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SMART MIRROR

A THESIS
Submitted in partial fulfillment of the requirements for the award of the degree of
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Last but not least, we owe a great deal of gratitude, thanks and appreciation to all members of my family, for their kind support, help and encouragement.

Declaration

I hereby certify that the work which is being presented in the thesis entitled “SMART MIRROR” is in partial fulfillment of the requirements for the award of the degree of Bachelor of Engineering and submitted in Emirates International University, faculty of Engineering, Department of Mechatronics Engineering in authentic record of my own work carried out during a period from May 2022 to July 2023 under the supervision of: Dr. Radwan Albouthigy, a head of the Department of Mechatronics Engineering.

The matter presented in this thesis has not submitted by me for the award of any other degree of this university or any other universities.

Mona Amin Qasim Al-alimi

This is to certify that the above statement made by candidates is correct to the best of my knowledge.

Dr. Radwan Albouthigy

Abstract

In earlier days, data was accessible through our electronic devices. Our device is similar to the daily mirror, but with advanced technology like displaying the weather forecast, temperature, time, and daily news. Using the Raspberry Pi, data will be displayed on the device. Our planned system permits us to build such mirrors that mirror to receive online news and display the mirror with present temperature, and weather reports. Our device makes use of a raspberry pi primarily based on a total processor board along with presentations that can be interfaced together. We tend to use an exactly modeled panel to construct the outer frame. Then we use specialized glass with a back frame to enclose the system. The frame cavity is currently fitted with precisely positioned mounts for the display housing to be fitted in the mirror. This is often necessary to achieve the desired effect. Currently, we use the raspberry pi to attach web victimization to an IOT circuit through the employment of a Wi-Fi module.

Smart Mirror that creates an interactive seamless access to internet services and displays real time information from IoT devices. Internet of Things (IoT) is a concept where an object having the ability to transfer data over a network without the need for human interaction to human or human to computer. IoT is known for its advantage that can help simplify people's everyday routine.

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Chapter 1

Introduction

1 Introduction

Smart mirrors are straight from science fiction. They are part of an optimistic vision of the future that imagines a world where screens and data are everywhere, ready to feed you whatever information you need at a moment's notice. Provides a functional, user friendly and interactive UI to its user for accessing their social sites, messengers, etc. It has widgets for displaying the current weather conditions, Time, Events, Latest news headlines The Smart Mirror would help in developing smart houses with embedded artificial intelligence, as well as finding its applications in industries. Switching home appliances becomes easy with mirror. Virtual dressing, a smart way of having trials with your fashion sense make things quite easy in malls. Having such intellectual mirror will only surge the beauty of home. The raspberry pi is programmed using python and connects to a monitor with inbuilt speaker so as to provide an onscreen interface and voice assistance as well. [1]

1.1. Algorithm and Design

- Step 1: Switch on the power supply.
- Step 2: Get the date, time, and weather details from predefined from URL.
- Step3: Get the news from
- Step 4: In code section write down all the compliments to be displayed on mirror. Step 5: Display it on mirror via LCD monitor.
- Step 6: Check for user in front of mirror, If Yes, display user profile, if No, GOTO step 5.
- Step 7: Switch off the power supply when it is of no use.[1]

Table1-1: shows basic required objects for building mirror and their functionality.

1	Two-way glass mirror	To provide transparent and reflective surface
2	Monitor	Forms the display of mirror
3	Raspberry Pi	Forms the CPU of mirror
4	IR Frame	Provide touch interface to mirror
5	Microphone	For voice input
6	8-Channel Relay	For connecting to home appliances

Power connection, microphone for voice input, camera for image processing forms the basic input devices for the mirror. The monitor and speakers form the output devices of the mirror. Fig 1 depicts the basic structure of the smart mirror.

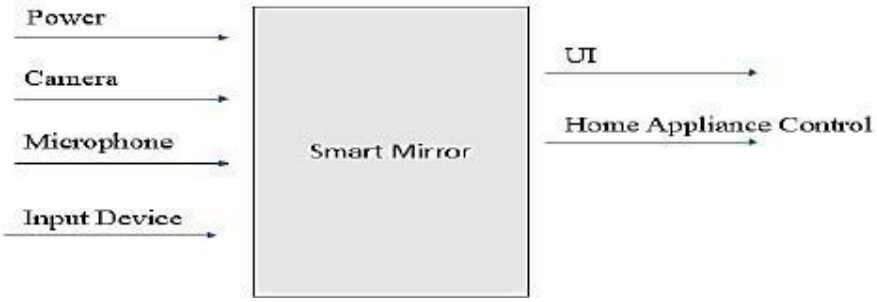


Figure 1-1: Basic Structure of Smart Mirror

1.2. Working

The working of each component in smart mirror is explained in this section. Let us talk about them one by one:

1. **Two-Way Glass Mirror**: The two-way mirror is what gives the mirror its real identity. It is magic mirror as it has reflective surface at one side and its transparent for light with good intensity. The mirror stays at the front where the user can watch himself/herself in the mirror at the same time the allows the light from monitor to pass through it and make available the UI.
2. **Monitor**: The monitor is directly connected to Raspberry Pi via HDMI interface thus providing display as well as voice output. For providing touch ability to monitor IR frames are used which are explained further in next sub-section.
3. **IR- Frames**: While research on internet we did not find any sign of how to give the mirror touch ability, so we found a way ourselves to do so. The IR-frames provides the touch interface to the smart mirror. The IR -Frames has IR sensors on its siding and connect to Pi via USB interface. Thus, making smart mirror touchable.
4. **Raspberry Pi**: The raspberry pi is the most vital part of the mirror; it forms the processing unit of the mirror. The Pi is like motherboard having all the required constituents which forms a great CPU. Its size of a credit card and still it can perform like a full-fledged computer. The programming of Pi is done using Python language. The programs can be first developed and compiled on windows or any other platform and then can run on Pi. The Pi also has its own inbuilt IDE to program in languages like C++, Python, C, Java, etc. Installation of OS on Raspberry Pi is quite a simple process. First you must download NOOBS along with Raspbian which is great OS of Raspberry Pi for beginners. The Raspbian is just a flavor of Debian OS. There are many IDEs

available to do programming for Python but what we found was PyCharm Community is free and good among them who serves our requirements. Qt Designer is amazing tool to make UI of Python. Figure 3 shows a fully functional calculator wrote in Python script. The GPIO pins on Raspberry Pi controls the 8-Channel relay which is explained in next sub-section 3.4. The Raspberry Pi has inbuilt Wi-fi and Bluetooth for connectivity purpose as well as it allows 4 USB devices to be plugged in. Figure 3: Functional Calculator wrote in Python script.

5. **8-Channel Relay**: The 8-Channel relay connects directly to high voltage input source of power and low power GPIO pins on Raspberry Pi. The GPIO pins cannot control the home appliances directly as they have very less output power that is about 5V, so we require 8-Channel relay circuit board which close the circuit of home appliances when given a high of 5V.

6. **Microphone:** The microphone is used to give voice input to the mirror. Along with touch capability a voice input makes the system very reliable and robust in working. A sensitive microphone takes voice command from the user and processes it to do corresponding action.[1]

1.3. Advantages

- Easy to communicate
- User friendly
- Voice input
- Fast and easy images replacement
- Adjustable images switches times
- Low power consumption
- 10mm acrylic frame is available when thin and light magic mirror light box display are major concerned
- Installation of magic mirror light box is as simple as any other ordinary light box. [1]

1.4. Existing Systems

The genesis of the smart mirror starts with the HUD Mirror where the rear-view mirror is transformed into a smart mirror, providing the user with car and driving information as Heads-Up-Display (HUD). To make the mirror quite interactive, a voice based smart mirror has been designed to access simple information such as date, time, calendar, Stocks and weather reports using voice commands. It is sufficient for the user to be in its audible range. However, it lacks customization i.e., new features cannot be added. An improvised version of voice-based smart mirror for playing music autonomously was developed by Brussenskiy. It uses a gesture control for turning music ON/OFF and voice controls for playing the same. It also employs temperature check for humidity in order to perform safe voice-based operations in bathrooms. It allows addition of new contents, though manually. The gesture control features are further enhanced in New York Times Mirror. Here it uses Microsoft Kinect for movement tracking of users tagged with RFID and voice control for HCI operations. With increase in development of smart mirror technologies, to ease smart mirror application development across any platform over web, Smart Reflect has been proposed by Gold. It uses MVC model and the browser serves as primary display container. It can display basic internet services on the mirror. Smart mirror can also be used as a part of IoT based home automation. Its functionality can be extended to control home appliances to provide ambient home environment in addition to its personalized information services with touch-based features. Touch based systems are very expensive compared to voice-based systems and are unsafe to use in wet bathrooms. Some work such as Wize mirror and Fit Mirror involves using a smart mirror for a healthy lifestyle. Such mirror either grabs health information directly via cameras or passively from user smartphones to track vital information such as cardio-metabolic rate and provides suggestions to improve their lifestyle. Some smart mirrors focus on privacy issues by providing facial recognition-based authentication. Aditya and Anjali automated the smart mirror based on individual users, by observing their access pattern. To improve the prediction accuracy, users are identified by analyzing certain important events from their event history. By analyzing the pros and cons of existing smart mirrors discussed aforementioned, we propose our Smart Mirror which is a prototype implementation that integrates the best features of most smart mirrors. Some of the prominent features of our mirror are: voice-based operations, extensibility (as it uses plugins), controls home appliances, connection to health monitoring devices to provide health tips and operates at different modes based on internet connectivity.[2]

1.5. Proposed System

The smart mirror consists of a one-way mirror which is positioned in front of the LCD display. Raspberry pi 3 kit is connected to the display. Apart from basic components, the kit consists of additional components such as microphone, sound card, memory card, sensors, power adapters to realize the available services. The user can access the services through voice commands via microphone. The voice commands are then processed in the cloud and returned as text. Then the services corresponding to the text are invoked and executed. Finally, the result is displayed on the monitor (Figure 1-2).

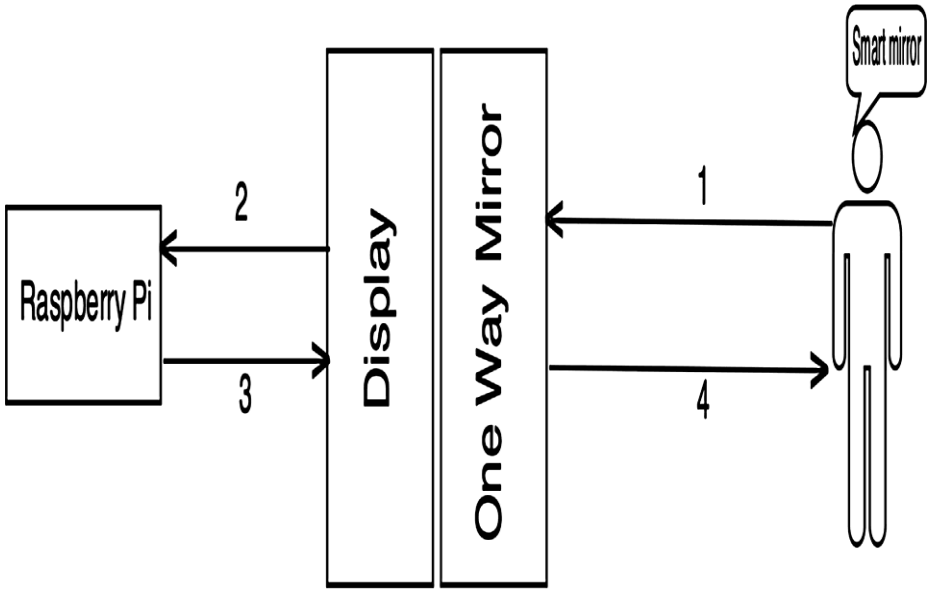


Figure 1-2: System architecture

1.5.1 Working Modes

The smart mirror can work in three modes: independent mode, internet mode and internet mode with health monitoring device.

Independent Mode. This mode does not depend on the Internet. It displays information that was previously obtained when the device was connected to the Internet.

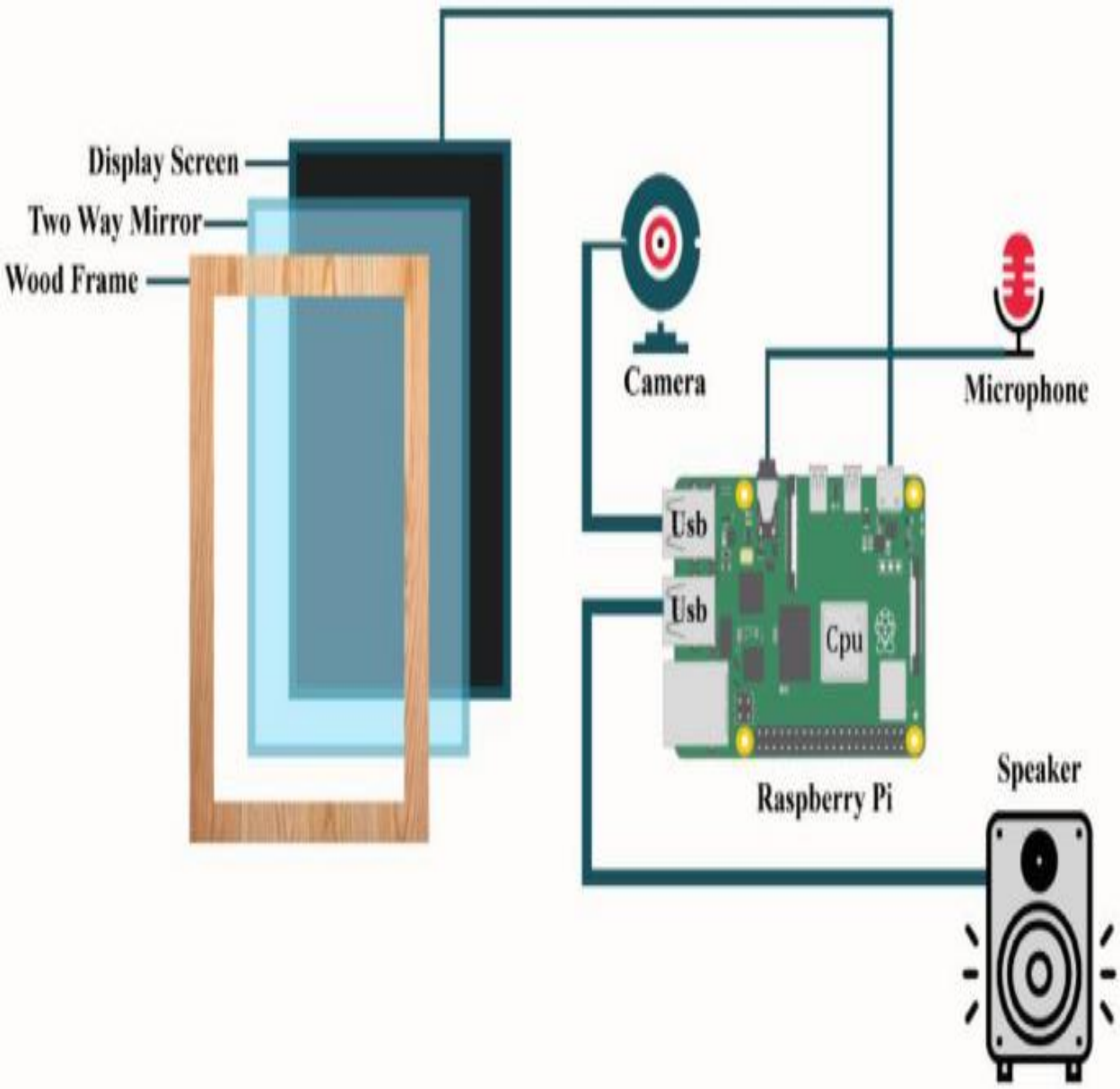
Internet Mode. This mode provides real-time information when connected to the Internet.

Internet and Health Monitoring Mode. In this mode, real-time information and user's health data from health monitoring device is displayed. Smart mirror has two states: inactive and active. Both basic and advanced services are provided only inactive state. Inactive state is triggered either by timeout or by voice commands. During inactive state it functions as a normal mirror.[2]

Figure 1-3: smart mirror

Chapter 2

Background and Literature Review



2.Literature Survey

Using the MCU and PC techniques weather, Twitter, news, to-do list, and calendar is displayed to provide the user-specific information along with grooming feature of the mirror. This was proposed by Varsha Singh. Raju Nadaf designed and implemented a smart mirror to provide Security by detecting any of the intuitions passing around the area of the mirror using Raspberry pi. Derrick Gold designed and implemented smart magic mirror to allow users to interact with the mirror and to access information. Kun Jin designed and implemented Smart Mirror for home automation system to meet consumers need towards intelligent life using Raspberry pi which is helpful for the Home Communication. Design and implementation of smart mirror for intellectual purposes which is time saving and affordable assistant which displays weather, news, date and time, this was proposed by Ayushman Johri . Design and implementation of Smart Mirror to enhance such mirrors with intelligence and security was done by Charles Njaka . Design and implementation of the smart mirror to provide an improvement attempt to reinforce the mirror with magnified features was proposed by R Akshaya . Design of mirror that offers the services to the home environment was proposed by Mohammed Ghazal. Fatima Ok designed and implemented Smart Mirror which majorly concentrated on providing users to access information via internet. Sun Young developed design and implementation of an intelligent mirror based on Raspberry Pi designed for home of internet of things. Mohammed Yusri designed and implementation of smart mirror for intellectual purposes. Oihane designed and implementation of a smart mirror which can be used by multiple users to provide healthier work environment. V E Pawar designed and implementation of a smart mirror to provide both mirror and computer aided information services to its users using Raspberry Pi 3 Microcontroller card.[3]

2.1 Hardware and Software

2.1.1. Hardware Components

a) Raspberry Pi: Raspberry Pi is the key hardware component used in the smart mirror to display user-specific information on the monitor. It is a small single-board computer which runs code on the operating system installed in it. This component has a pre-installed Operating system called Raspbian (Operating system), which is debian-based Operating system. The code can be written in any of the supporting language. This paper is based on JAVA Script. This helps the monitor to display weather-forecast, date and time, email notifications, calendar, news-feed and music with the written code dumped to the device. This also includes the usage of web-based services to display weather, news and other information by extracting

the information from the internet as tokens to present on the monitor in order to provide it to the users. To accomplish this, the Raspberry Pi module has a Wi-Fi module to connect to the internet. The voice recognition is achieved by receiving the input from the microphone connected via USB card which allows user to give the voice input to the mirror to set up reminders and for conversations.

Figure 2-1: Raspberry Pi

b) LED Monitor: LED is a Light Emitting Diode monitor which acts as an interface between the raspberry Pi and the mirror to display the user specific information on the screen via a HDMI cable. This displays information such as weather-forecast, date, time, calendar, complements to the user, news-feed and email notifications. This information is displayed under the control of the voice input given by the users. This display is visible to the users with the use of Two-way mirror which has both reflective and refractive property. Hence, by placing Two-way mirror in front of the display the user can view the information while grooming themselves.

c) Microphone: The voice input to the mirror is provided by connecting a microphone to the Raspberry Pi module via the USB card. Hence, by connecting microphone to the device the user can input voice commands to display certain specific information and also command the mirror to do tasks like setting up of alarm, reminders and for voice conversations.

d) Speaker: A speaker is connected to the Raspberry Pi in order for the Two-way conversation between the mirror and the user by giving the audio output.

e) Two- way mirror

Daily use mirrors have a reflection property which reflects the entire light entering the glass and hence allows only users to view their reflection. But Two-way mirrors have the property of both reflection and refraction where only some part of the light is reflected and the rest is refracted passing through the glass surface and hence allowing the user to view the information display on the monitor. [3]

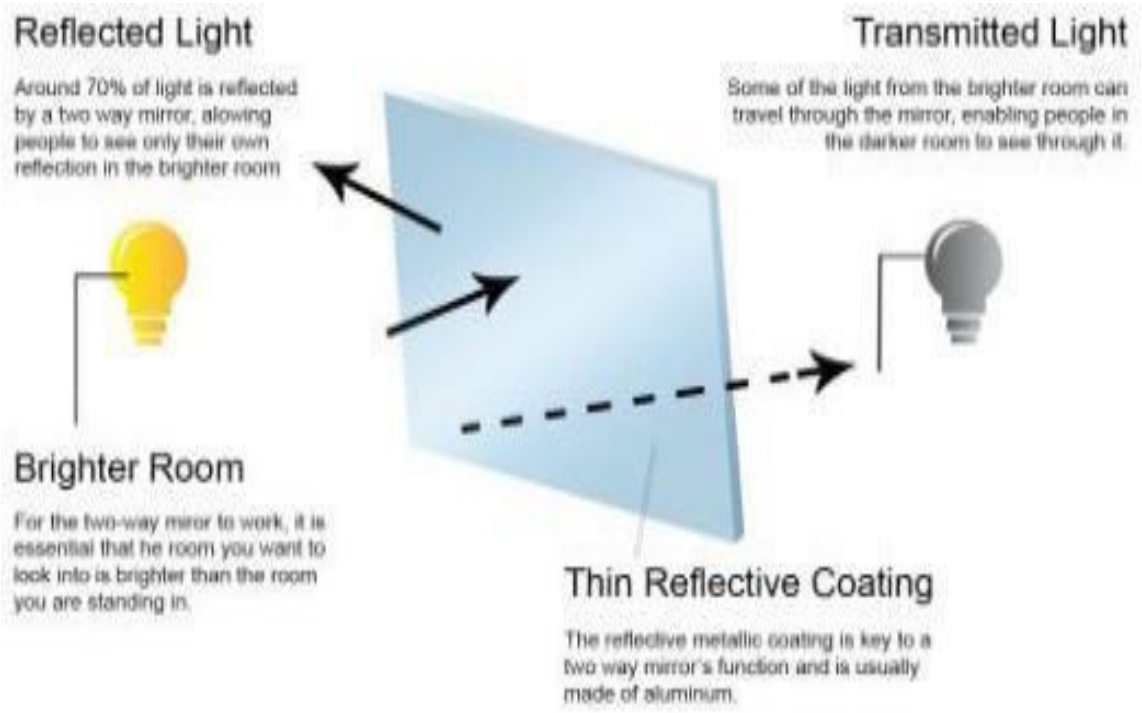


Figure 2-2: Working of Two-Way mirror

2.1.2. Software components

Raspbian Operating System: Raspbian OS is a Debian-based Operating system which is pre-installed in the raspberry pi component hence, making the users easy to code. JAVA Script: The coding language used to display information in this paper is JAVA Script. JAVA Script or JS is a programming high level language, just in-time compiled and prototype-based object-orientation.[3]

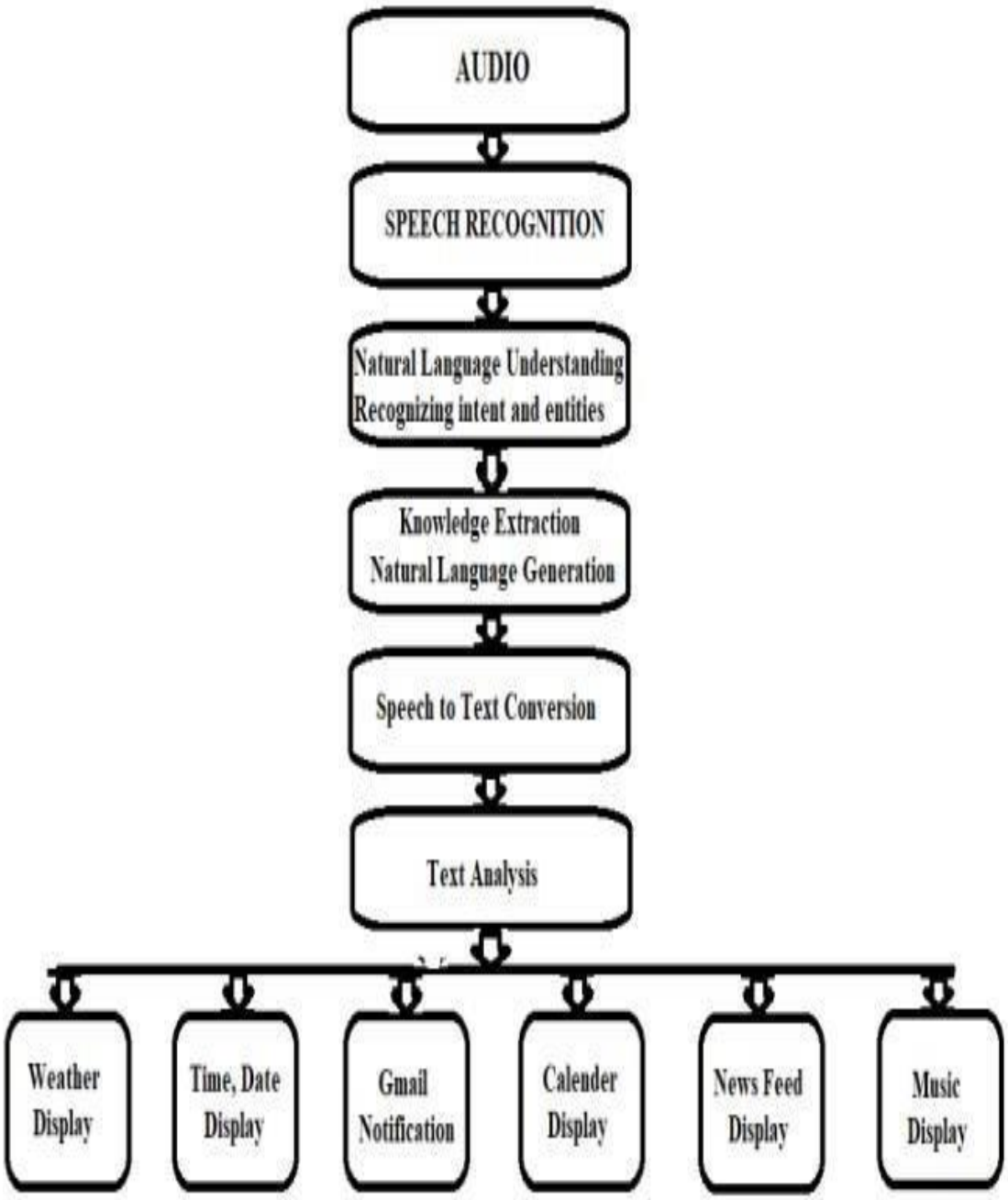


Figure 2-3: Block Diagram of Working of Smart Mirror.

The working of the model is according to the above Block Diagram. The voice input, which is the audio is taken as an input by the system. The Speech recognition module recognizes the input audio and hence converts it to a computer understandable language using algorithms through knowledge extraction and Natural Language Generation. This recognized Speech is now converted to text Using speech to text converter code. The given text is now analyzed and based on the analysis the control is sent to the respective module which contains the code for the display of requested input. Audio: This is the voice input given by the users in order for the response from the mirror. Speech recognition: it is the capability of a machine or program to indicate words and phrases in spoken and convert them into a machine-readable form. Rudimentary speech recognition software consists of minimal or limited vocabulary words and phrases. Also, these are identified only if they are spoken very clearly. If the software is more sophisticated then it has the ability to accept natural speech. The speech recognition works with the help of algorithms through acoustic and language modelling. The acoustic model shows the relationship between linguistic units of speech and also using audio signals. The language modelling matches sounds with word sequence so as to help us differentiate between words that sound alike. Knowledge extraction and natural language generation: it is the generation of knowledge from structured (relational databases) and unstructured sources (text, images). The resulting knowledge has to be machine readable as well as machine interpretable form and should represent knowledge in a way that helps in inferencing. Speech to text conversion: this is the process of converting spoken words into written texts. This can also be called as speech recognition. The terms available here are almost synonymous. It is sometimes used to explain the wider process of extracting meaning from the speech which means the speech understanding. An ADC will convert the analog waves of your voice into digital by sampling the sound. As higher the sampling and precision rates increase, the quality also increases simultaneously. In order to convert speech into on screen text or computer command, a computer has to perform several steps. Text Analysis: This can be of two methods. Storing the predefined texts and hence comparing the Speech input texts with the stored texts. The text which matches is then taken to the respected modules. The generated text can be analyzed by comparing the texts with the Google words using naïve Bayes Algorithm. Modules: The analyzed text is then sent to the respective modules for their display. This includes: Weather Display: Displays the information of weather of the given city along with future weather prediction. Time, Date Display: Displays time and date of the given city. Gmail Notification: Notifies with the pop-up message. If there are any mails received. Calendar Display: Displays the calendar with upcoming holidays. News Feed: Displays the news happening around the city. Music: Plays the music stored inside the module. Our proposed model can show various capabilities which it can perform: It can work as an intelligent mirror with an aim that the client can use it as an ordinary mirror. The two-way reflection can work as an intelligent as well as a see-through mirror. This is connected to a LED screen and gives two important functions; they are: Emulating a mirror as a filling in as a show for ongoing information. [3]

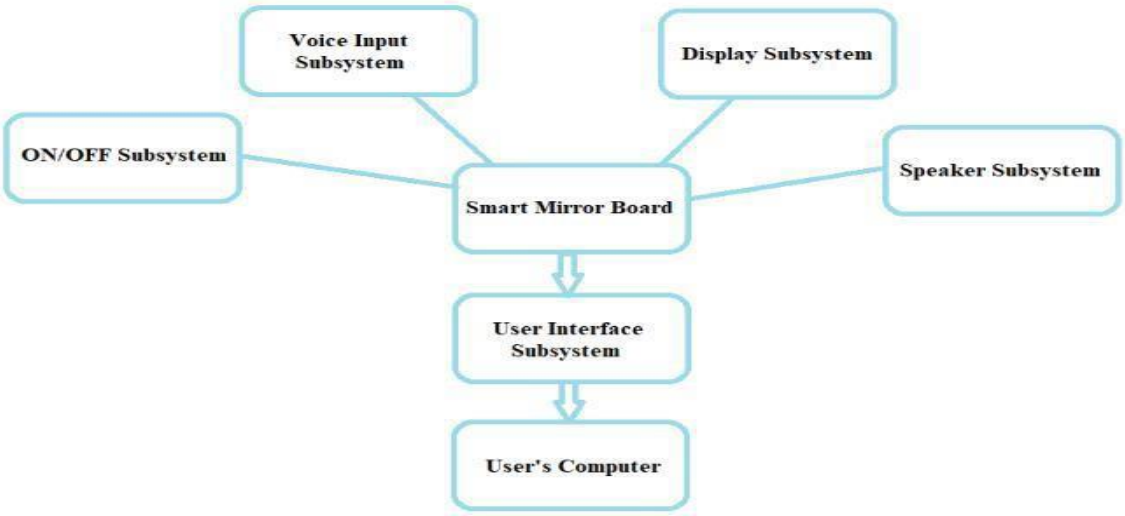


Figure 2-4: Overall Subsystem Flow-diagram

2.2 Literature selection methodology

A selection methodology of current research work was defined and performed in order to study the most relevant smart mirrors literature for this review. This section presents a description of the literature selection procedure which is summarized in (Figure 2-5) [4]

Figure 2-5: Literature selection methodology

2.2.1 Keywords Filtering Phase

The selection methodology of related articles began with a search from Google Scholar database with at least one of the following keywords in the article title: (1) smart mirror, (2) smart mirror IoT, (3) magic mirror or (4) smart mirror Raspberry Pi. This phase results in 65 research articles.[4]

2.2.2 Publishers Filtering Phase

The literature selection methodology focused in research articles published in the following publishers: (1) ACM (2) IEEE, (3) Elsevier, (4) Springer, (5) United states patent and (6) IOS press. Percentage of articles per publisher is presented in Fig.2. This phase results in a reduction from 65 to 48.[4]

2.2.3. Abstracts Filtering Phase

Considering the 48 articles from the previous phase, an abstract reading was performed in order to identify only the most relevant articles that specifically study the smart mirrors. Hence, 40 articles were selected from the smart mirror's literature.[4]

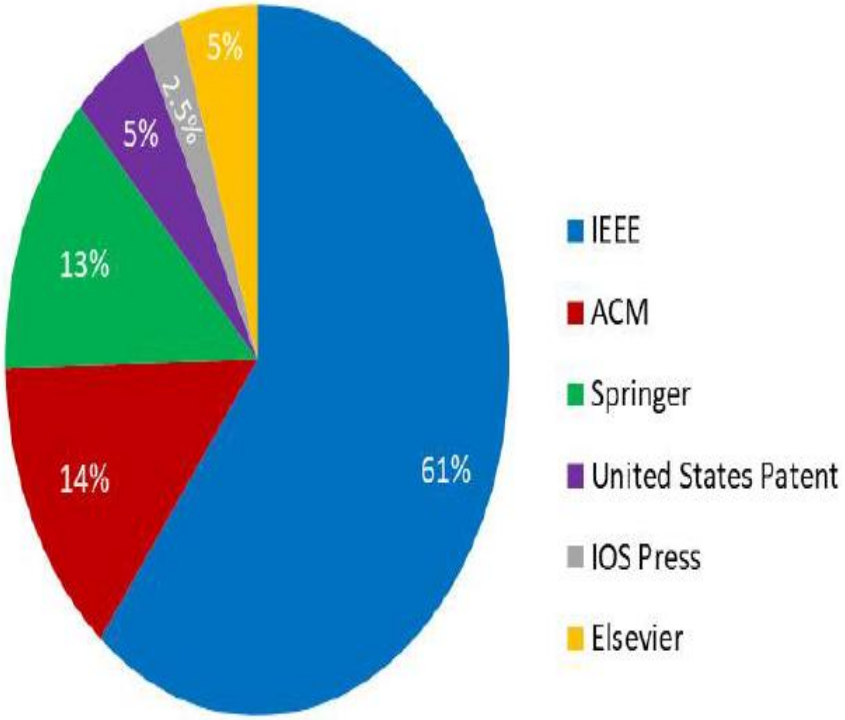
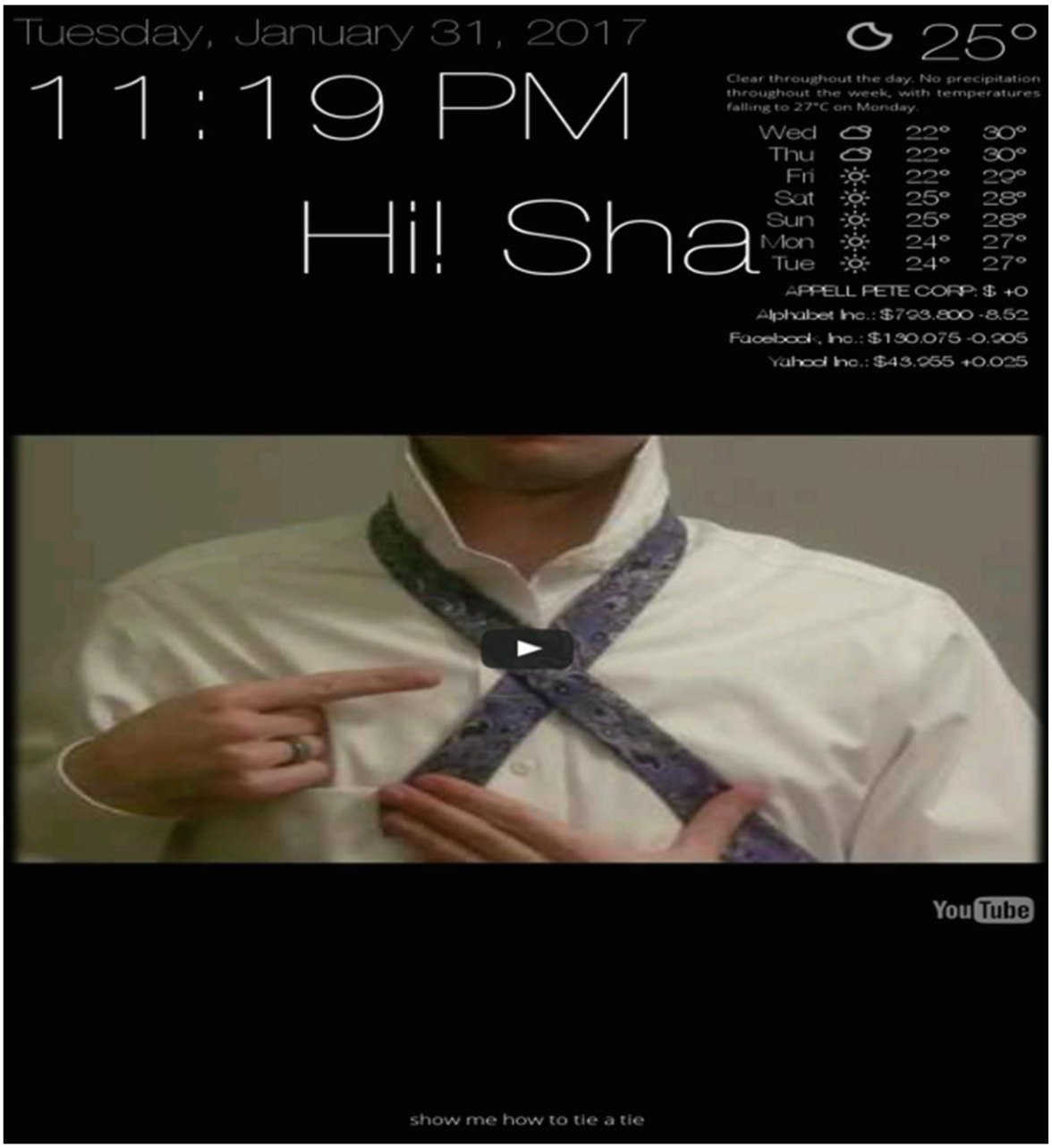


Figure 2-6: Percentage of articles per publisher in the 40 articles.

Chapter 3

Implementation and Test



3.Implementation and Test

3.1 System Implementation

This chapter explains the methodology selected in completing this project. A methodology in this context refers to the splitting of development work to distinct phases containing activities with the goal of a better planning and management. The Methodology approach used in this project is called The Evolutionary Prototyping. Prototype model is a life-cycle model that allows applications to be developed in stages so that it can be modified easily according to feedback from users. Evolutionary prototyping focuses on gathering a correct and consistent set of requirements. The process lends particular strength to building quality software by means of the ongoing clarification of existing requirements and the discovery of previously missing or unknown requirements. Traditionally, the iterative reexamination of a system's requirements has not been the panacea that practitioners sought, due to the predisposition for requirements to creep over and the difficulty in managing such requirements. Figure 3-1 shows a flow chart of the system implementation in Smart Mirror. Users can give instructions to the system to view a list of commands that are available.[5]

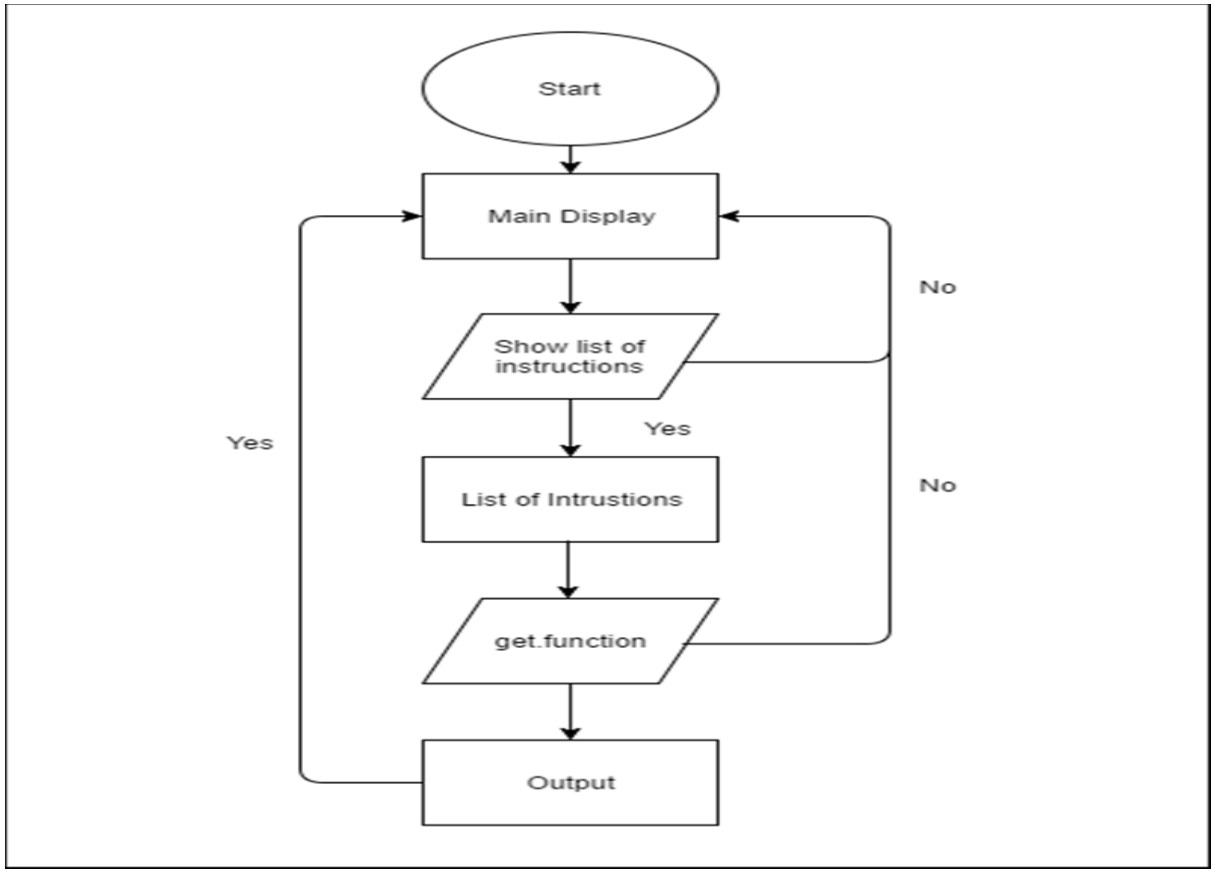


Figure 3-1: Flowchart of Smart Mirror.

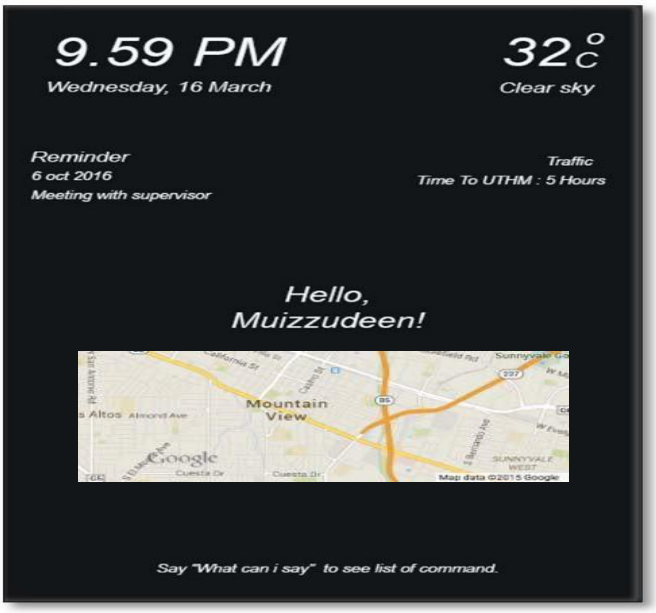


Figure 3-2: Example of the system's response when the user gives instruction to get location map.

Figure 3-3: Example of the system's response when the user gives instruction to create reminder.

3.2 Project Inputs and Outputs

The input in our smart mirror is mainly through the voice commands that it listens and gives results according to it. The tasks include setting a reminder, appointment, meeting and even uses its assistant to view photos through the mirror, the photos that are synced with the user's smartphone.[6]

Figure 3-4: Input

The output is generated from the smart mirror in the form of voice as well as text feature. Mainly the output contains the basic features of a smart mirror like weather, time, calendar, holidays etc. The output is also generated through the assistant that we use through voice commands as input. The output and input generated through the smart mirror can also be seen in graph though the analytics feature provided by the assistant.[6]

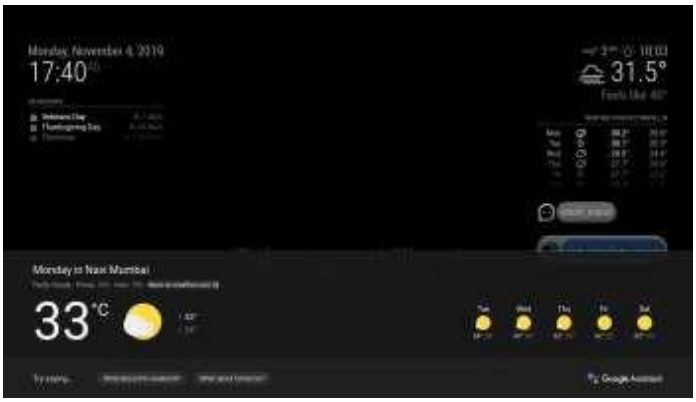


Figure 3-5: Output

3.3. System Testing

A group of developers have conducted several tests on the system to ensure that the system meets the functional requirements. There are three sections involved in the testing phase, which are test cases, expected results and actual results. The term "Success" and "Fail" indicates whether the field has performed well or resorted into failure. To implement and test the developed system, Google Chrome has been selected as the web browser. Developers have tested the system using unit testing method, starting from the design of webpage to the system's functions. Unit testing was the selected technique as it can help in isolating bugs. Table 3-1 shows the results of unit testing carried out by the developers.[5]

Table 3-1: unit testing results

Test Case	***Expected Result***	***Actual Result***
Design of webpage is clean and easy to view	Display content in correct order, user can clearly understand.	Success
Text box and text area are able to capture the data entered	Data can be entered successfully.	Success
Different types of data are entered including negative number, positive number, and special characters	System's validation function is able to validate the input data according to the criteria set in the input element of user interface. System is able to alert user on wrongly entered data type.	Success

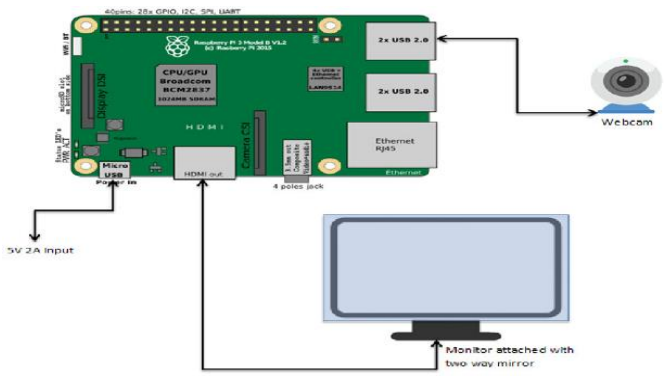


Figure 3-6: Block diagram

Table 3-2 shows the results of system testing. This testing method was selected for testers to evaluate the system's functional criteria.

Table 3-2: system testing results

Test Case	***Expected Result***	***Actual Result (1)***	***Actual Result (2)***
Running the system	• Running Smart Mirror	Success	Success
Configure PI	Rotate monitor Disable screensaver and remove panel Hide the mouse during inactive mode	Success	Success
Configure sound	• Audio input and output configuration	Success	Success
Configure voice	• Setting up Speech Recognition	Fail	Success
Control lights and allow Enabling Motion Detection	• ConfigUI to configure and enable motion detection	Fail	Success

The tests involved were divided into unit testing and system testing. After the unit testing was carried out on Smart Mirror, with one-time evaluation, there were no problems encountered in terms of webpage design where it is found clean and easy to view, text boxes and text areas are

able to capture the data entered and different types of data can be entered including negative number, positive number, and special characters. Meanwhile, in system testing, the evaluation criteria include running the system, configure the PI, configure the sound, configure the voice and control the lights and allow enabling motion detection. This test was performed twice and the results are shown in Table 3-2. The first test was performed with two test cases resorted into failure, i.e., configuring the voice and controlling the lights and allow enabling motion detection. After some maintenance, the test was performed for the second time. The second test presented improved results where all functions of the system worked properly.[5]

3.4. Applications of smart mirror

In this paper, forty articles on smart mirror applications were reviewed and classified based on the field. The fields are general, medical, fashion, academic and sports fields.[4]

3.4.1 General Field

The authors have developed a smart mirror that acts as a personal assistant to solve the problem of lack of time that faces many people. It displays some general information like time, weather, news, etc. The users can read and reply emails, also view and edit daily schedules for multiple users. Users can also interact with the mirror using a graphical keyboard within the mirror. Whereas many features were added such as the Arduino Uno micro-controller with a Global System Module (GSM) to send emergency calls. The system also uses energy-saving sensors if there is no object near the device. As a result, the smart mirror allows time can be properly exploited by performing different tasks at the same time. The authors have provided an interactive smart mirror using AMbient Intelligence (AMI) services encompass interactivity through multimodal user interfaces. The interface can understand and recognize surroundings in connect with IoT. The proposed smart mirror system aims to provide users with an interactive interface to simplify personal services for the user in home such as news, multimedia, time, weather and others. In addition, it provides fitness trackers and supports two languages, which are Arabic and English. It was implemented using Light Emitting Diode technology (LED) screen presenting a two-way mirror that is connected to the smart mirror mobile application. Other features such as a real time sigma filter for reducing the noise and Bluetooth were included as well. The result of this system is an interactive mirror which is easy to use and adapt while performing daily tasks. The authors have designed a small low-cost smart mirror using a simple operating system with wide application range. The mirror is useful especially for people and it suits them needs. The users can display the weather, road traffic, news and their schedules. The system was developed using a Raspberry Pi. In addition, some of the system features such as face and recognition, voice playback, remote control, Wi-Fi connectivity and a clothing indicator were included on a plasma screen. The smart mirror consisted

of several modules: the control module, display module, clock module, wireless transceiver module, and Bluetooth module. In general, the results showed that it is possible to design low-cost smart mirror using simple materials with Raspberry Pi.[4]

The authors have proposed a smart mirror that displays a calendar, weather, synchronized reminders and social media notifications. In addition, it detects if someone in front of it by using passive InfraRed (PIR) sensors and it supports a Wi-Fi to connect to the Internet. The users can interact with the mirror by using voice commands. In general, the mirror interaction method is useful for old and disabled people. The authors have focused on the problem of the user's social emotion especially the negative emotions to improve it through the magic mirror. To analyses the user's feeling, the mirror has four modes: mirror mode, alleviation mode, reminder mode and silent mode. Moreover, it supports identity recognition, facial expression and social emotion. Furthermore, in case of negative emotions appearance, the mirror displays positive words on the screen and runs the user's favorite music to cheer them up. In general, the results showed that the system helped to improve and treat the bad mood of many users. The authors have provided a smart mirror that helps to improve the quality of people's life. The main feature of the mirror that it allows the users to perform many tasks such as viewing news and web browsing simultaneously with easy access to their information. The users' commands can be received by voice identification and facial recognition through Multi-Layer Perceptron (MLP), Naive Bayes (NB) and J48 algorithms. Finally, a mobile application was developed and connected to the mirror to get an image of the user to use it in face recognition processes and time optimization.[4]

A smart mirror based on facial recognition and user interaction through Artificial Intelligence (AI). The system provides general information about weather, email notifications, news update and calendar. The results showed that this smart mirror system can recognize a user with 80% accuracy. The authors have concentrated on the design and the implementation of a smart mirror that can recognize and analyze faces, which is called the smart magic mirror. Different cases have been introduced in this mirror. At first, the offstate where the mirror behaves as a normal mirror. Secondly, the stand-by-state is enabled through mirror sensors, when it senses the presence of people in front of mirror. Finally, the on-state after mirror activation state. The mirror interacted with the environment by recognizing people, identifying them and monitoring their emotions. In general, this mirror can identify, track and analyze the users' faces to record their facial expressions and emotional states. The authors have combined speech/image processing technology, Internet information and reflective glass features to create the Snow White's magic mirror. The mirror displays Genius 3D graphics to receive user commands. In addition, displaying general information such as date, daily schedule, news and time. The mirror can distinguish between males and females through user voice commands. Moreover, it provides multimedia services so the user can play music, video or movie on the mirror. The authors were inspired by the design and implementation methodology that used in the older version of the magic mirror, which provides constantly updated information to the user in an interactive way. In general, the results showed

that the magic mirror provides various multimedia services that are useful to users and interacts well with their needs. The smart mirror system allows users to easily manage some household chores and their diurnal activities. This system is important to save users energy in managing stuff and to control the use of home electrical appliances that connecting over the network. In addition, the mirror provides the ability to control the lights of the house by voice recognition and track general information such as time, weather, traffic, etc. In general, the results showed that the functions of the system work correctly. The inventors have provided an electronic device as a smart mirror that focuses on control techniques generally, because most smart mirrors focus on displaying information only rather than balancing information display and mirror reflection. In addition, there are different techniques used in this device such as eye tracking and focusing. An eye gazing sensor was used for eye tracking to interact with the user. Generally, this technique is desirable when user movements are limited. The authors have focused on facilitating and simplifying service under the Do-It-Yourself (DIY) concept to display basic information such as time, weather, date and news headlines. The system was developed using Raspberry Pi. The users can login through the website on their phones or tablets to add or remove tasks that will be run in the mirror. The authors have developed a smart mirror to help people improving their personal appearance and daily life. The mirror displays some daily use information such as weather, date and time. Furthermore, the mirror was applied using Raspberry Pi 3 and Alexa voice service application to receive voice commands. The authors have developed smart mirrors which displays many features such as weather, time and temperature. In addition, there are two key buttons: website and maps. In general, the most important result of this paper is that this smart mirror can be used in several areas and it is easy to use. The aim of study is to design and implement a smart mirror system for multiple users in the work environment. At first, employees are recognized by their corporate ID card to access the interface. The smart mirror provides information about the surrounding environment (thermal, humidity and light), also general information (e.g., weather and daily news). In addition, motivational information associated with the physical performance which promotes their physical activity weekly. The general aim of study is to track faces in order to apply the distortion and manipulate process. Considering faces is very important in the social communication because it detects the real-time reactions. The main goal of this virtual mirror is to apply entertainment in a simple way, this is done by recognizing the faces that appear in front of the mirror and ignoring any object in background that could affect the results. In general, the tracking results were well and video distortion results were pleasant to use.[4]

The main objective of this study is to provide education and entertainment for the public. The virtual world it is important in some application such as scientific experiments. In addition, it is used in many places such as museums, science centers and other public places via camera and screen act as a mirror where one can see a reflection of oneself and virtual objects together. By using an Augmented Reality (AR) system and transparency, real and virtual data is combined with the virtual world as fact to improve AR. The authors have focused on designing a smart mirror for the home environment. The main purposes of this mirror are to control the house devices and to

view some general information. Besides, to use these features, users' identities must be verified through face recognition technology that implemented by using a web cam to take an image of their faces as an input. The authors have developed a smart mirror for the purpose of smart home security and displaying some general information. The system was implemented using a Raspberry Pi 3 within a touch screen. Biometric authentication with multi-factors such as voice and face recognition technology were implemented. As a result, the system is secured and it works for registered users only. The authors have developed a smart mirror that can be used in intelligent home communications. The importance of this smart mirror is that it is efficient, intelligent, safe and relatively costly. Furthermore, the authors have designed this smart mirror according to the principle of unidirectional photography. In general, the results showed that the smart mirror increases the possibility of voice control in different conditions also, improves the safety through the face recognition technology by comparing between user's face and the previously recognized faces to send an alarm in case of nonconformity to the owner state occurred.[4]

3.4.2 Medical Field

The authors have discussed how to detect facial expressions and signs to discover the health condition of a person. The purpose of these papers is to help users to improve their lifestyles by giving them the opportunity to monitor their health with tips and guidance. The authors have presented a unique multiple sensors intelligent device, the Wize mirror. It was developed to identify and convert the facial expressions and face signs associated to the risk of a cardio-metabolic into measures and arithmetical descriptors. Using different measures, the quality of the users' health is assessed and judged. Various methods such as face tracking, detection and reconstruction, emotion, heart rate and age estimation were applied. The authors have developed a magic mirror that aims to help in neurorehabilitation process to support the upper limb dysfunction patients. Generally, the results proved that the patients accepted the developed system. A smart mirror was built to identify the user mood using the face recognition technology. At first, the mirror presents general information. Furthermore, a face and mood recognition features were performed through observing and analyzing user's face and outbound movements. Overall, the application of this mirror is more general so it can be applied in different environments such as hospitals to detect unwell people automatically.[4]

3.4.3 Fashion Field

The authors have made a smart mirror as a virtual fashion consultant, which can analyze, estimate and recommend the appropriate wearing and outfits. Under fashion directions, the users have been guided to find out what to wear to make their own decisions by providing AR and gestures recognition. In addition, there are icons to choose the clothes in 2d visualization.

The authors have produced a Kinect based Virtual Reality (VR) system. It provides the possibility for the users to virtually try multiple handbags in front of a simulated mirror (TV screen) at home. In addition, the possibility of teleportation, which allows the users to see the handbags with different background environments. The authors have designed a virtual fitting room through a smart mirror allowing people to design and try fashionable t-shirts virtually. Furthermore, a projector and a printer were connected to print the produced user-created designs through textile printers or on needlework machines. Generally, this system combined between AR and body pose tracking. The authors have designed an automatic personal makeup system. The system implemented through a smart mirror, to determine makeup features that mostly fits for user's face by applying it on the facial images. In addition, the system was built during analytical users' faces with Machine Learning (ML) and AI techniques. The authors have proposed a smart mirror, which aims to provide a system for the smart makeup mirror and lets the users to be able to apply different makeup styles on them faces in a natural way and enjoy this experience. The mirror helps to decide which makeup is right for the face. It provides convenience, efficiency and usefulness to users. The system connected with a web page that allows friends to vote on makeup results that suit the user. Users use 3D to apply the makeup virtually on them faces.[4]

3.4.4 Academic Field

The objective of the study is to use a magic mirror for teaching anatomy. Using a magic mirror system to display anatomical structures on the user's body for an easier understanding. In addition, body pose tracking by AR. Moreover, when the user stands in front of the camera, it creates perceptions and fantasies through the system besides 3D models for the body organs, text information and images about anatomy. After using the mirror, the user's feedback was positive, especially for children. A smart mirror was developed to adjust and record user's moods through recognizing their face expressions. The results are showed in three colors (Red for happy, blue for sad and yellow for angry mood). The mirror was tested by a number of college students whose comments varied between negative and positive on efficiency of the mirror in identifying emotions correctly.[4]

3.4.5 Sport Field

The main goal of this study is to interactively support fitness and wellness exercises for the visitors of the touristic resort. Moreover, it can evaluate the current physical state of the user by a technology-reinforced mirror. It consists of interactive home controller, AR and multimedia player. In general, it clarifies the scale of well-being by used some simple and compact indicators through provided mobile application. The smart mirror, Fit Mirror, was created as an interactive device that aims to improve the user mood and increase motivation having a positive effect on the

user's feelings. Moreover, Fit Mirror motivates the users to wake them up in the morning and to do their exercises at this time. In addition, the mirror was associated with the Android Fit application to display the user's data of what they have done during a week of exercise, the user's pressure and stress. The user can connect with the system through touch or voice.[4]

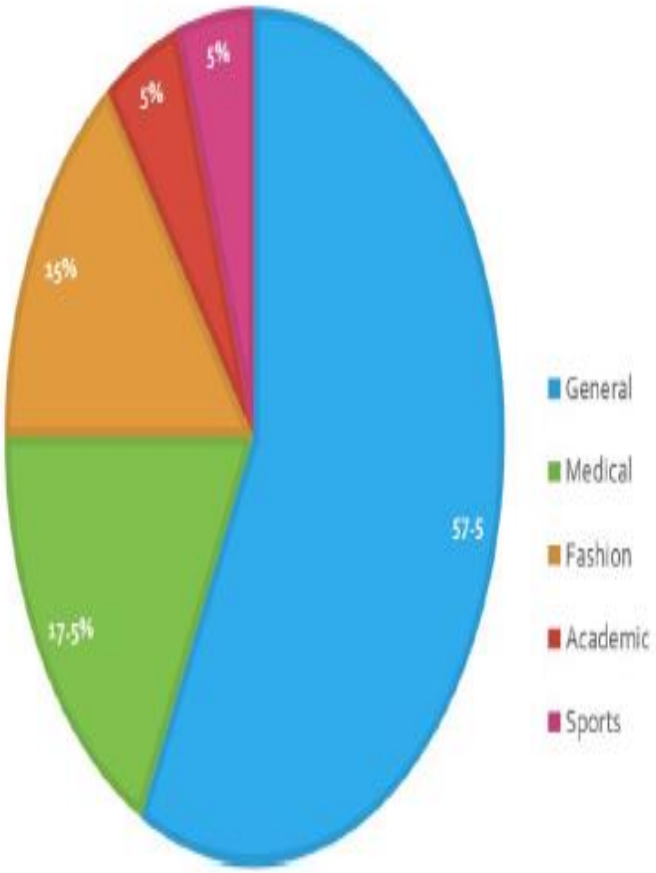
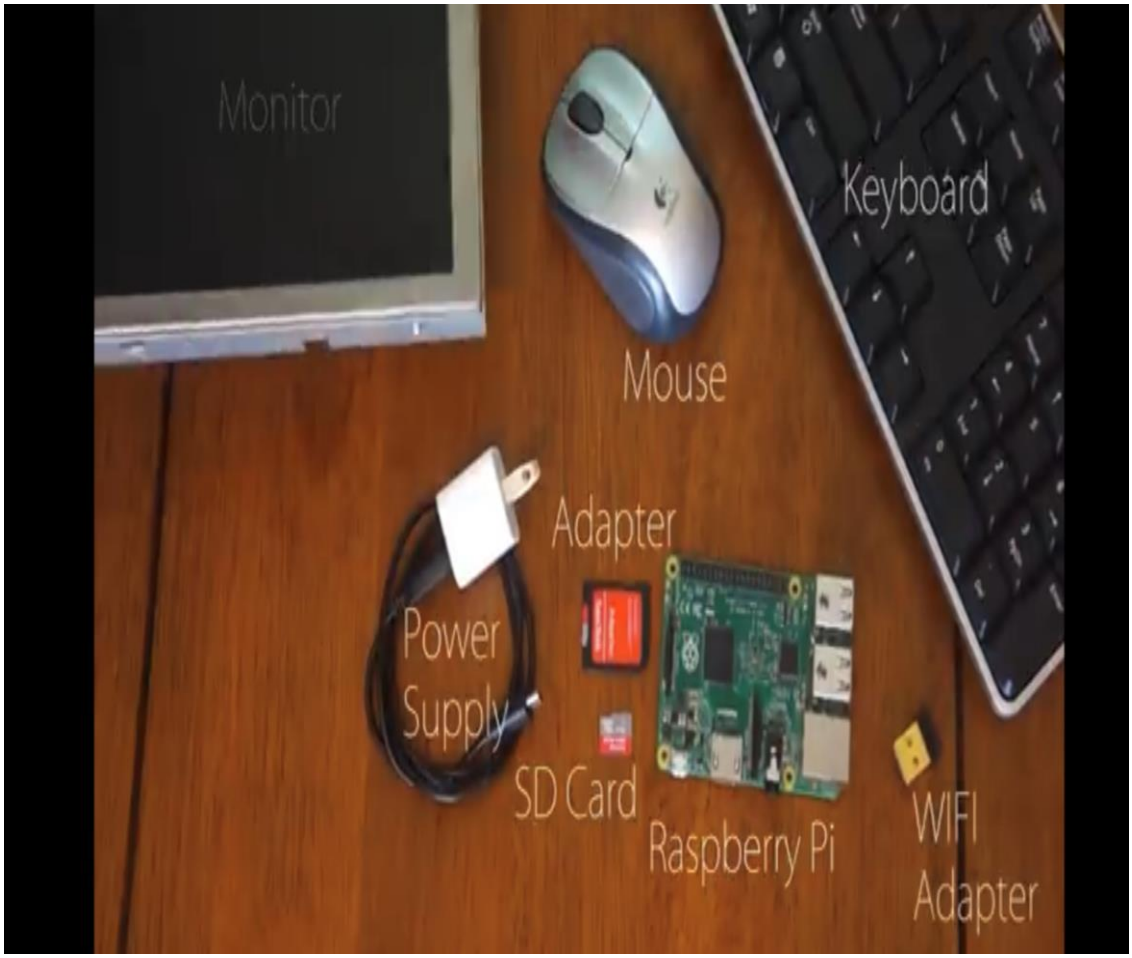


Figure 3-7: The percentage of studies on smart mirror applications

Chapter 4

Methodology and Case Study



4.Methodology and case study

4.1. Development Methodology

A. ***Smart Mirror as Mirror***

We can see our deem we will see it during a natural mirror while looking and grooming with the assistance of a one-way mirror with a high concentration of aluminum content.

B. ***Smart Mirror as Information System***

Time, Date, weather details, and news are fetched online using a predefined URL. News is fetched from websites like CCN, BBC, etc. DHT22 –the digital sensor is used to get the humidity and temperature details. DHT22 is connected to GPIO pins of the Raspberry Pi board using jumpers.

C. ***Smart Mirror as Security System***

When there's nobody during a home it is often switched into a security system by employing a VNC viewer to detect human presence. When someone enters an area, the PIR sensor will detect the movement of the person when he passes by the mirror and capture the image, and stores it in drop box. Also informs the owner by updating the captured image in drop box, in this way smart mirror system can also be used as a security system.[7]

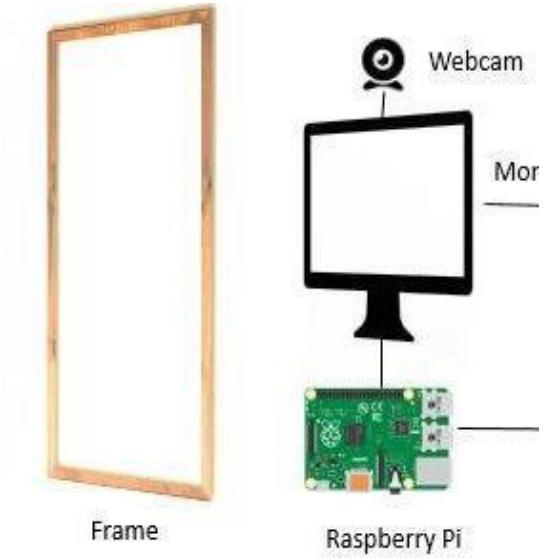


Figure 4-1: Components of Smart Mirror

D. ***Calculation for Information System***

Step 1: Turn on the force supply.
Step 2: We will get the date, time, and climate subtleties from the predefined URL.
Step3: Get the report from www.zeenews.com
Step 4: In the code, area record every one of the commendations to be shown on the mirror
Step 5: It shows on the mirror by means of the LCD screen
Step6: Change to hoodlum discovery mode utilizing VNC watcher.
Step 7: Turn off the force supply when it is of no use.

E. ***Calculation for Thief Detection***

Step 1: Start
Step 2: Setup the Camera
Step 3: Check whether PIR sensor yield is high or low Step 4: If it is low, go to stage 3.
Step 5: If it is high, the camera is turned ON.
Step 6: Image is caught and put away on raspberry pi.
Step 7: Check for Wi-Fi association.
Step 8: If it is associated picture is transferred to drop box.[7]

4.2. Case Study

To prove the utility of Smart mirror, beyond merely invoking internet services for the required service, we have implemented a scenario to show how the data accessed via Smart mirror can be further processed to generate useful analytics. As a case a study, we took Fitbit Tracker. We have accessed the basic data provided by Fitbit and added little analytics using best proven machine learning algorithm such as Random Forest and K-nearest neighborhood algorithm. These algorithms are tested for accuracy in achieving the given target which is the attainment of the daily goals computed based on the health parameters in our case.[2]

4.2.1 Health Monitoring Device - Fitbit Tracker

The Fitbit smart watch tracks the day-to-day activities of the user periodically and stores data online in the user's Fitbit account. Since it can monitor intraday data (up to 1 s resolution), the data can be used for analysis extensively. The health and fitness data stored online can be accessed through Fitbit API. The data is then stored in a PostgreSQL database. We have added analytics part to the Fitbit dataset, so that, based on the recorded health parameters, the user is suggested for suitable change in lifestyle or exercise. The Health Monitoring service that calls the Fitbit API takes the following parameters: client id, client secret, access token, refresh token and interval (Figure 4-2).[2]

Figure 4-2: Fitbit statistics

4.2.2 Representation of Fitbit Data

The collected Fitbit data is sent to a service that runs in the background for the purpose of representing the data graphically. Python pandas along with related libraries like matplotlib, NumPy, SciPy, psycopg etc. are required for the service. The database is connected using psycopg2. Health data such as heart rate, sleep etc. is read into pandas data frames. Variety of graphs are then generated in order to depict the data. Intraday data can be obtained by expanding the JSON Arrays to individual JSON values. Such graphs are then shown to the user on demand to facilitate the user to view useful information.[2]

4.2.3 Data Analytics on Health Data

The collected Fitbit data is also sent to a service that runs in the background to analyze the data. To perform data analytics, one and a half months data has been recorded for the following 5 parameters – steps taken, distance covered, floors climbed, minutes active and calories burned and these data are fed into the service. Daily goals are set for each of the 5 parameters to verify that the target is met. If all 5 goals are met, goals are declared to be achieved for the day. If any 2 or 3 goals are met, the goals are declared as partially achieved for the day. Otherwise, it is declared that goals are not achieved for the day. To analyze the attainment of the required goals, classification is done over the collected health data. Classification is the problem of identifying to which of a set of categories a new observation belongs, on the basis of a training set of data containing observations whose category membership is known. In our case, the status of the daily goals can be classified under 3 labels Yes, Partial and No. To train the data, all 5 parameters were taken in the training dataset along with the label. The status of the goals is then classified for the testing dataset and presented to the user on demand. Sometimes, the user may want to know in advance the number of calories burned for the given values of other parameters. Hence, Regression analysis is performed over the given dataset. It is a statistical process for estimating the relationships among variables. It includes many techniques for modelling and analyzing several variables, when the focus is on the relationship between a dependent variable and one or more independent variables (or 'predictors'). In our model all the parameters were taken for training. The algorithm predicts the calories burned for the given test data. We have used Random Forest Algorithm and K-Nearest Neighbor (KNN) algorithm for classification and regression. The classification accuracy of the model is computed using the below formula.[2]

$$\text{Classification accuracy} = \frac{\text{No of observations correctly classified}}{\text{Total no of observations}} * 100$$

The two algorithms are used over the dataset and were found to produce more or less the same accuracy for small datasets. However, for large datasets, Random Forest is observed to be of higher accuracy than K-nearest neighbor. Also, for large values of K, KNN has lower accuracy than random forests. The accuracy of the algorithm is determined based on *Mean Square Error (MSE)* and *R Square Scores (RSS)*. MSE measures the average of squares of the errors or deviations. Higher MSE indicates lesser accuracy. RSS is a number that indicates the proportion of the variance in the dependent variable that is predictable from the independent variables. Hence, closer the value of RSS to 1, higher the accuracy. Based on the aforementioned discussion, we infer from Table 4-1 that Random Forest algorithm shows higher regression accuracy than KNN.[2]

Table 4-1: Algorithms comparison

Measure	Random forest algorithm	KNN algorithm
RSS	0.6854	0.6604
MSE	93098.3	100496.3

4.2.4 Performance Evaluation

The smart mirror prototype has been evaluated based on two performance parameters such as user experience and efficiency. User experience is the overall experience of the user in using the product with ease. Users were allowed to use the system and were observed on how easily they were able to understand the system and use it without the help of others. Next, by efficiency we mean the quickness of response for both applications and notifications. We performed the user testing based on the parameters for user experience and efficiency for 100 users and the results are tabulated in a 5-point scale in Tables 4-2 and 4-3 as shown below.

Table 4-2: Rating of smart mirror user experience

Feature	Averaged rating (5-point scale)
News	3.93
Maps	4.13
Music	4.03
Weather	4.2
Fitbit	4.13
Warnings	4
Notifications	3.66
Overall	3.8

Table 4-3: Efficiency of smart mirror

Task	Averaged rating (5-point scale)
Applications	3.2
Notifications	2.86

From Table 4-2, notifications have a low rating. This is due to the missing of sound in notification. On the other hand, Fitbit has a very good rating as it gives detailed suggestions to users to improve their health. Further, with respect to efficiency of the system, performance of the applications seems to be better in terms of responsiveness. Further, feedback from the users on how to improve the system was collected and some of the suggestions given by the users are, aggregated notification reports are clumsy making it difficult to recognize individual notification, voice command requires more audibility etc. These feedbacks will be incorporated in future works to further improvise the system.[2]

4.2.5 Design Overview

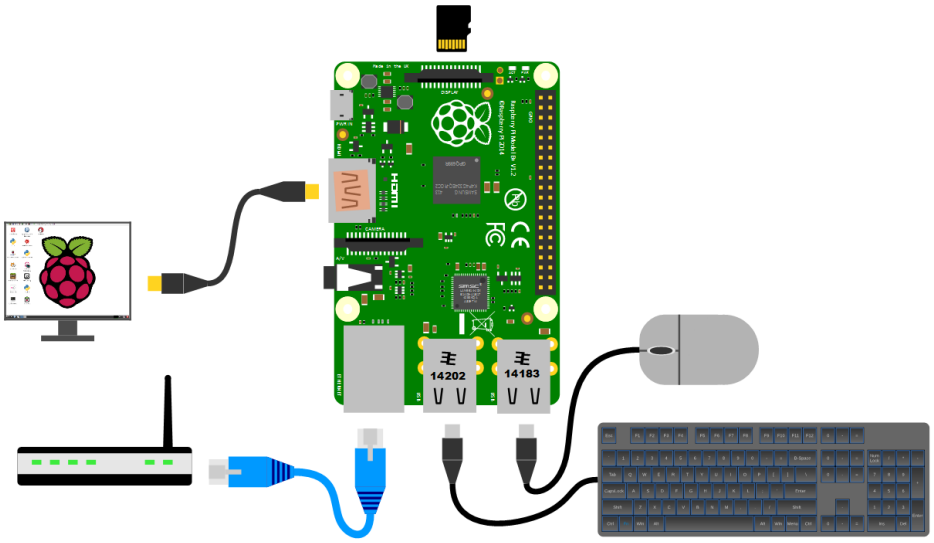


Figure 4-3: main components

Step 1) I download the raspberry pi OS Debian into the memory SD-card and install it in the raspberry pi 4. Then I connect the keyboard, mouse, monitor, and camera.

Figure 4-4: raspberry pi 4

Step2) I used raspberry pi 4, to afford the image recognition property.

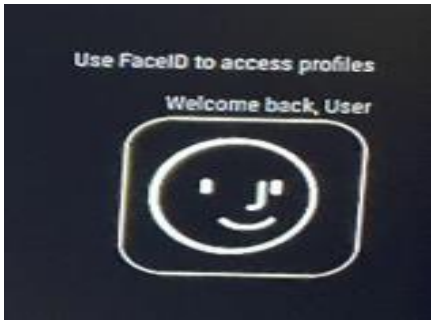


Figure 4-5: image recognition

Step3) I installed the codes and run it for the first time.

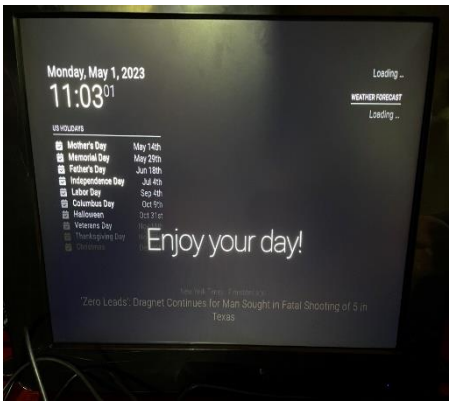


Figure 4-6: running smart mirror

This figure can show the place of modules that can be added to the mirror.

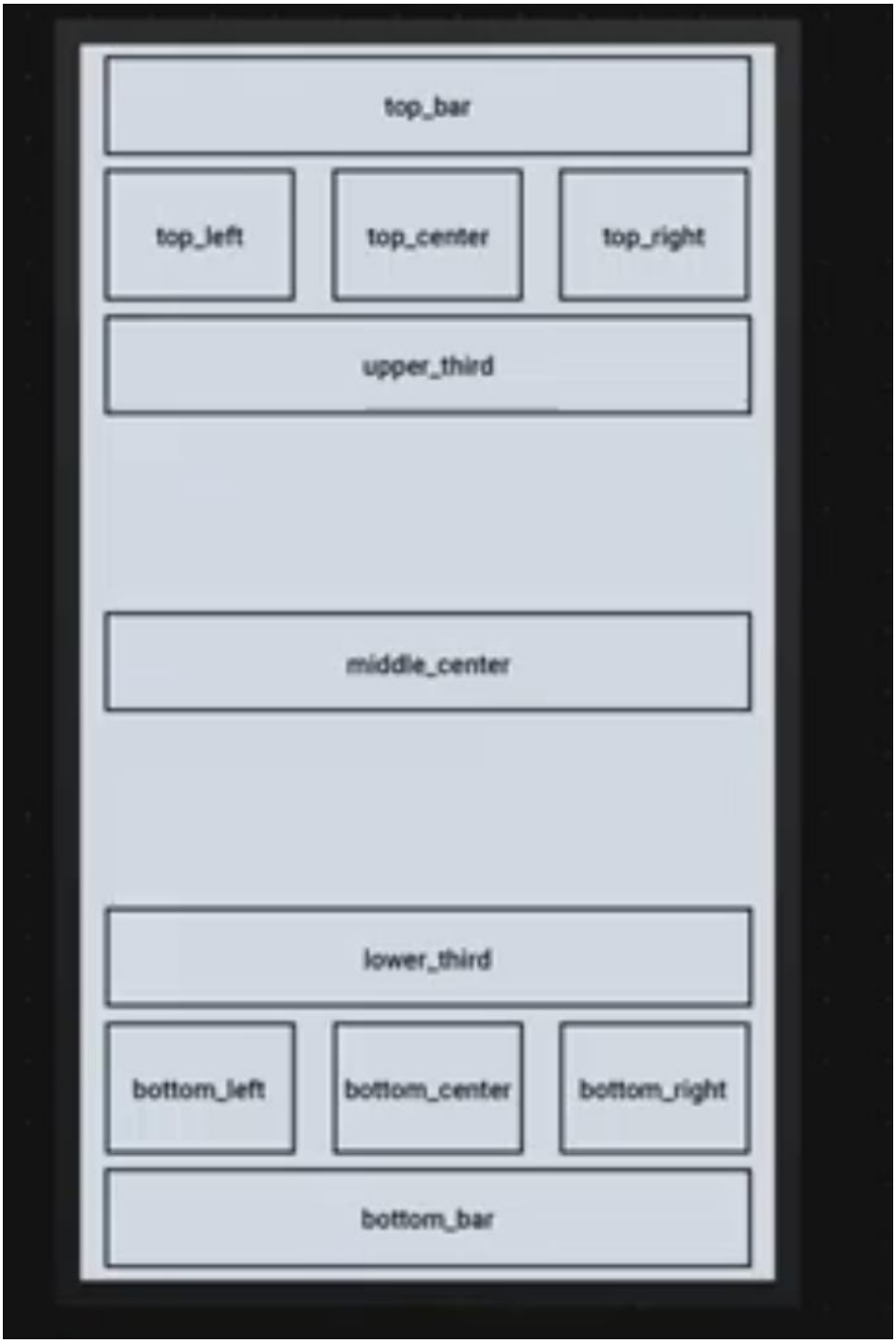


Figure 4-7: mirror array

Step 4) I add some modules to my mirror. Like Spotify for music and YouTube window for playing videos. Also, it has face detection property, weather, news, compliments, holidays, smart touch and time.

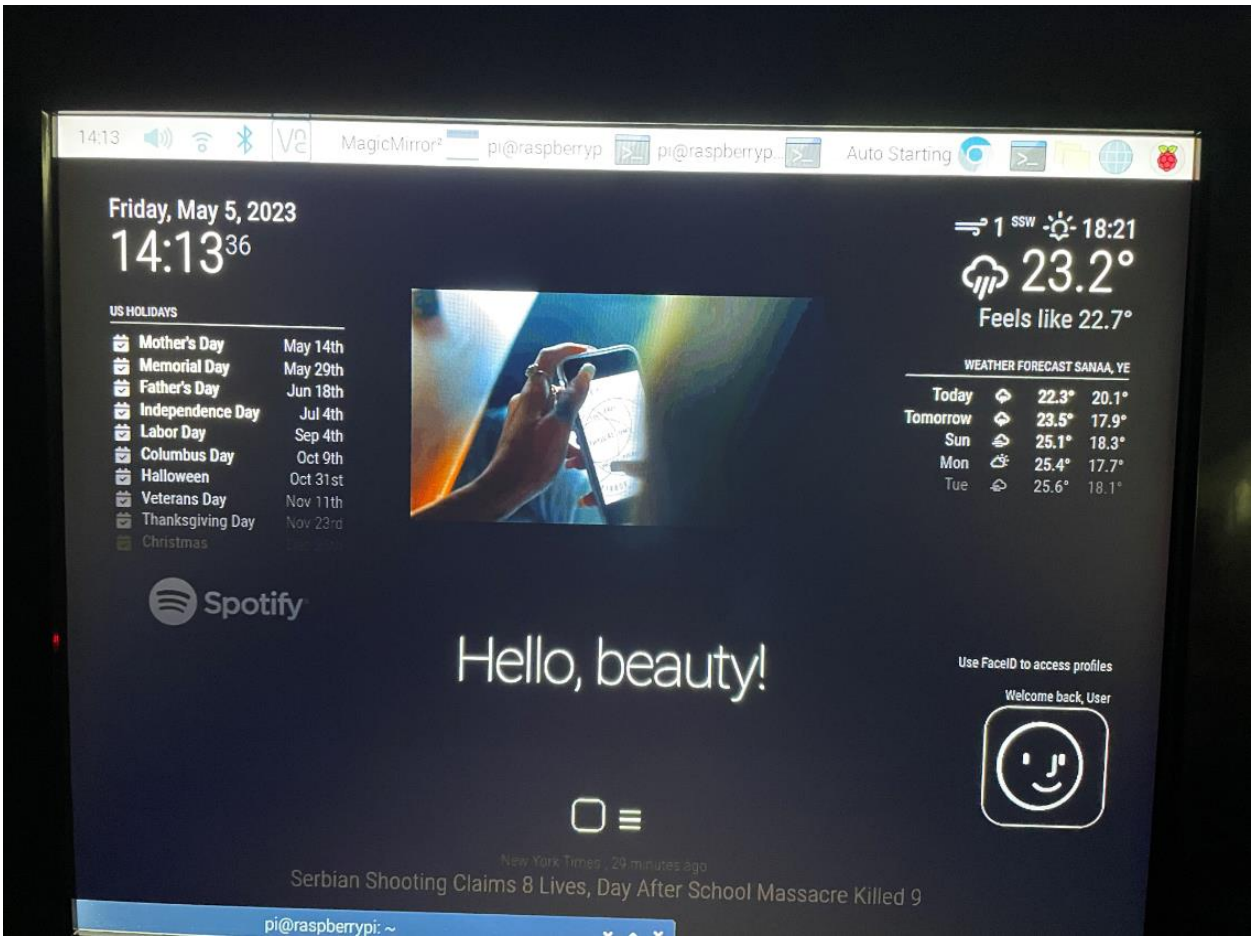


Figure 4-8: smart mirror

Step 5) I used two-way mirror.

Figure 4-9: smart mirror frame

Figure 4-10: smart mirror example

step 6) I used IR FRAME sensor for smart touch.

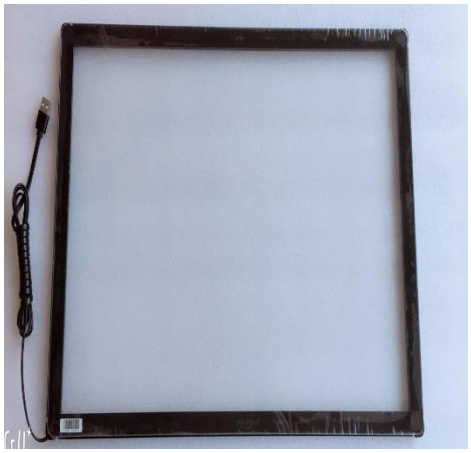


Figure 4-11: IR frame

Step 7) I used also echo dot voice assistant Alexa to communicate with the user.

Figure 4-12: echo dot alexa

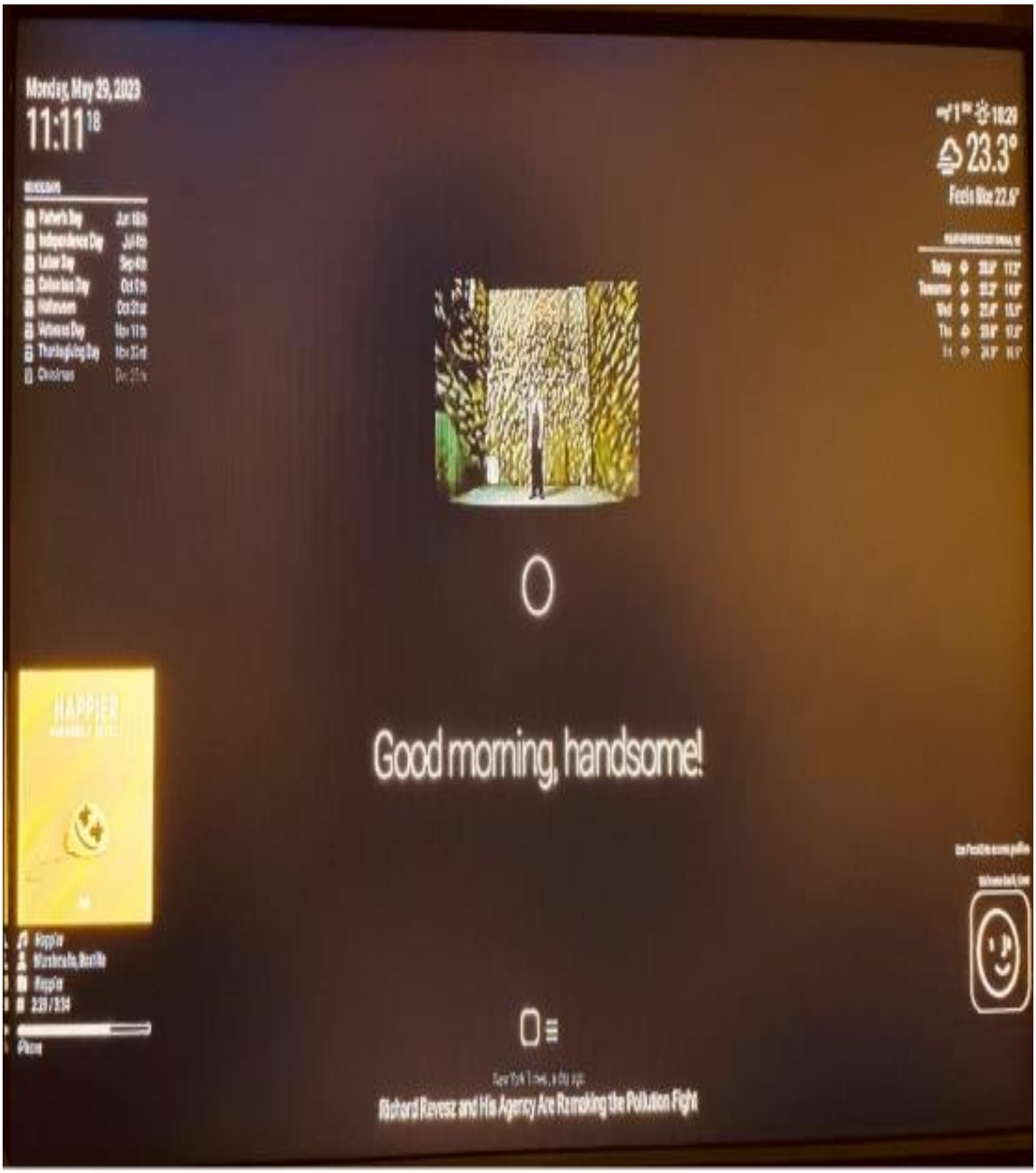
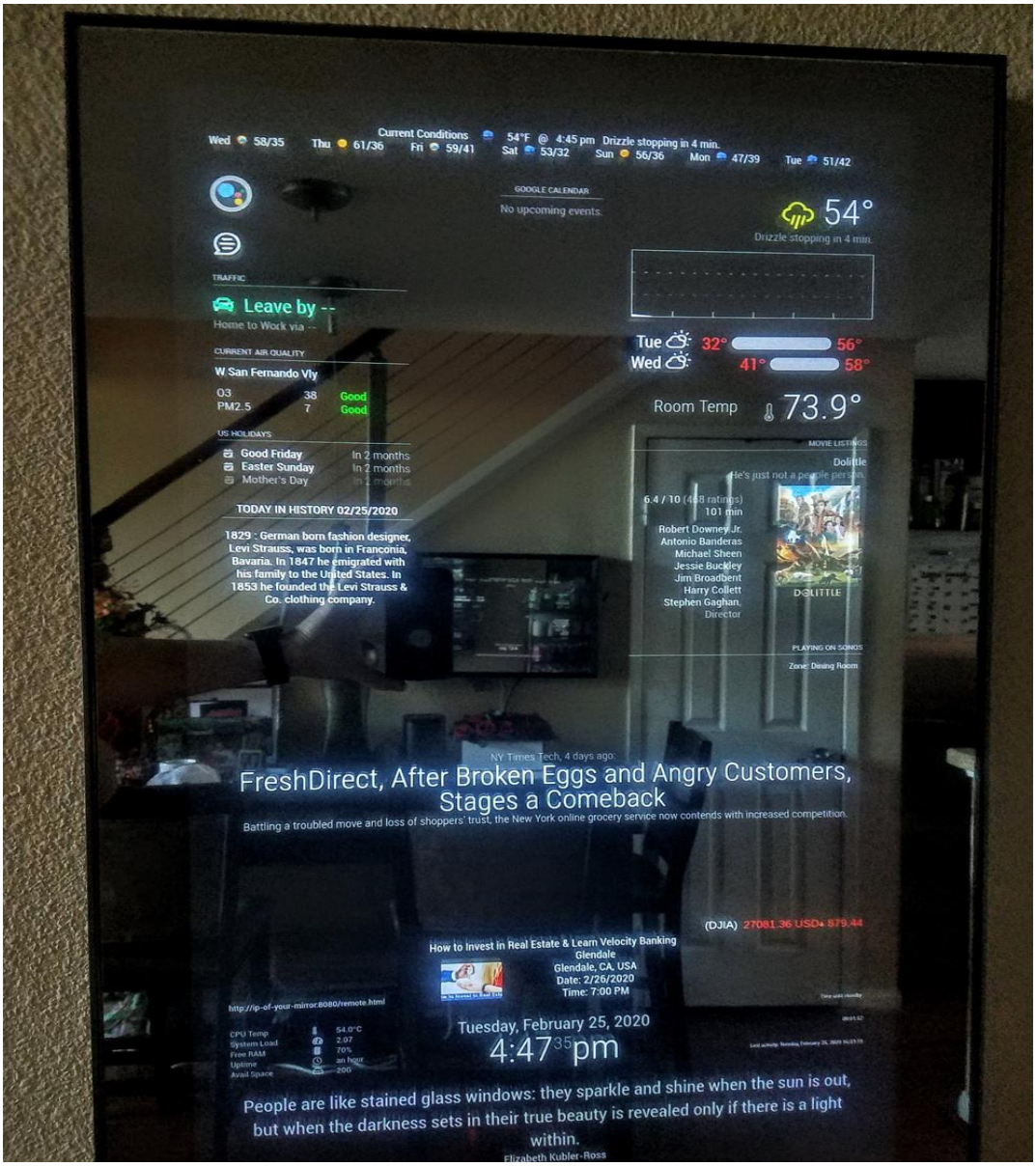


Figure 4-13: my smart mirror

Chapter 5

Conclusion



5.Conclusion

Our system integrated the concept and methodologies that have been implemented in many existing systems a smart mirror system. It is a novel application of creating a smart interacting system. The system is reliable and easy to use, in this interactive system; we have been concentrating on an interactive system for home. There exist many benefits from the smart mirror. A service-oriented architecture has been adapted for the development and deployment of the various services, were the mirror interface, the news feeds all use Web service communication mechanisms. By utilizing sensor, we can reduce the power consumption since the mirror will display information only in the presence of a human. The future prototype is ripe with potential and probably robust in terms of functionality. It uses voice commands to switch between each view and gestures to interact with content. Rather than confined to a home we can implement the functionality to a glass material. So that it can have a wide range of applications like one can setup this functionality to a glass table, which he used in office. This will help him to know about notifications from many sites at the same time in a single screen. Another application is that this functionality can be setup in public places.[6]

Chapter 6

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