IOT-BASED EMOTION SENSITIVE SMART MIRROR FOR ROOM AUTOMATION

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ABSTRACT: *People can perform their daily routines effectively and efficiently with The Internet of Things (IoT). This technology is expanding and getting advanced day by day. Some devices do not need human interaction to work when they are integrated with IoT. At present, IoT technology is connected to our home appliances as well. Things can be performed more efficiently and accurately with this type of smart equipment. More advanced tasks can be done easily when Image Processing is combined with IoT. This project focuses to integrate IoT and the mirror which is used in our daily lives. When life becomes busy, our free time gets reduced. Therefore, time management plays a major role in the present world. As support for managing time, this project targets to improve the regular mirror into a Smart mirror with IoT, which operates with voice commands. The aim of this project is to design a smart mirror for the home environment bundled with the maximum possible features while maintaining a low budget. This mirror provides a better user experience by including features such as motion detection, controlling the light according to the light intensity of the room, face recognition, displaying time, date, weather information, and news headlines, playing music, and showing quotes according to the mood of the user (Emotion detection), and controlling appliances in the room using voice command (Voice recognition and Room automation). This mirror can greatly help its user to manage life easier, faster, and more efficiently. Besides, we have also maintained a low budget for building this smart mirror. Face recognition, emotion recognition, and room automation are all interesting features of this smart mirror. This paper describes the design and construction of the smart mirror using raspberry pi.*

Keywords: IoT, Smart Mirror, Raspberry Pi, Emotion Recognition, Room Automation

1. INTRODUCTION

Technology has improved the ways of communication between people and objects faster and with more secure technologies (Balogh et al., 2019). In today's world, everyone requires next-level simplicity in their lives and everything is available in the blink of an eye. The Internet of Things is the best solution for all those real-world problems. IoT is a collection of interconnected technological devices, mechanical and computerized equipment, products, creatures, or humans with unique identification and the ability to send and receive data over a network without the need for human-to-human or human-to-PC interaction (Gillis, 2022). Many different applications of IoT can be seen all over the world.

The Home automation system is also very popular as an IoT-related project. The system uses one or more computers to control the required home appliances, and these appliances work automatically through either wired or wireless methods. Most automated homes are called smart homes. IoT can add more advanced functionalities to smart homes with the use of intelligent programs and devices.

Everyone uses watches, calendars, mobile phones, and other equipment to check the weather forecast, news, etc. life will be much easier if all that can be done using one single device. Moreover, health is considered the greatest wealth, so it will also be more beneficial if a gadget can help someone to relax his mind (Aziz et al., 2021). Therefore, the aim of this paper is to present an IoT-based emotion-sensitive smart mirror for room automation. This mirror can display time, date, weather forecast, news headlines, play music and show quotes according to the user's mood. It also provides an integrated room automation to make life easier.

The aim of this project is to provide the user with a user-friendly interactive interface that can be utilized in the place of a regular mirror. The smart mirror system proposed herein is integrated with motion detection, face recognition, emotion detection, room automation functionalities, and many more personalized options. This mirror is equipped with technologies to respond to the user's voice command and display time, date, calendar, and news headlines, which makes it much smarter and more useful than a regular mirror.

The smart mirror detects the person who comes in front of the mirror and recognizes their face. Then the image processing routines attempt to judge the type of emotions expressed by the user through his/her facial features, and the system automatically decides on the quotes to be displayed and music to be played in the background. This smart mirror takes decisions to fix and relax the mind of the user. Therefore this smart mirror can help to improve the user's mental health by avoiding health issues such as depression. Moreover, lights are turned on automatically if the room light intensity is too low to detect the face. Also, this smart mirror allows controlling the room appliances using voice commands. Hence the user can manage his time more efficiently. The main contributions of the paper are as follows:

- Detecting motions and recognizing faces using PIR and web camera.
- Detecting emotions of the user using OpenCV and Keras Libraries.
- Playing and showing music and quotes respectively according to the user's mood to fix and relax the mind.
- Displaying time, date, and weather forecast & newsfeeds.
- Controlling the light according to the light intensity of the room through Wi-Fi.
- Controlling other appliances in the room through Wi-Fi.
- Maintaining a low budget with advanced IoT concepts.

2. LITERATURE REVIEW

Bharath et al. (2021), developed a smart mirror, which can display notices, newsfeeds, clock, current weather, weather forecast, and weekly schedules. They used Raspberry pi 3 as a microcontroller and used a two-way mirror, 15" monitor, microphones, and speaker to give input and take outputs. It turns on with the motion of the user and takes voice commands. Dr. Carmel and Rupavathy (2021) have also developed a smart mirror that displays time, weather, date, news feed, and compliments. They have used a rectifier and regulator circuit to power the raspberry pi microcontroller and also they have integrated google speech recognition API. They have suggested future enhancements such as touch screens, geolocation, and voice recognition. Njaka and

Li (2018) have integrated the Alexa voice service with the smart mirror. Hence the mirror is with a very user-friendly architecture. Besides the regular features, there are multimedia services and extra security functions needed for a smart home system.

Yu et al. (2021), developed a smart mirror for a different application. This is related to the health field. The sentiment of the people is not stable due to the Covid-19 pandemic situation. This mirror can analyze users' sentiments using the pre-trained dataset like anger, sadness, neutral, and happiness and it plays the music, recites wise sayings, and sympathizes according to each type of emotion. Aziz et al. (2021) has focused on the smart mirror for mental health. This mirror detects depression using emotions and resolves it by providing Quranic and mindfulness therapies for mental relaxation and positive thinking.

Nadaf and Bonal (2019) have converted the smart mirror into a security system. The project has used OpenCV and YOLO (You only look once) concepts in machine learning. When a strange person is in front of the smart mirror, it captures a photo and emails to the given email addresses, and also this mirror can process both touch and voice commands. Li and Smon (2019), developed a smart mirror for the home. They have used the smart mirror as a display that monitors all selected appliances. This mirror shows the date, time, and all of those ordinary things. They have used Node.js and electron framework to design the interface, etc. They have suggested adding an IR frame to improve this project as a more user-friendly one and adding social media APIs like YouTube, Facebook, etc., to take this to the next level.

Silapasuphakornwong and Uehara (2021) have proposed a system for elders; It detects the faces and tracks their emotions using the kagglesFER2013 dataset and maintains a local database to check for long-term depression situations. This system has used face detection and voice Recognition on MLP using the RAVDESS dataset to detect users' emotions. Hence the accuracy of the final result is a bit higher than face emotion detection. The project has mentioned some drawbacks like accuracy issues because of the face shapes.
Balogh et al. (2019) have proposed the article to create an integrated Raspberry Pi intelligence with an HD camera that can process and evaluate the scanned image and discover movement. An application made that users can follow and record the activity of others using the camera. There is a monitoring system able to recognize changes in the environment. As mentioned, the main problem is that cameras can provide a significant amount of information, the vast majority of which is personal data, and there are severe concerns that personal privacy could be compromised.

Suchitra et al. (2016) have proposed "Real-Time Emotion Recognition from Facial Images using Raspberry Pi II" to help and care for elderly persons who live as individuals. The main drawback here is the face recognition of elders since the change in shapes and properties of the faces. Rathour et al. (2021) developed a smart mirror for IoMT Based Facial Emotion Recognition System. According to this research paper, the accuracy of emotion detection is 73% better with the 2013 ERF dataset than the current results reported as a maximum of 64%. This project includes a wristband to do

a t-test. This t-test is performed to find significant differences in a person's systolic, diastolic, and heart rates by observing three different subjects (angry, happy, and neutral). In this project, they have proposed to attach solar batteries. They have proposed to use various embedded boards and modern datasets to improve the accuracy by over 73%, which this project has reached. Najeeb et al. (2020) developed Aliza to help children who have autism. This report has suggested improvements by adding some local languages to the Gamified Smart Mirror.

3. METHODOLOGY

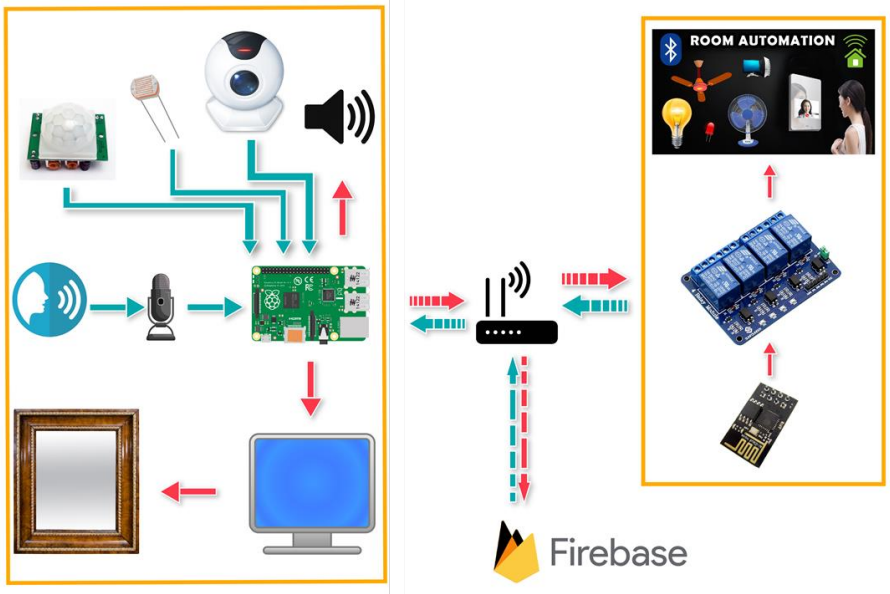

Figure 8. System Architecture

The Smart Mirror is a work similar to that of the Computerized Interactive Mirror. However, it has limited features only. In this work, we added some extra features like room automation, emotion detection, and many more smart features. The proposed IoT-based budget smart mirror represents a natural interface that facilitates access to personalized services like a newsfeed, date, time, weather updates, etc. The room automation system and emotion detection system are exciting features of this mirror. It will be very convenient for the user to control room electronics devices and get updates. The mirror is designed to make use of advancements in the IoT and its applications and allow residents to access some information while improving their user profile and experience. The architecture of the proposed system is shown in Figure 1 and explained in the following sections.

a. Motion Detection

As shown in Figure 2, when someone comes in front of the smart mirror or to the specific detection range then the smart mirror detects the movement of a user by using passive infrared (PIR) sensors. Subsequently, the smart mirror display is turned on and the 'Face Recognition' process begins. This setup was primarily made to reduce the power consumption of the smart mirror and to increase the durability of electronic components. The raspbian HDMI controlling codes were used to control the monitor status (Turn on/off) when there is a user.

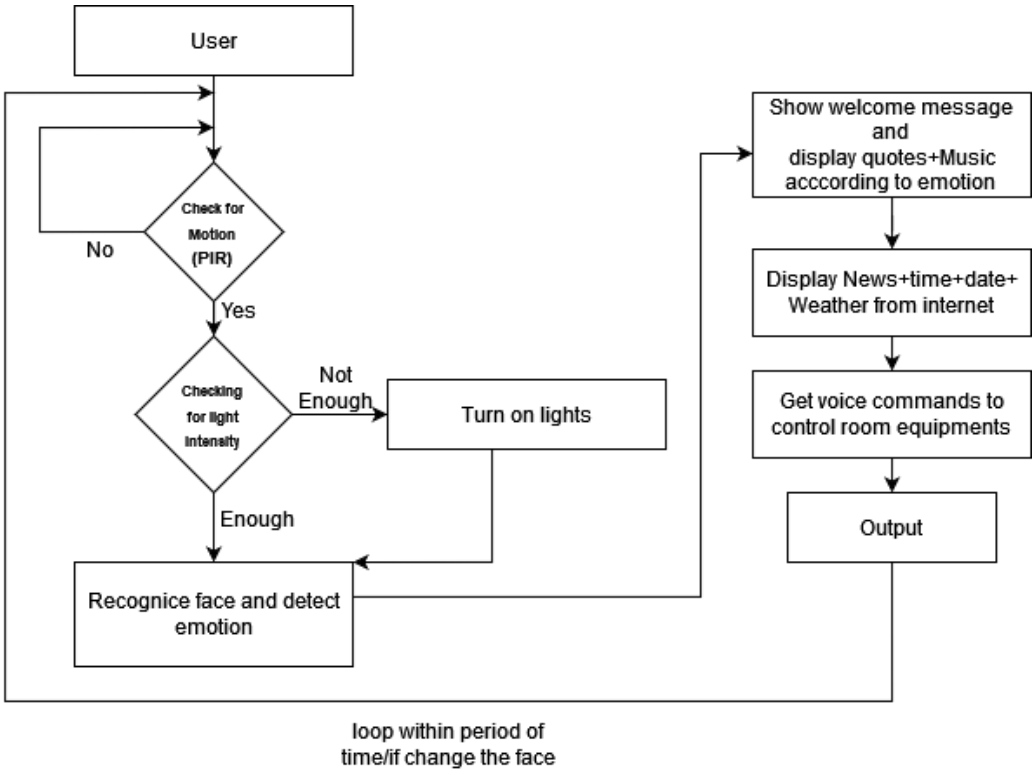

Figure 9. System Flowchart

b. Light Intensity Detection

If there is not enough light intensity when someone comes in front of the smart mirror, LDR (Light-Dependent Resistor) detects the situation and regulates the room lights. Here we used Raspberry Pi GPIO pins directly with the relay module.

c. Face Recognition

As shown in Figure 3, Face recognition technology is used to determine the user of the smart mirror and display the requested information in the user profile. If the user is not listed in the programmed database, it will display only limited default information. This Face Recognition feature is useful to protect the user's privacy because only the specific user has access to the customized display of information in the mirror.

In this process, OpenCV, NumPy, and scikit-learn packages are used for building the training model. Various photos of 6 persons were added to train the model. Here we can use a few characters for training the model. Since this smart mirror is built for the home environment the number of users of the smart mirror is expected to be a limited set of users. So, the face detection model was trained on a small database of 6 people. To increase the accuracy, we collected 20-50 photos of each user.

Figure 10. Face Recognition

d. Emotion Detection

When a machine can recognize human emotions, it can be customized to suit different human behavior, resulting in increased work efficiency. Human emotions can be detected through text, vocal, verbal, and facial expressions. It is planned to implement human emotion detection using facial expressions only. The facial expressions of a person in front of the mirror camera are used to make a judgment on his emotional level at the time, and subsequent responses of the mirror are customized accordingly.

Once the emotion of the user is detected, the smart mirror plays a piece of suitable background music and displays appropriate inspirational quotes based on the emotional state of the user. To develop the emotion detection model, the following three steps were followed in the process.

1) Collected datasets for various emotions to improve the accuracy
2) Applied deep learning algorithms for training the prediction model
3) Used the model to predict the emotions

The following five classes of emotions were predicted: Happy, Sad, Angry, Neutral and Surprise. Happy and sad emotions were detected as shown in Figure 4. The main libraries used to train the model are Pandas, OpenCV, Keras, and TensorFlow for emotion detection, and Face classifier XML file for the face detection task.

Figure 11. Emotion Detection

The brief process includes; extract a single frame and convert it to grayscale. Then it is passed to the face classifier. The detected faces returned to four variables (x,y,x,h) and then got resized. After that the classifier predicts each class according to the frames. We count the Mod of every 50 predicted emotions and select the emotion accordingly.

e. Voice Recognition

Besides the face recognition feature, the smart mirror was also incorporated with the voice recognition feature as well. Voice recognition technology helps to control smart mirrors and make their experience better. The user can use these voice commands to operate the smart mirror's features entirely with his or her voice. When receiving the audio of the user, the smart mirror will check for the database (Firebase) and if only that voice command matches with the database, the smart mirror will run according to the command as per the request of the user.

Otherwise, the mirror will not work until the right command is received from the user. We also expect to control most of the things using Ai Bot (Google Assistant) and the room automation system will work using voice commands that are recognized by Ai in the same way. The proposed system design for voice controlled room automation is shown in Figure 5.

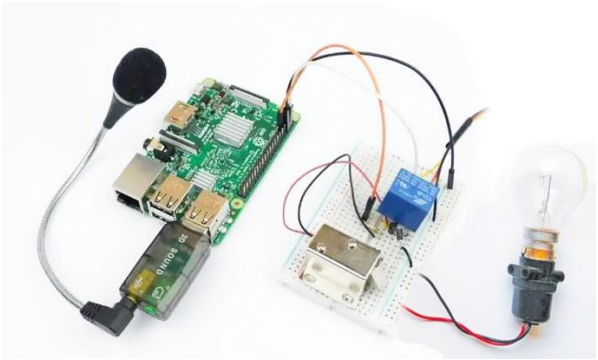

Figure 12. Voice Controlled Room Automation

f. Two-way Mirror

The smart mirror proposed here uses a two-way mirror to facilitate incorporating an LED display mounted behind. When the display is activated, it is visible through the two-way mirror. If not, the total area will act as a regular mirror. Here we use the advantage of a 'two-way mirror' to one-way reflection.

g. Processing Platform

We chose the Raspberry pi microprocessor as the project design and development controlling platform. As this smart mirror project has to cover a large scope, we require enough capacity and processing power for this project. Hence the Raspberry Pi is the best solution that we could find for this. Although this device seems like a regular mirror, it has a screen (17-inch LCD Monitor) attached to it. Raspbian OS was used as we can compile all Python scripts, Interface designing scripts, and Room automation using voice commands scripts on one platform. Little frame droppings are happening in the Emotion detection and Face Recognition part. Because codes were tested in a Core i5 laptop as raspberry Pi hasn't got much processing power. But we managed that using a better web camera and giving a good light condition to the room. Also, this Raspberry Pi board's power consumption and size were a good advantage to this project.

h. Room Automation

Room Automation using voice commands is another interesting part of the project. An ESP8266 Node MCU model with inbuilt Wi-Fi (2.4GHz) was used for this purpose. So, we could control room devices wirelessly. Also, we used 2 relay modules and it connects to a Bulb and a Fan. When we give commands like ("Turn on Fan") or ("Turn off Light"), then our Python script detects the main keywords like ('Turn', 'on', 'Fan') and according to the main commands, passes the command to the ESP through "Firebase". Here we used the Google Firebase database as the access point for the ESP and Raspberry Pi. Both are automatically connected to the firebase using an internet Router and then pass commands and updates throughout. To achieve voice detection, we used 'SpeechRecognition' and 'pygame' Python libraries. This voice command feature makes the user's life easier. Because the user can control things easily just with their voices. We can upgrade this feature to the home automation level as the user wants.

4. INTERFACE DEVELOPMENT

HTML, CSS, and JS (Java Script) were mainly used for interface development. So the information and data display on the Chromium browser on Raspbian OS. As shown in Figure 6, Black and bright white colors are used in this interface. Black for the background and white for the text and icons. Time & date, Real-time weather data and forecast, latest and top local news headlines and quotation displaying are the current functions of the interface.

Figure 13. Smart Mirror Interface

a. Time and Date

The code implemented uses the browser time and date as the reference time and date to display on the top right corner of the interface.

b. Reat-time Weather

Openweather API is used to display real-time weather data. First, the JS script checks for the location and sends it to the site. Then the site responds with the weather data.

c. News Headlines

To give a better experience to the user we choose a local news website. From that, we scrap top news headlines using python script. For that, we used beautifulSoup library to scrap data. Then we save the news headlines to txt file. After that, we read that news headline text file using JavaScript and display it on the interface.

d. Quotes Displaying

First, quotes are gathered from the internet and categorized according to their nature (like which quote, resolves the particular mood that we detect from the user). Then the quote database is addressed according to the emotion that the web camera detects. When the script selects the quote it randomly chooses from each category. So it's not showing the same quote again and again.

5. RESULTS AND DISCUSSION

As shown in Figure 7 and Figure 8, a two-way mirror and a photo frame are used to build the mirror and they are pasted tightly on a 17 Inch LCD monitor. Also, a PIR sensor and a web camera are attached to the mirror frame. The brightness of the monitor is kept at 50% level to get more reflected details. All the parts of the esthetic design are black colored and the smart mirror uses one power cable to power up the device.

As previously mentioned, the main aim of this project is to construct a low budget smart mirror bundle with maximum possible features. The total cost for the construction of the smart mirror

is given in Table 1. This clearly shows that the total cost of the proposed smart mirror is substantially less than the market price at that time.

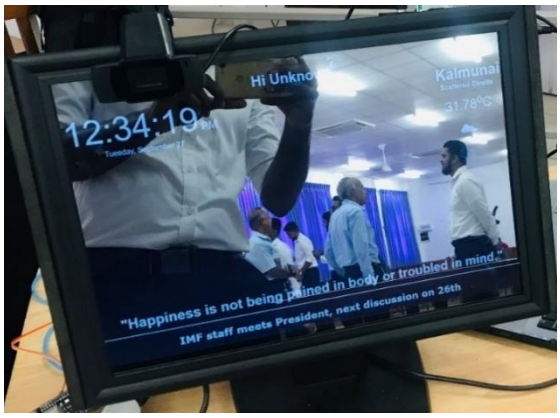

Figure 14. Output

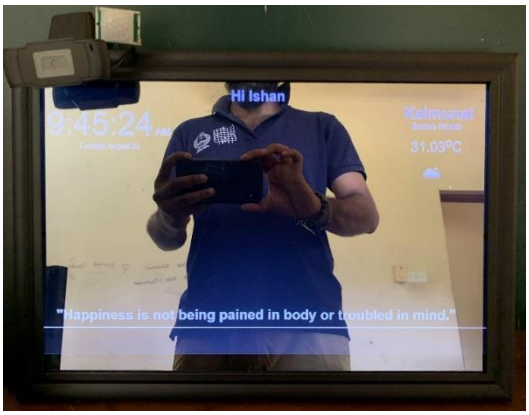

Figure 15. Smart Mirror Testing

Table 10. Budget for the Smart Mirror (As at 18th Feb 2022)

Components	Price (LKR)
Raspberry Pi 3 Model B+	9,500
Micro SD (16GB)	1,500
Monitor (17'')	5,000
Mirror + sticker	1,000
Microphone	500
Web Camera	2,000
Speakers	1,000
Micro HDMI Cable	700
Motion Sensor	400
Wooden Frame	2,000
Miscellaneous expenses	2,500
Total	26,100

6. CONCLUSION

This paper discussed the design and construction of IoT based emotion sensitive smart mirror for room automation. The proposed system consists of the following main parts: motion detection, light intensity detection, face recognition, emotion detection, voice recognition and room automation. Which help the user to improve the mental health and also make life easier. The main objective of this project is to design a smart mirror for the home environment with the maximum possible features while maintaining a low budget.

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