, refers to traits or characteristics that are constraints and considerations to the behavior of the system.
3. Conceptualize a project: The concept phase of the IoT project is different compared to other projects. This is because the concept of the project will be determined through the software and hardware framework to be used. The listed hardware and software are based on user requirements and system specifications that have been analyzed.
4. Project design: The fourth phase is to determine the design of the project. A project can be designed using a variety of architectural techniques. This Smart Mirror project uses layered architecture and client-server architecture, which are integrated to form the enhanced design.
5. Concept Prototype: This phase started with building a prototype with minimal direction of IoT system deployment. The completed prototype was evaluated and included in the plan for review and improvement. The prototype started with the connection of hardware, such as the RFID detector, to the Raspberry Pi and downloading the MagicMirror2 system into the Raspberry Pi. After that, the smart mirror modules were integrated before the testing process.

The following section highlights the smart mirror requirements and design for all the phases.

SMART MIRROR REQUIREMENTS AND DESIGN

The smart mirror considers the standard requirements and adds new requirements to enhance the functions and develop the designed system. System requirements are fundamental to the design and production of a system. It details the activities or processes occurring in a system. Table 1 shows the enhanced smart mirror requirements, including the user and functional and non-functional requirements. The hardware and software used are briefly described in Table 2. The description of the testing requirements is shown in Table 3.

The software design of this smart mirror is based on several modules built to produce a project capable of working comprehensively with the new functions (RFID, laser keyboard, and voice controller). Each module has the main objective of each function contained in this Smart Mirror. These modules are developed to be operated via the smart mirror OS. These Smart Mirror modules are developed separately, enabling the improvement of existing modules for the future addition of new modules. The main modules developed in this project are the RFID scanner, Clock, Weather, and Internet modules, as shown in Figure 2. The user can perform an interaction through the user interface that is displayed through the Smart Mirror OS. The Smart Mirror OS gets information from the Internet to perform the functions of some Smart Mirror modules. To offer input and output to the user, hardware and linked tools will also interface with the Smart Mirror OS, as shown in Figure 3 and Figure 4, which is the architectural design and the RFID detector connection circuit to Raspberry Pi.

TABLE 1. Smart Mirror Requirements

Requirement	Description	Category
Voice Control	Users can use smart mirrors through the voice control function. The voice recognition function allows users who are currently using their hands to give mirror commands to use existing functions.	User and Functional
RFID tag	Users can scan RFID tags, and information can be displayed in smart mirrors. RFID tags are customizable and the information inside the tags can be used according to the purpose for which the smart mirror is used by the user.	User
RFID scanner	Detect and read data stored in the object's RFID tag.	User and functional
Laser Keyboard	Users can interact with smart mirrors using a laser keyboard that is implemented into the mirror. This laser keyboard also has a mouse and keyboard when used, thus reducing costs compared to using an unwired keyboard and mouse.	User and functional
Gateway	Users can modify smart mirrors through Gateway servers integrated with Google Assistant. This device can also control the activity of smart mirrors directly. Getting user input from the server and sending information to a smart mirror.	User
Usability	This smart mirror must have a user-friendly interface and can be used and understood by various age layers of the user.	Non-functional
Efficiency	This Smart Mirror can work smoothly without making it difficult for the user. The data obtained needs to be presented accurately and quickly to provide satisfaction to users.	Non-functional
Reliability	Smart mirrors should run smoothly and stably without experiencing any technical glitches.	Non-functional
Availability	Smart Mirrors need to be ready at any time for use by consumers.	Non-functional
Safety	Smart Mirror needs to protect and ensure that the user's personal data is in a safe condition. Smart mirrors can only be accessed by registered users.	Non-functional

TABLE 2. Hardware and Software

Requirement	Description	Type
Computer	Intel core i5 or equivalent CPU, 8GB RAM or more, and local storage 256GB or more. This computer is used for the system building process.	Hardware
Raspberry Pi 4	This appliance is a key component in storing all smart mirror systems and software. It also serves as a smart mirror operating hub.	Hardware
Screen	The monitor is used to display smart mirror software to the user.	Hardware
Laser Keyboard	This tool is used to get input from the user based on the alphabet and numbers typed on the keyboard.	Hardware
Microphone	The microphone is used to get voice input from the user.	Hardware
RFID Detector	RFID scanners are used to scan data stored in tags.	Hardware
Microsoft Windows 10 (64bit)	This operating system is used in the early stages of the production of software on laptops.	Software
Raspbian Operating System	This system is an operating system used by Raspberry Pi 4. The system will seamlessly control and run all smart mirror software.	Software
Electron Application	Electron is a framework for generating applications using the latest technologies, such as HTML, CSS, and JavaScript. Electron will be used to build software suitable for the Raspberry Pi 4.	Software
Node 17(Node.js)	The software uses an unhindered I/O model and is suitable for use alongside various rigs that support the cross-platform runtime environment. This will be used to build server-side and network applications.	Software

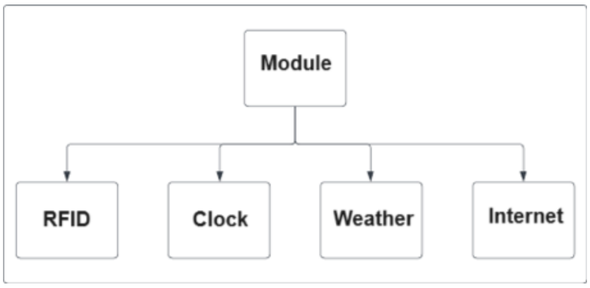

FIGURE 2. Smart mirror modules

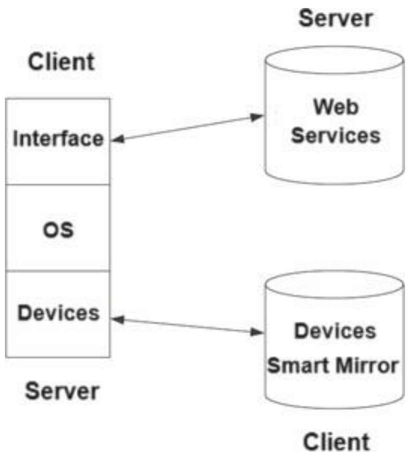

FIGURE 3. Smart mirror architecture design

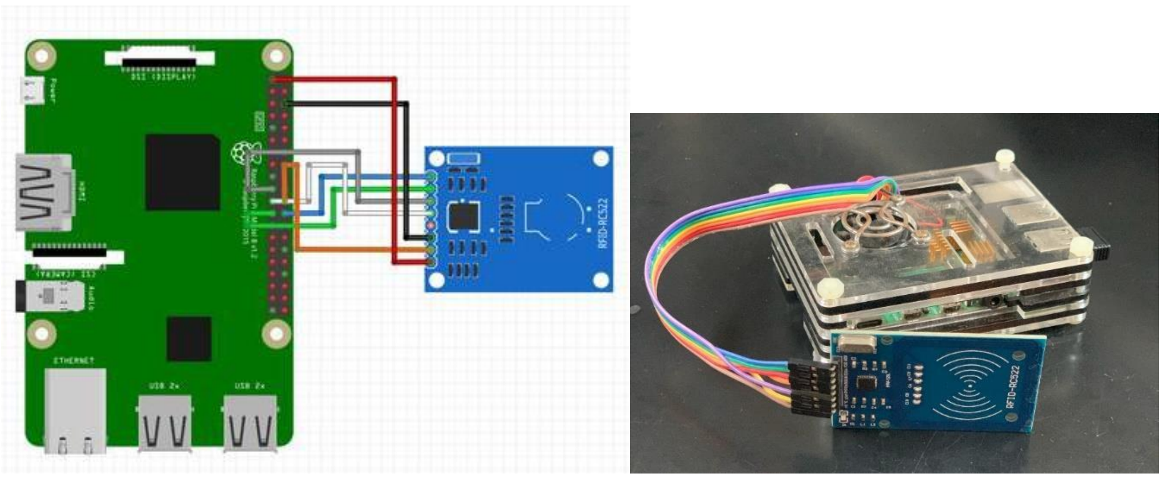

FIGURE 4. RFID Detector connection circuit to Raspberry Pi

TABLE 3. Testing Requirements

Criteria	Pass Description	Fail Description
The smart mirror system displays information on the screen.	The information displayed is accurate. The smart mirror system displays the interface on the screen.	The information displayed is inaccurate. The smart mirror system does not display the interface on the screen.
The smart mirror system can be controlled via voice direction.	Google Assistant is enabled through keywords. Google Assistant gives the correct answer to the instructions given.	Google Assistant is not enabled through keywords. Google Assistant gives inaccurate answers to the instructions given.
Smart mirror system receives input from laser keyboard and mouse.	The input of the laser key display received is correct. Input from the mouse is received by the smart mirror system.	The input of the laser key display received is inaccurate. Input from the mouse is not received by the smart mirror system.
Smart mirror systems can scan and validate RFID precisely.	RFID tags can be affected by smart mirror systems. The RFID tag information displayed on the screen is accurate.	RFID tags are not successfully affected by smart mirror systems. The RFID tag information displayed on the screen is inaccurate.
Smart mirror systems can connect to the Internet to receive real-time data.	The information displayed by the module is accurate. The smart mirror system successfully receives real-time data.	The information displayed by the module is inaccurate. Smart mirror systems do not successfully receive real-time data.
Raspberry Pi CPU pressure test	The Raspberry Pi can last for a long period of time with CPU load at the max level.	The Raspberry Pi shuts down for a short period of time or before it reaches maximum load
Test ping from Raspberry Pi to the Internet	The Raspberry Pi can connect to the Internet and has low immersion.	Raspberry Pi does not successfully connect to the Internet and has a high immersion.

Figure 5 shows the completed smart mirror front the front and the back view. The following section highlights the testing and discussion of the completed project.

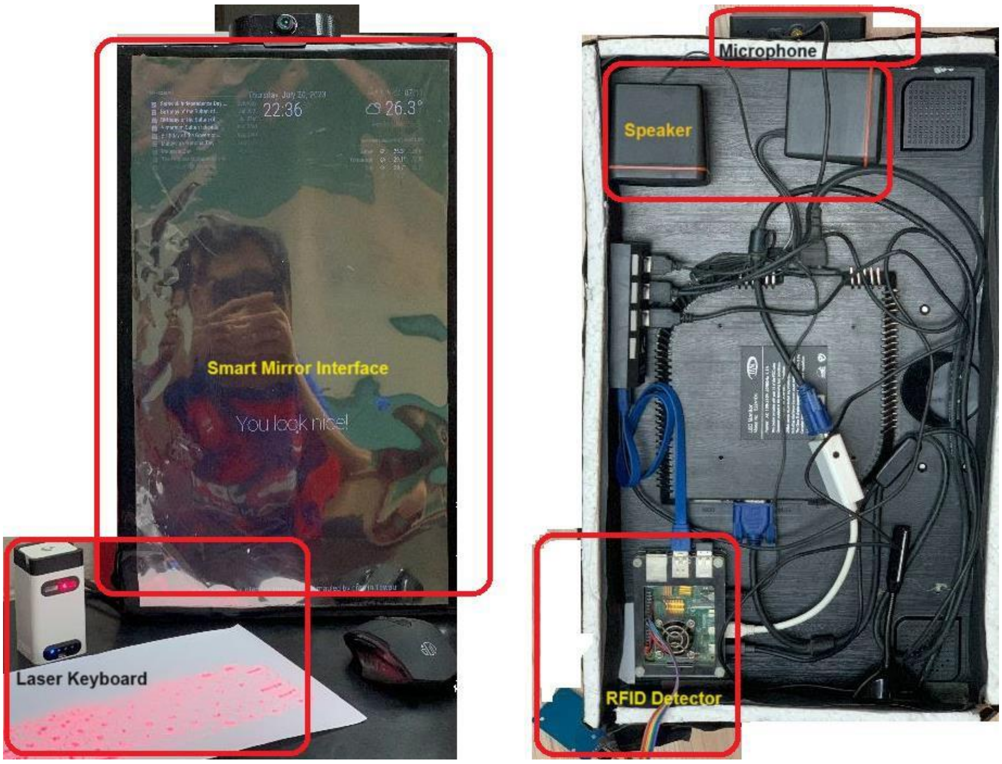

FIGURE 5. Completed smart mirror (front and back view)

TESTING AND DISCUSSION

The completed project went thorough testing process based on the test plan that has been drawn up. The test results are as follows:

1. Functional Requirements Test: Functional requirements tests were performed based on input scenarios from the user when using the smart mirror. The test results of the functional requirements of smart mirrors are all successful. Figure 6 shows the successful interface connection and information on clothing, as requested.
2. Non-Functional Requirement Test:
   a. Pressure Test (Graham, 2022) (shown in Figure 7): This pressure test for Raspberry Pi 4 was carried out using Stressberry, a pressure testing software that continuously tests the processing rate at full rate and is evaluated by the temperature released by Raspberry Pi 4. Several parameters set this test before it is carried out.
      i. (-n "Stress Test") – Name of the exam being conducted.
      ii. (-i 300) – 5 minutes idle period before and after test
      iii. (-d 1800) – 30 minutes pressure test time
      iv. (-c 4) – 4 terraces
      v. (Pressure.out Test) – The file name of the data collected.
   b. Ping Test (shown in Figure 8): A ping test is a network test used to measure the speed and stability of a network connection between two devices, such as a computer or server. The ping test sends a data packet to a specific destination and measures the response time taken for the reply packet back to the source. This ping test is intended to test the Raspberry Pi 4's Internet connectivity and strength. The test requires a Raspberry Pi 4 to ping IP 8.8.8.8 or

www.google.com and www.youtube.com are the two largest primary public servers to determine test results.

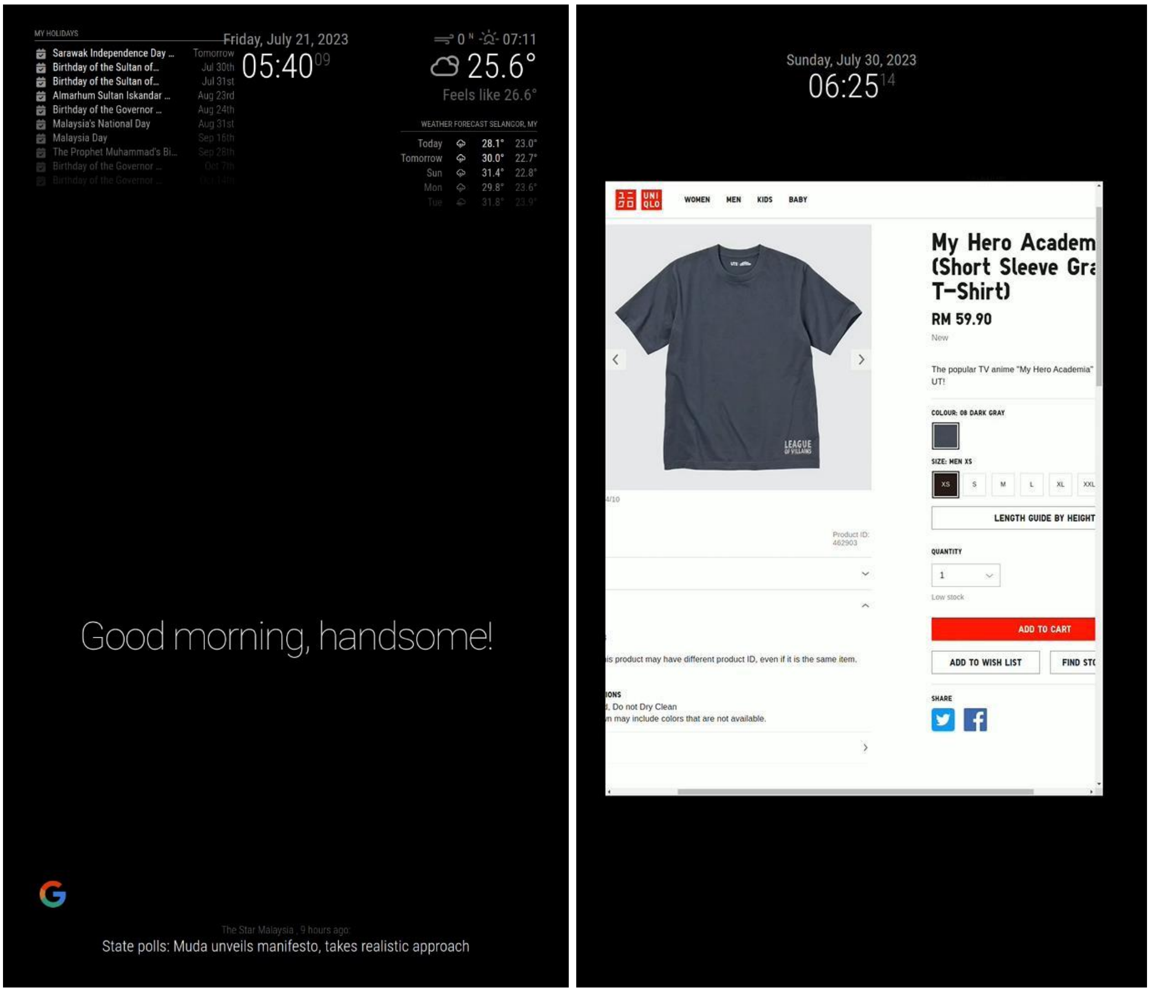

FIGURE 6. Interface

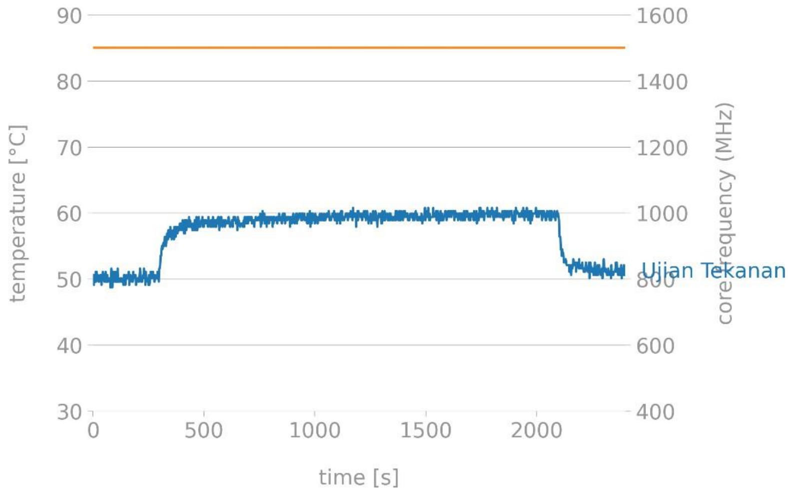

FIGURE 7. Pressure test.

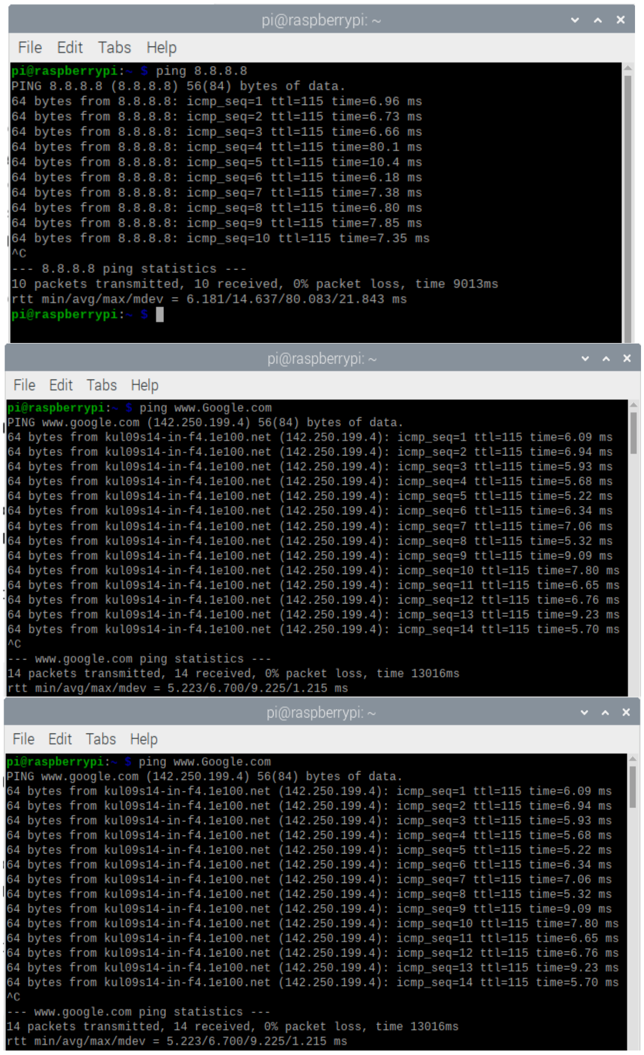

FIGURE 8. Connection ping test

The Raspberry Pi-based Smart Mirror project was built to meet both functional and non-functional requirements effectively. A dynamic, responsive, and smoothly functioning smart mirror is the result of the meticulous development and testing process. Based on the test results, the smart mirror has successfully passed all tests for the functional and non-functional requirements that have been set. All test criteria meet the expected standards, and no significant failures were found during the testing process. Thus, this smart mirror project has achieved the desired reliability and quality while providing an optimal user experience.

The project faced several constraints that affected the smoothness and functionality of smart mirrors. First, the absence of a supply of reflective mirrors that fit the project's criteria became one of the main constraints. These shortcomings have forced the use of substitute materials for reflective mirrors that cannot be met, which may decrease quality and user experience. In addition, the project's dependence on internet connections for smart mirrors is also an important issue. Loss or interruption of internet connection may cause problems in the operation and accessibility of smart mirrors, affecting the overall user experience. Therefore, backup solutions or ways to increase resistance to internet connection interruptions must be sought to overcome these constraints.

A number of improvements have been identified to increase the completeness and effectiveness of this smart mirror. The first is integrating additional sensors, such as temperature or light sensors. With the addition of these sensors, the smart mirror will be able to adjust exposure and functionality based on the surrounding environment. For example, a smart mirror can adjust the optimal brightness or lighting temperature based on ambient light to improve comfort and quality of visibility. The next improvement is building a mobile app that can be integrated with smart mirrors. The app will give users easy and practical access to remotely control and manage smart mirrors. With the mobile app, users can control various functions and smart mirror features without being near them, providing flexibility and ease of use. In addition, the use of artificial intelligence (AI) and machine learning is also an important addition to this smart mirror. By integrating AI and machine learning technology, smart mirrors can provide a more personalized and intelligent user experience. For example, smart mirrors can recognize individual users and provide backups of information that is relevant and considering user preferences, such as clothing style recommendations or health tips based on data collected.

CONCLUSION

In conclusion, using this RFID Detector, the Raspberry Pi Smart Mirror Improvement project has generally achieved its objectives. The concept, which integrates information technology with standard mirrors, might be used as a platform for other consumer-friendly innovations. Although basic, this mirror can still be improved upon by other findings. This smart mirror was made utilizing the Raspberry Pi 4, which aims to control and process data to fulfill the study's objectives to give users accurate information based on scanned RFID tags. This smart mirror system uses MagicMirror2 software that produces an interactive interface and can be configured according to different development modules. An RFID RC522 reader has been attached to a Raspberry Pi 4 to read, write, and show data from RFID tags on the mirror screen. Additionally, there are multiple ways for users to engage with this smart mirror, including voice control and a laser keyboard that is integrated into the mirror. This project shows how technology can enrich the user experience and open opportunities for smarter innovation in the future. This project provides great potential for future development with further improvements and innovations. With a combination of technology and creativity, this smart mirror can significantly improve daily life and information monitoring at home and work.

ACKNOWLEDGEMENT

This research is supported by Malaysia Cyber Consumer Association (MCCA) and Codam Protocol Sdn. Bhd. (CODAM) under research grant TT-2022-005.

REFERENCES

Alboaneen, Saffar, Alatiq, Alqahtani, Alfahhad, Alqahtani, Bashaieri, Alamri, and Lama. 2020. Internet of Things Based Smart Mirrors: A Literature Review. 3rd International Conference on Computer Applications & Information Security (ICCAIS), Riyadh, Saudi Arabia. pp. 1-6. doi: 10.1109/ICCAIS48893.2020.9096719.

Bianco S. 2021. A Smart Mirror for Emotion Monitoring in Home Environments. Sensors. Vol 21(22). doi: 10.3390/s21227453.

Chaparro JD et al. 2021. The SHAPES Smart Mirror Approach for Independent Living, Healthy and

Active Ageing. Sensors. Vol 21(23). doi: 10.3390/s21237938.
Graham. 2022. How to stress test temperature on Raspberry Pi (stressberry) - tutorial australia. Core Electronics. https://core-electronics.com.au/guides/how-to-stress-test-temperature-on-raspberry-pi/ [2 November 2022].
Gus. 2022. How to setup a raspberry pi RFID RC522 chip. Pi My Life Up. https://pimylifeup.com/raspberry-pi-rfid-rc522/ [8 October 2022].
Görkem, T. Bedir, and T. Eray. 2018. IoT System Development Methods in Internet of Things challenges, advances, and applications. Chapman & Hall/CRC Press. pp. 146-147.
García, E. R. L. Salmón, R. V. Riega and A. B. Padilla, "Implementation and Customization of a Smart Mirror through a Facial Recognition Authentication and a Personalized News Recommendation Algorithm," 2017 13th International Conference on Signal-Image Technology & Internet-Based Systems (SITIS), 2017, pp. 35-39, doi: 10.1109/SITIS.2017.17.
Jin, X. Deng, Z. Huang and S. Chen, "Design of the Smart Mirror Based on Raspberry PI," 2018 2nd IEEE Advanced Information Management,Communicates,Electronic and Automation Control Conference (IMCEC), 2018, pp. 1919-1923, doi: 10.1109/IMCEC.2018.8469570.
Ogunjimi A, Rahman M, Islam N, and Hasan R. 2021. Smart mirror fashion technology for the retail chain transformation. Technological Forecasting and Social Change. Vol 173 (121118). doi: 10.1016/j.techfore.2021.121118.
Praveena B et al. 2021. Smart Mirror Information System Using IoT. Inventive Computation and Information Technologies. Lecture Notes in Networks and Systems. 3rd International Conference on Inventive Computation and Information Technologies (ICICIT). AUG 12-13, 2021. Coimbatore, INDIA. doi: 10.1007/978-981-16-6723-7_46.
Shakir M et al. 2022. Smart Mirror Based Home Automation Using Voice Command and Mobile Application. EAI Endorsed Transactions on Scalable Information Systems. Vol 9(35). doi: 10.4108/eai.12-11-2021.172102.
Shaikh, Shakir & Karim, Shahid & Fatima, Zaheen & Kumar, Vishal & Mehmood, Mamoon & Memon, Shahzor & Mustafa, Halar. (2021). Smart Mirror Based Home Automation Using Voice Command and Mobile Application. ICST Transactions on Scalable Information Systems. 9. doi: 172102. 10.4108/eai.12-11-2021.172102.
Sun, L. Geng and K. Dan, "Design of Smart Mirror Based on Raspberry Pi," 2018 International Conference on Intelligent Transportation, Big Data & Smart City (ICITBS), 2018, pp. 77-80, doi: 10.1109/ICITBS.2018.00028.
Yang BS, Kang TW, Choi YS, and Jung JW. 2022. Error-Resistant Movement Detection Algorithm for the Elderly with Smart Mirror. Applied Sciences-Basel. Vol 12(14). doi: 10.3390/app12147024.
Yu H, Bae J. Choi J, and Kim H. 2021. Smart Mirror with Sentiment Analysis for Mental Comfort. Sensors. Vol 21(9). Doi:10.3390/s21093092.