VOL. 16, NO. 21, NOVEMBER 2021 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

INTERACTIVE VOICE RECOGNITION BASED SMART MIRROR FOR MALAYSIA COMMERCIAL GUEST ROOM

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ABSTRACT

This paper describes a scheme and implementation of a mirror turned intelligence that results in interactive mirror planned via a Raspberry Pi as the key controller. The most important principle of graphical representation of this prototype is that it can display customized information such as clock, calendar, current weather, food menu and even for news feed based on two-way voice communication. In other words, the Smart Mirror can function as a virtual assistant that responds to the user's request and questions delivered automatically. Thus, user can easily get information of various places near the hotel, or any information that the user wishes for by using voice commands and even smartly user can control appliances that are powered by Google Home. The guest would enjoy a wide range of interesting functionality through the mirror featured innovations that could certainly plays a significant part of technology in the human daily life.

Keywords: smart mirror, hospitality, really simple syndication, google home, raspberry Pi.

1. INTRODUCTION

Aligned with the increasingly key development of technology such as sensors, network communication, etc. towards the notion of Internet of Things (IoT), numerous data can be discovered simply at the tip of the tongue that could bring considerable numerous positive effects on humanity [1]. Integrating innovation into daily human life are more likely to save more time so that it can be well managed. Currently, people nowadays are living in the millennium era in which Malaysia particularly are targeting towards implementing the technology of Industrial Revolution (IR4.0), where all things happen based on the application of Internet of Things [2][3].

In conjunction with the technology advancement, the fundamental idea of this innovative mirror is most of the times, people will use the mirror to see their face and appearance. At the same time, they are more likely to see any notification on their PC and smartphone [4]. What if this feature can be combined together as a new technology era, in which an intelligent device that can monitor and control anything via mirror interaction using voice commands? This aspect marks the distinct value added if compared with the smart phones or smart televisions [5]. Smart Mirror was finally chosen in this work because it contains extraordinary features such as web technologies, smart electronics, etc.

Various kinds, forms, magnitudes and applications of smart mirrors that can be applied in different fields such as sports and fashion by using diverse implementation approaches and software design languages. Nowadays, smart mirrors are on the horizon and started to catch the attention of the hospitality sector [6][7]. This is due to the service value provided in the hospitality business that can be turned into one of the most vital aspects for achieving a supportable competitive gain and customers' assurance in the greatly competitive marketplace. By simply looking beyond the mirror's reflection, guest's room such as hotel or homestay can have their whole commercial room experience at a different level under their control interactively [8].

Hospitality development can increase the value of travel where the smart mirror is established to provide convenience for commercial guestroom users to access the information of hotel's services [9]. It is also to keep the guestroom users updated while staying in the room both within the hotel as well as to search nearby interesting places of local map to visit. On top of that, it is also can manage the utilization of electrical devices in the room with network link particularly the lamps and switches via an interactive means [10][11]. In this case, users verbally able to give the commands to the system and the voice command interface will recognize the voice of the consumer to receive instructions and responding to simple input-queries reliably [12]. As a result, this would further enrich the guest travel experience.

The proposed system is developed based on three objectives. Firstly, it is aimed to develop a smart mirror prototype based on IoT using the Raspberry Pi technology. The next objective is that the system is integrated with voice command interface to facilitate the implementation of Smart Mirror. Finally, the objective is the performance of the system is tested for usability evaluation to users' satisfaction. The paper is organized as follows: the literature review describes the background of this proposed work implementation. Then, it is followed by the third section which briefly presents the proposed work

methodology. Section 4 presents the results and their discussion and finally, section 5 will conclude this work.

2. LITERATURE REVIEW

Rapidly growing demand for microprocessor technology is expected to fuel the digital market growth over the forecast period. In this case, a System On Chip (SOC) sets off as one of the signs. It is due to its cheaper price. Such as the Raspberry Pi, the most based around the SOC, it provides many novel features with minimum human intervention for creating smart devices for development of smart rooms [13]. Smart mirrors have gained a lot of attention in the market that are in line with the IoT trend. Primarily, it was produced by merging old laptops and semi-reflective observation glass, which seems as a normal mirror but with mirror image consists of text that appear to float in mid-air. Furthermore, in 2016, Microsoft [14][15] intentionally broadcast the detail information how to construct smart mirror via online. Hence, the study in this case follows similar steps in which the Raspberry Pi acts as the key controller.

As time goes by, the makers around the globe challenge each other to improve furthermore on previous smart mirror designs. In the first place, these mirrors were only developed to get the data via an internet web interface based on Application Programming Interface (APIs) and the mirror will show general information such as date or weather. The smart mirror has evolved and the technology was diversified towards the e-Health sector through the development of smart mirror used as an e-Health assistant [16]. The so-called health checking smart mirror is planned to identify the user's health associated matters by analyzing the user's body condition without giving feedback. In this case, smart mirrors so far proposed this work as acting passive devices with only one-way communication.

Considering the studies on smart mirrors, it can be seen that there are many different usage areas. The mirror is a great implementation; where the authors in [17] were inspired to add an online news feature by made use of the Raspberry Pi and Arduino Uno with internet interface. It was motivated due to the problem where occasionally modern people will face lack of time to tap the newspaper app or turn on the network feed (TV station) in the morning for the news headlines. However, it is very less interactive which makes it appears incomplete for a device where people might need for daily use in any places.

Another alternative of the smart mirror is that it could be simulated using a smartphone or tablet. These devices can display informational widgets and allow the user to interact through a touchscreen. However, the disadvantage of this kind of smart technology is the lack of screen size and reflectiveness when the display is operated on to act as a functional mirror [18][19]. Simply to say it won't bear the gesture control. Hence, the research on this work decided to develop a smart mirror that is more interactive and offers dynamic information while on the go.

As new technologies continue to emerge and aligned with the concept of intelligent interoperability, the Americans has come up with a fully interactive touch screen smart mirror for home user with limited home control functionalities [20]. It is also can be helpful to be used in business sectors due to the smart mirror feature that could simplify the company daily operation. Kun Jin *et al*., [21] and his team has provided the user with a series of intelligent satisfaction such as accessing home appliances, data acquirement, remote monitoring and operation at home. In this paper, the smart mirror that is proposed would target the commercial guest rooms available in Malaysia economic sector to help boost the tourism industry by providing upgraded room guest experience with IoT feature.

Along with the advancement of Information Technology (IT), all business sectors have unavoidably involved with new technical wonders and experienced their benefits, As such, the tourism industry is not an exception [22][23]. As mentioned previously, the service quality in the tourism sector of hospitality industry becomes one of the most important factors for gaining a sustainable competitive advantage and customers' confidence. From the viewpoint of tourists, the focus of smart technology in travel has become increasingly important which could result in travel satisfaction and in turn produces tourists' happiness. The author in [24] had studied the tourists' value-seeking processes and concluded that tourists' happiness can be increased through travel experience pleasure and service experience contentment. The next section discusses about the hardware and software components used for the proposed system.

3. SYSTEM DESIGN

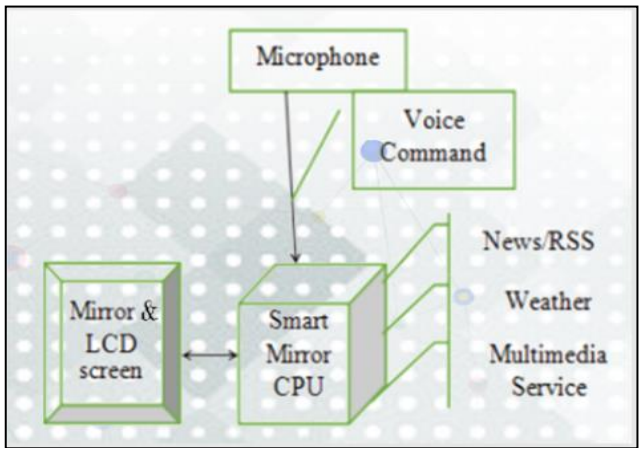


Figure-1. Block diagram of smart mirror.

The functional block of the proposed system consists of a two-way acrylic mirror which mimics a natural mirror interface accommodated by the wooden frame. It is interfaced with the Raspberry Pi development board, microphone and other online functionality, as shown in Figure-1. A flat Liquid Crystal Display (LCD) screen is used to provide real time display of the smart

mirror content in the form of widgets illustration. Basically, the widgets in the mirror's user interface commands the Raspberry Pi board in the smart mirror system to manage a requested device or to gain other personalized information services. Once the sound signals from user's voice are identified, the microcontroller changes the text in the microcontroller and manipulates the necessary functions to direct the commands Overall, this project suggests to develop and create such a futuristic intelligent mirror that will provide a whole interactive experience for all the guest room users.

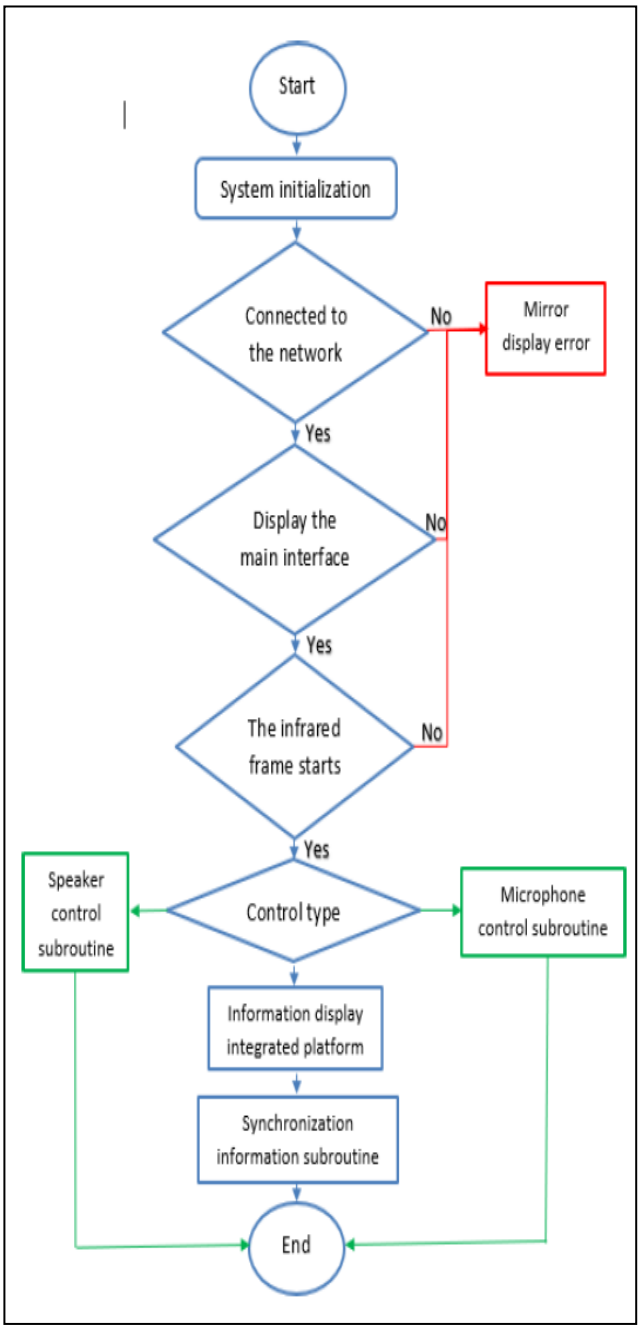


Figure-2. Smart mirror project workflow.

The whole framework of the proposed system is a combination or hybrid of a layered architecture and a client-server architecture. The software of the smart mirror is enabled by the Google Home Assistant and operates on the basis of function designated modules which can be combined together on a single platform known as the dashboard. With this feature, the dashboard of smart mirror can be configured to access many information, such as temperature, time clock, calendar, newsfeed and many other third-party functionalities. The Google Home Assistant is integrated with cloud feature which acts as a centralized operation system. Its function leads all the task in the smart mirror, as well as to provide intelligent useful interaction to the end user through the sensors and the information visualization through the mirror User Interface (UI).

A flowchart of the smart mirror design is illustrated in Figure-2. Fundamentally, this smart mirror occupies 24 hours of internet access. When the mirror is activated, it connects to the Docker which contains all the interface and software required for the mirror to operate. Technically, the Docker contain the API of Google (virtual voice assistant from Amazon) that will respond to the user's voice. This will require web access to be provided by the Wi-Fi module on the Raspberry Pi. In this case, the LAN may also be used. When turned on, the virtual interface that will be prepared on the mirror using the features of HTML and CSS. As such, the smart mirror will then display titles for calendar, weather, and newsfeed while maintaining a mirror effect. This information is updated in a timely manner. The access control for the subroutines information of the smart mirror has two types. One type is a Universal Serial Bus (USB) microphone connected to Raspberry Pi board to receive input audio from the user. Another type is the speaker to be utilized to play the audio feedback of the Google Home Assistant. Specifically, the system will fetch the corresponding information from the cloud and executes any requested services like turning on the room's lights and checking the hotel food menu.

4. RESULTS AND DISCUSSIONS

The research work conducted to produce results when simulating the functionality of the smart mirror where the purpose is to exhibit the information on the mirror. In this case, the main functional modules were simulated and tested where the final results of the smart mirror design are presented at the following section. Among the Figures displayed under the following section are time module, weather module, Malaysia calendar module, current weather module and newsfeed module.

4.1 Malaysia Calendar

By referring to Figure-3, the module displays a default calendar that has already been allocated to Michael Teeuw's MagicMirror2 OS which is located at the United States. As such, users can customize the Calendar module setting on their own pace. This module displays events from a public ordinary calendar, where it can combine multiple calendars as well.

Figure-3. Malaysia public calendar display at smart mirror.

4.2 Newsfeed

The default newsfeed displayed on the mirror, as shown in Figure-4 comes from The Sun Daily. The newsfeed module works on any really simple syndication (RSS) feed, of which there are millions that can be chosen from. Technically, it can be achieved with square brackets [ ] known as the array of feed URLs. It is used as a source, which means that it can have multiple entries for headlines. Users will be able to obtain minute updates of the latest newsfeed and public headlines.

Figure-4. Result display the sun daily RSS in smart mirror for the newsfeed module.

4.3 Current Weather

This module displays the current location and weather, the sunset or sunrise time, as well as the temperature. This is depicted in Figure-5. In this case, the site of the origin was replaced by Bintulu, Sarawak while the weather data is acquired from the OpenWeatherMap. It is an online service that offers weather data, including current weather data and forecasts. Users may also adjust the default location assigned by the Current Weather Module to the chosen location of the user's choice. All output results are truly based on Geo Cords location. The name of the place can be changed to anything, but the result for weather are depended on the Geo Cords location that has been inserted by the user.

Figure-5. Smart mirror display weather result for current weather module.

4.4 Menu Display

Figure-6. Smart mirror display output menu for breakfast.

The Menu Display is custom made by modifying the standard template of the proposed design for smart mirror. For this case, the Today's Menu as shown in Figure-6 are been implemented in the Smart Mirror to display breakfast, lunch, and dinner menu. The menu will change automatically and it depends on the allocated current time given.

The main project development test was benchmarked with the author's previous work in [25].

Table-1. Comparison application between pervious work and proposed work of Smart Mirror.

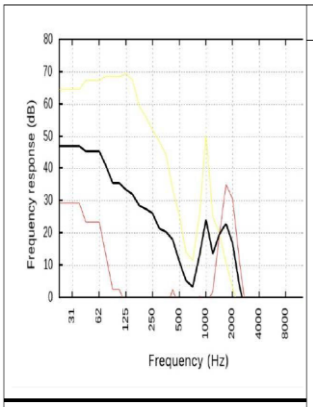
	Previous work [19]	**Propose work**
Display widget data	Display only clock, date, weather and reminder	Display clock, Malaysia calendar, weather, news feed and hotel menus
Voice command	Can only show results based on web internet	Can only show results based on web internet and capable to control room appliances
Place to implement	Home	Hotel & Tourism Spots

Comparison of the test results of the smart mirror application between pervious work and proposed work are presented in Table-1. The major difference between the current Smart Mirror project compared to the past project is that the current Smart Mirror can control appliances, while the past project vice versa.

Both projects have different market targets, as well. For the past project, they only apply the Smart Mirror at home which limited to few users to gain experience on the Smart Mirror. While, the current Smart Mirror project is focused more on the hotel and tourism industry, which produce more significant impact on the society as well as affect mankind daily life.

The next test which is the microphone range test is then carried out. It is considered as quite important test to be studied here so that the voice interaction based on distance between the human and mirror were well-obtained. It is mainly to analyse the range where the microphone can capable to acquire or capturing the user's voice. For this project, the far voice that can be captured is within a 3-meter range of the user from the microphone.

Table-2. Results of user-to-microphone range test.



Signal colour	Frequency Hz	Respond dB	Distance user-to-microphone
Red	54.39	39.7dB	3 Meters
Black	1178.48	50.3dB	2 Meters
Yellow	11211.6	58.8 dB	1 Meters

The result obtained is shown in Table-2 for the user-to-microphone range test. This test takes 3 sample distance user-to-microphone which indicated as the Red, Black, and Yellow lines. The Red line shows user-to-microphone far from each other within a 3-meter range. For Black line, it shows user-to-microphone in distance range of 2-meter to microphone and finally the Yellow line depicted a range of 1-meter user-to-microphone. As can be seen from the Table 2 result, the Yellow line is the best option from among those 3 lines. The reason is due to the distance between the user and microphone is near to each other within a 1-meter range compared to Black line which is 2-meter and Red line 3-meter user-to-microphone distance. The frequency and respond (dB) value also been shown for those 3 samples. The higher the frequency and respond captured by the microphone, the clearer the voice travels to the microphone. Subsequently, the normal human voice is considerably 50 dB upward.

As depicted in Table-3, since the smart mirror is for usage to available consumers, a qualitative data of user acceptance test was collected from 100 users [26][27] towards obtaining the feedback pertaining to the smart mirror appearance and design. Initially in a week, 100 volunteers were collectively asked to try to use the smart mirror and test its functionality. The users' comments include their experience when using the smart mirror and interact with its system. A survey form is provided to them to fill in after they had experienced to use the smart mirror.

Table-3. Summarized feedback from 100 individual surveyed.

	Smart Mirror Test		Component: Smart Mirror	
Test	**Smart Mirror should look good in design**			
No	**Action**	**Expected Outcome**	**Pass/Fail**	**Comment**
1	Survey of the overall appearance of the mirror by at least 100 different people	At least more than half of the respondents think that the design of the smart mirror is good.	Pass	Of the 100 individuals surveyed, 98 thought it looked fine. Small issues were raised where at the back of the smart mirror they said it not looks good.
2	The widget displays data.	At least 70% of the respondents consider the widget is accessible, and at least 50% may consider it aesthetically attractive.	Pass	Of the 100 individuals surveyed, 98 consider the widget accessible. And at 97 respondents may consider it aesthetically attractive.
3	The Smart Mirror feedback responsive feature (including control appliance using voice command)	At least 80% of the respondents found that the Smart Mirror gives good feedback responsive due to the stable bandwidth of the internet services provided	Pass	Of the 100 individuals surveyed, 99 consider the excellent responsive feedback result from Smart Mirror. Other respondents result is good, but others feels that it is little bit late in few seconds for the Smart Mirror to be responsive

As expected, many users raised questions about the technology regarding the features on the smart mirror. Despite small issues such as the appearance of the back of the smart mirror did not look good, the level of curiosity and interest from the 100 users who tried the smart mirror technology was very overwhelming. This case happens especially once they realized what features the smart mirror offered which is mentioned at the third section. In general, all the respective guests had no problems when interacting with the smart mirror provided that they were initially being guided how to use the smart mirror correctly. More than 70% of the guest proclaimed how remarkable, convincing and enjoyable it was to use the smart mirror in terms of the voice command and data display. The respondents uttered their satisfaction with exceptional comments, such as “Very Nice!” and “Love it so much.” In most of the times, it was found that the voice command worked well despite a little bit late in few seconds for the smart mirror to be responsive. As such, it is advisable to use strong and stable internet connection to avoid the latency in smart mirror responsive experienced by the user later on.

Table-4. Comparison internet latency between Celcom and Unifi.

Comparison	Celcom	Unifi
Average Latency	100 ms	15 ms

An internet performance speed test was taken to look at this matter where latency is the main criteria in the internet connection that shows the respond time between the sender and receiver, measured in milliseconds. It is found out that the internet provider called Unifi is more stable in term of smooth responsive feedback when using the smart mirror. In conclusion, the lower the latency value, the faster the feedback data that can be obtained. Table-4 shows the comparison internet latency between two internet providers.

5. CONCLUSIONS

As a result, the revolutionary smart mirror delivers natural interaction between users and the technology. The smart mirror which focuses as an efficient commercial room control platform is a futuristic system that provides users with an easy-to-use mirror interface, allowing users to access to customizable services in a highly interactive manner. This service is provided while performing other tasks simultaneously. The Smart Mirror offers the user with a great mirror experience, where by using various displays, the user can experience the function of it, such as clock, calendar, weather, newsfeed, food menu, as well as controlling room appliances by using voice command. Smart mirror design has the advantages of reliable size, simple operation, high degree of user friendliness, and many other advantages which is suitable for many applications such as college, home, offices etc. As such, the proposed smart mirror system integrates numerous functionalities to grant users access to personalized information services. As for future work, numerous innovative plugin chances are now available with the capability to access external hardware. It would be nice to add Virtual Network Computing (VNC) viewer which help remotely control Smart Mirror from the host hotel desktop computer. In additional, the mirror can be equipped with more microphones in the hotel room, so that the Google Voice command can detect anywhere in

the range of the hotel room capacity. With this feature, the user will experience anywhere in the hotel room surrounding to interact with the Smart Mirror without raising user's voice or fulfil the necessity to go near to the Smart Mirror location in order to use it.

Further research is aimed at developing the mechanisms automating the implementation of the proposed technique.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

The paper conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing-original draft preparation, and visualization, have been done by the first author and second author. The supervision and project administration have been done by the third and fourth authors, while the writing-review editing work have been done by the fifth author.

ACKNOWLEDGMENT

The authors would like to express their deepest gratitude to the Centre for Research and Innovation Management of Universiti Teknikal Malaysia Melaka (UTeM) under the grant FRGS/1/2020/FTKEE-CETRI/F00450.

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