SMART SURVEILLANCE AND ALERT SYSTEM

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Abstract

In contemporary world, face detection systems play a vital role in security and surveillance. The development of biometrics and availability of highspeed internet made security and surveillance as a convenient tool. These biometrics include fingerprints, voice, signature, iris, face etc., The current Alert System deals with providing security alerts regarding the entry of unknown person. Pi camera is used to capture the images. Haar Cascade Classifier is used to calculated Haar features and it will create Integral images. Later Adaboost is used to train classifiers by choosing best features. When unknown person enters, Pi camera captures the image of that person and sends mail and SMS alerts. Face Recognition is performed using Local Binary Pattern Histogram (LBPH) algorithm. Mail alerts are sent using Simple Mail Transfer Protocol (SMTP). This process is performed in Raspberry Pi. GSM module is connected to this system and deals with sending SMS alerts.

Keywords: Raspberry Pi, Pi camera, Local Binary Pattern Histogram (LBPH), Haar Cascade Classifier, GSM Module

I. INTRODUCTION

Real-time human identification systems are important for security, surveillance and biometric applications. These systems are playing crucial role in public places like airports, shopping malls, offices and homes. Computer-based face detection and recognition systems rapidly becoming popular in various sectors such as malls, universities etc., The objective of the present work is to build a system that can detect and recognize faces of people using image processing techniques. In order to ensure the security, this concept can practically be applied in huge spaces.

The computer system which is primarily designed to do multiple tasks is known as Embedded system viz., accessing, processing, storing and managing the data. This system helps to get accuracy of the task. The hardware platform of this system is the memory, processor, serial communication ports etc., will be the various components of this system. These are shown in the below Figure.1

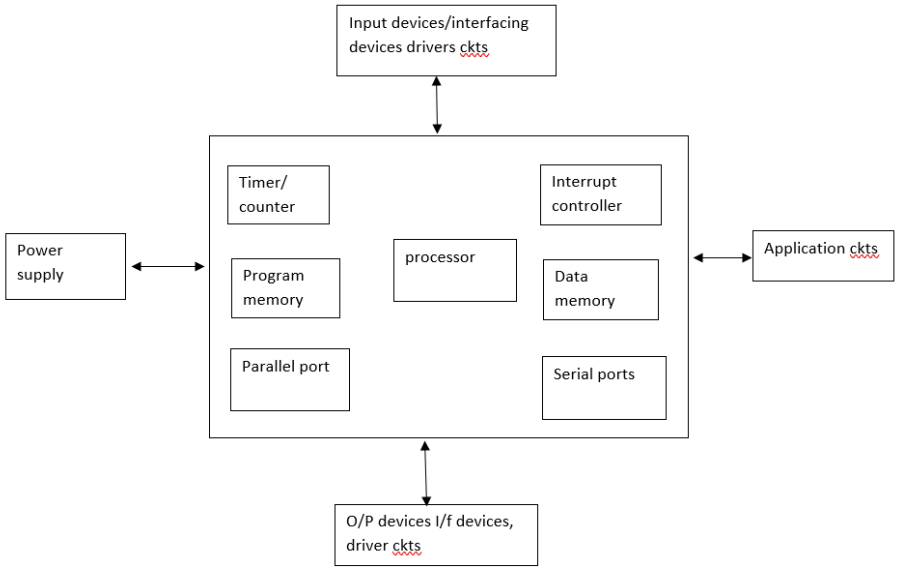


Figure.1 Indicating the Components in a typical embedded system

(Source: https://i.imgur.com/yG1vjKq.jpg)

An embedded system needs a hardware platform to operate power supply, memory, output circuits, processor, serial communication ports, timers etc., Different processors like a microprocessor, a micro controller and a digital signal processor, are used by this system to complete the tasks. The software of this system compiled down to provide code that can be lodged within non-volatile memory in the hardware. The source code has to be burned either with the microprocessor or microcontroller so to integrate hardware and software together The representation of the process flow that shows the conversion of embedded software to an executable binary image is shown in Figureure.2. Embedded systems can be applied to a wide range of applications in various sectors like automobiles, telecommunications, smart cards, computer networking, missiles, digital consumer electronics, satellites, etc

Figure. 2 Flow of conversion of embedded software to an executable binary image

Traditional security system requires mini tools, such as key, password or access cards. Sometimes people forget these tools and face problems. Robbery, burglary are some of the serious problems being encountered by the people. So there developed a need for a software that ensures a higher security level which carries out its operations through images. So, the need raises for development of the current work.

There are two types of biometric and behavioural characteristics. The biometric characteristics are face, fingerprints, palm iris etc., and behavioural characteristics are signature, key stroke dynamics. Illness, fear, emotional disturbances have impact on behavioural traits. But, biometric characteristics will help immensely. In face detection, while in recognition process, it has to be compared single face image with multiple images. This involves BCM2835 processor known as Raspberry Pi board. This board has special feature like camera interface, that makes it suitable for real image processing. As it is under BSD licence, libraries are free to use it. In spite of some drawbacks like waiting for long time, imitations of voice etc., this system is widely used.

II. LITERATURE SURVEY

A network that consists a group of computers connected with a microcomputer with a camera. The system takes images of people, analyse, detect and recognize human faces using image processing algorithms. The system can serve as a security system in public places like Malls, Universities, and airports. It can detect

and recognize a human face in different situations. It implements “Boosted Cascade of Simple Features algorithm” to detect human faces. “Local Binary Pattern algorithm” to recognize these faces. Raspberry Pi is the main component connected to a camera for image capturing [1].

It described a simple and easy hardware implementation of face detection system using Raspberry Pi, which itself is a minicomputer of a credit card size and is of a very low price. It is programmed using Python programming language [2]. Object detection is performed and tested across various face databases with and without effects such as noise and blur.

A method to manage the crowd by counting multiple humans in the scene by head detection. It develops a system using Raspberry Pi 3 board that detects the human heads and provide a count of humans in the region using OpenCV-Python. A Haar cascade classifier is trained for human head detection. The direction of movement is determined from the pixel values in consecutive frames[3].

It presents an approach to detect and identify a human face from the real-time video that tracks a face and compares it with stored data of known individuals. Our approach recognizes an individual within a fraction of a second which completely ignores any background effect. It also shows additional information about that individual[4]. Besides, it also works on different lighting conditions which make it suitable to execute its purpose in a wide variety of environment without encountering any significant error.

Describes the method of detecting and recognizing the face in real-time using Raspberry Pi. It describes an efficient algorithm using open-source image processing framework known as OpenCV. Our approach has five modules – Face Detection, Face Pre processing, Face Training, Face Recognition and Attendance Database[5].

A number of methods have been used in the area of automatic face recognition[6],[7],[8],[9] ever since the evolution of traditional face identification systems has begun[10],[11]. Face recognition systems broadly based on two approaches:1) holistic approach and 2) local approach. Some of the existing methods under different categories are eigen faces also called principal component analysis (PCA) [12], Fisher faces also called Fisher Discriminates Analysis (FDA), linear discriminates analysis (LDA)[13], self-organizing map and convolution network[14],[15], line edge maps (LEMs)[16], template matching[17], modular PCA[18], elastic bunch graph matching (EBGM)[19], local binary patterns (LBP)[20], and directional corner point (DCP)[21]. Thus various Raspberry Pi were found to be effective for many applications which includes face recognition systems.

III. SMART SURVEILLANCE AND ALERT SYSTEM

In the current work, pi cam and raspberry pi are used to perform face detection. The set of images are stored as database in Raspberry pi. This images are stored and system is trained using Haar Cascade Classifier Algorithm. Haar Cascade Classifier algorithm creates Positive and negative images that represents the images with the object that used for identification and images contains everything but do not contain the object that is used for identification respectively. When a person stands before the pi camera, pi camera captures the image of face of that person. Local Binary Pattern Histogram algorithm is used to compare the images. If any image matches with the input image, the face Id of that image is displayed. If input image is not matched with any image in the database, Mail and SMS alerts are sent to the mail Ids and Mobile numbers provided by the user. Mail alerts are sent to the user using Simple Mail Transfer Protocol (SMTP). To send SMS alerts, GMS module is connected to Raspberry Pi With Sim card(the sim used here is Airtel).

The block diagram of the proposed system has been indicated in the following Figure. 3:

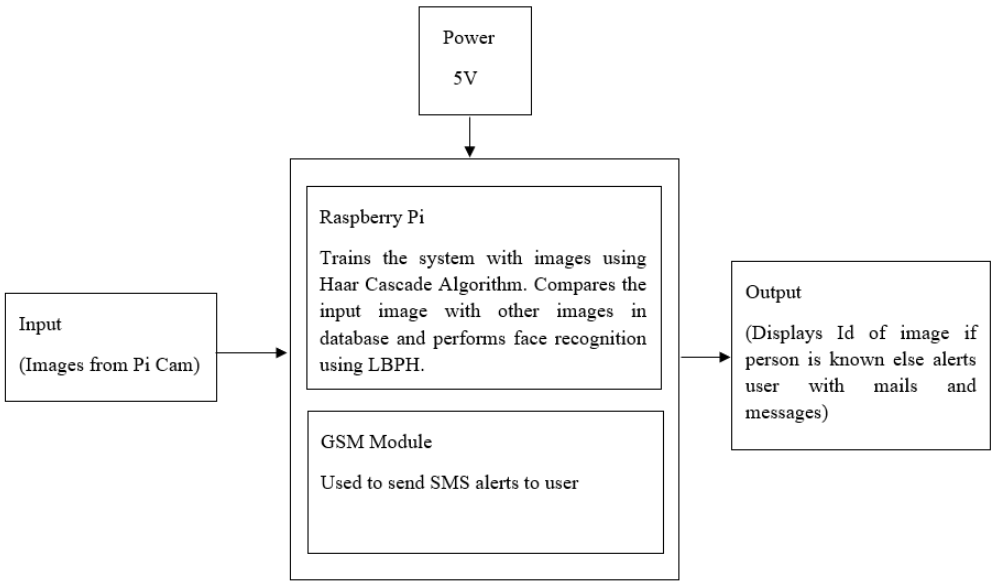


Figure. 3 Block diagram of proposed method

Local Binary Pattern Histogram

Local Binary Pattern Histogram(LBPH) is a Face-Recognition Algorithm. Four parameters are used in LBPH: Radius, Neighbors, Grid X and Grid Y. Radius is the parameter used in building circular local binary pattern and it is usually considered as 1. Neighbors are the sample points that are used to build circular LBP. The number of neighbors are set to 8 in this algorithm. Grid X and Grid Y are the parameters that represent the number of cells in horizontal and vertical directions respectively.

To train the algorithm, the database with facial images of people is required. Training algorithm is used to train the system and training algorithm used here is Haar Cascade. Face ID(this Id may be the name of that person or a number) is given to each image that is used to recognize the input image and generate the output. For instance, after having a facial image of A x B dimensions, it is divided into n x m for every region. LBP operator defined as shown in fig.4 is used for every region. In the LBP operator formula , (Xc,Yc) represents central pixel and Ic represents its intensity where In represents the intensity of neighbor pixel.

$$\mathrm{LBP}(X_c, Y_c) = \sum_{p=0}^{p-1} 2^p S(i_p - i_c) \qquad (1)$$

The central value of the matrix is referred to as Threshold. The function S(x) in above formula compares the threshold to its 8 neighbors i.e., if the neighbor is greater than or equal to threshold, it is set as 1 else set as 0.

$$S(x) = \begin{cases} 1, x \geq 0 \\ 0, x < 0 \end{cases} \qquad (2)$$

After determining the new binary values, all values are combined in clockwise direction to get a final binary value as shown in the below Figure.4 This binary value is converted into decimal and this will be set as the central value.

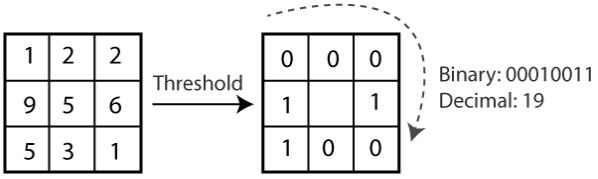


Figure.4 Obtaining final binary value

(Source:https://static.javatpoint.com/tutorial/opencv/images/face-detection-and-face-recognition3.png)

The algorithm is further improved if it fails in encoding the details. This improved algorithm is termed is Circular LBP. It aligns the arbitrary number of neighbors on circle. For this, it uses variable radius as shown in Figure.5.

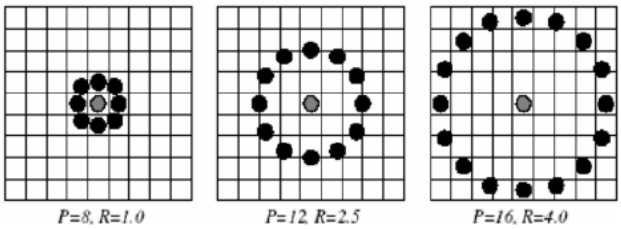


Figure.5 Circular LBP

(source: https://iq.opengenus.org/content/images/2019/10/cirlbp.png)

For the point (Xc,Yc), the position of the neighbor is calculated as: let (Xp,Yp) be the point of neighbor and let p belong to P(number of sample points) [26]. Then,

$$x_p = x_c + R\cos(\frac{2\pi p}{P}) \quad (3)$$

$$y_p = y_c - R\sin(\frac{2\pi p}{P}) \quad (4)$$

If the points does not correspond to image coordinates, they are interpolated using techniques such as bilinear interpolation. After generating LBP, Histograms are created. Grid X and Grid Y are the parameters used to divide the images into multiple grids. Each grid contains 256 positions(0 to 255) and represents the occurrences of each pixel intensity. Each histogram is concatenated to create new and bigger histogram and the final histogram represents the characteristics of original image.

Each histogram created represents each image in the training dataset. When an input image is provided, the same procedure is followed to create its histogram. In order to find whether the input image matches with any image in dataset or not, the input image is compared with each image and the image with the closest histogram is returned. There are various approaches to compare the histograms viz., Euclidean distance, chi-square, absolute value. If the input image matches with any image in the database, the algorithm outputs the ID of the image matched

Haar Cascade Algorithm

Haar cascade is an object detection algorithm that uses positive and negative images. It is proposed by Paul Viola and Michael Jones in paper titled "Rapid Object Detection using a Boosted Cascade of Simple Features". Haar features are collected by performing some calculations on adjacent rectangular regions in a detection window. It involves the summing of intensities of pixels in each region and then calculating the difference between these sums.

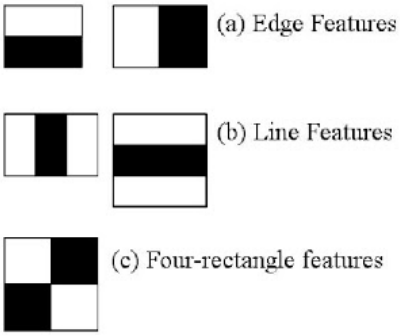


Figure.6 Types of Haar features

(source:https://miro.medium.com/v2/resize:fit:640/format:webp/1*yl-_BqUzycbyfhPAzwWOddQ.png)

These features can also be extracted creating integral images of a image and extracting its features. For this sub-rectangles are created, instead of computing at each pixel, array references are given to each sub-rectangle. However, while performing object detection, most of the haar features will be irrelevant. Here Adaboost plays a vital role to choose the best features.

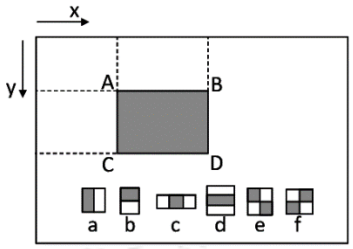


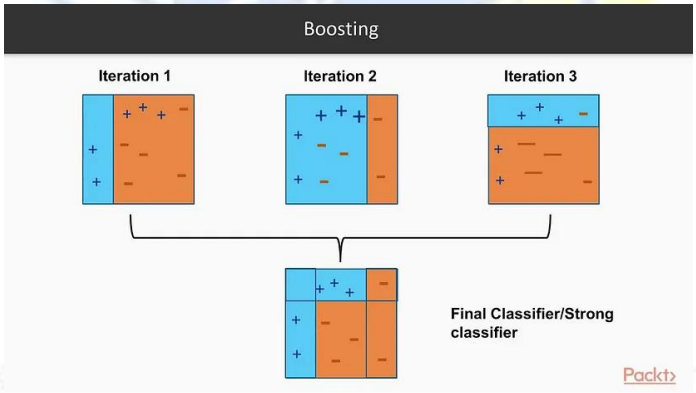
Figure.7 working with integral images

(source: https://www.researchgate.net/profile/Zhengyou-Zhang/publication//235616690/figure/fig2/AS:393321475264526@1470786555709/Illustration-of-the-integral-image-and-Haar-like-rectangle-features-a-f.png

Adaboost is used to choose the best features and train the classifier to use these features. The combination of weak classifier is used to create a strong classifier so that it can be further used in object detection. It assigns the weight to each example and examples with higher weights are likely to be added in training set. The equation for the final classifier can be as:

$$H(x) = sign(\sum_{t=1}^{T} \alpha_t h_t(x)) \quad (5)$$

Here T represents number of weak classifiers, $h_t(x)$ is the output of t(weak classifier and its output may be =1 or -1). α_t represents the weight of classifier t assigned by the Adaboost[43]. Here weak learners are created by moving a window over the input image and computing Haar Features for each subsection of the image[27].



(source: https://miro.medium.com/v2/resize:fit:828/format:webp/1*8cADlNiEJa5RAu4LqY4dgA.jpeg)

The cascade classifier is used to collect the weak learners and these are trained using boosting, so that it determines high accurate classifier from the mean prediction of weak learners. This classifier decides and indicated whether an object is found i.e., positive or not fount i.e., negative[27].

Simple Mail Transfer Protocol(SMTP)

If the captured image is not matched with any image in the database, then SMS alerts and mail alerts are sent to the user with captured image as attachment. Simple Mail Transfer Protocol will play a crucial role in sending mail alerts.

Simple Mail Transfer Protocol (SMTP) is an application layer protocol. It is a set of guidelines that allow software to transmit an electronic mail over the internet [24]. The client who needs to send mail opens a TCP

connection to SMTP server and sends mail across the connection. There are two components: User-Agent (UA) and Local MTA. User deals with the User Agent (UA) for instance, Microsoft Outlook. MTA stands for Message Transfer Agent. It is used to exchange the mail using TCP. It delivers mail to the mailboxes and it can be later downloaded by the user agents [32]

Hardware Components

Raspberry Pi

Raspberry Pi is a small sized computer and it uses Linux operating system. It is a mini size computer used mostly to run larger and smart programs to achieve output quickly. Raspberry Pi 4 B+ (RP4) is the latest model. It has all the required latest wired and wireless communication systems. They are used in most of the smart projects. Raspberry Pi 4 comes with a Quad-Core processor but it has three different versions which gives three different sizes of RAM., Raspberry Pi 4 uses mini HDMI and has 2 ports for two 4K displays. A typical Raspberry Pi is shown in the below Figure. 4.

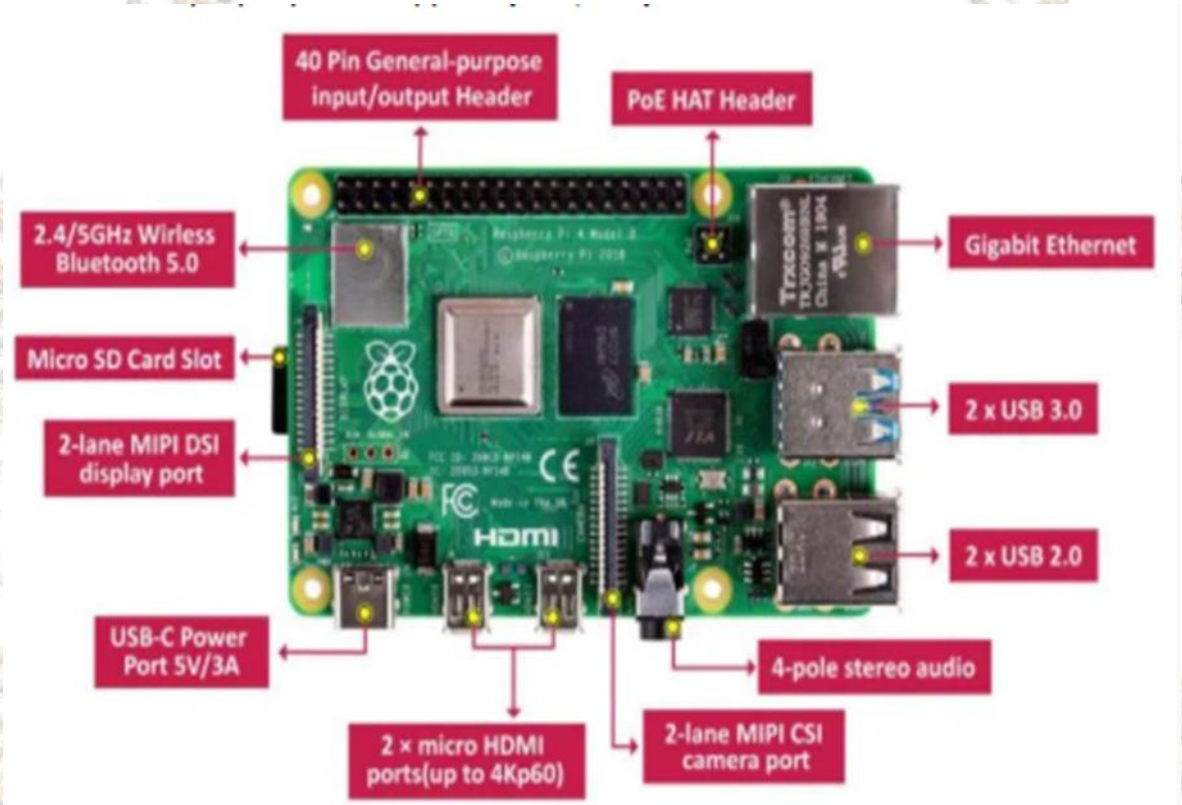


Figure. 9 Depiction of Raspberry pi 4 Board pertaining to its support
(source: https://hackatronic.com/wp-content/uploads/2021/11/raspberry-pi-4-specifications-.jpg)

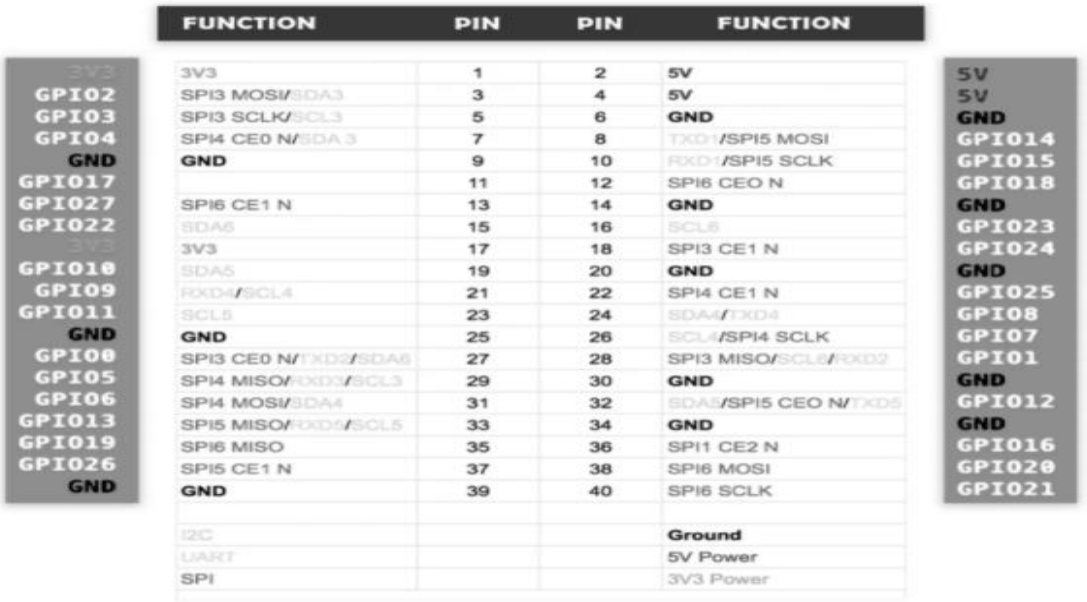
The below Table 1 shows the hardware and software specifications

Table 1 Software and Hardware Specifications

CPU type	Quad core Cortex-A72 (64-bit) @ 1.5GHz
Software Utilized	NOOBS, VNC, PYTHON3 IDE, and UVC streamers (Guvcview or GStreamer)
GPU support	H264 (1080p60 decode, 1080p30 encode) OpenGL ES 3.0 graphics, H.265 (4kp60 decode)
Wi-Fi support	Yes, with 2.4 GHz and 5 GHz speeds
Bluetooth support	Yes, with version 5.0
RAM Ports support	1GB, 2GB, 4GB.
Operating Voltage range	5V with 3A minimum
GPIO Ports	28 I/O Pins
LAN interface support	Yes, with Gigabyte support
PoE	Enabled
SD Card support	Yes
HDMI	2- Ports with 4k Display (mini-HDMI)
USB ports	2×v 2.0, 2×v 3.0
Camera	CSI
Power Source	DC Power Jack, mini-USB-C Port
Expansion Connectors	40 Pins (SPI, I^2C, LCD, UART, PWM, SDIO)
Display	DSI

Raspberry Pi Pin Configuration

This section includes information on the **pinout diagram** and headers **pins** details with an application of each pin.



	FUNCTION	PIN	PIN	FUNCTION	
3V3	3V3	1	2	5V	5V
GPIO2	SPI3 MOSI/SDA3	3	4	5V	5V
GPIO3	SPI3 SCLK/SCL3	5	6	GND	GND
GPIO4	SPI4 CE0 N/SDA 3	7	8	TXD1/SPI5 MOSI	GPIO14
GND	GND	9	10	RXD1/SPI5 SCLK	GPIO15
GPIO17		11	12	SPI6 CEO N	GPIO18
GPIO27	SPI6 CE1 N	13	14	GND	GND
GPIO22	SDA6	15	16	SCL6	GPIO23
3V3	3V3	17	18	SPI3 CE1 N	GPIO24
GPIO10	SDA5	19	20	GND	GND
GPIO9	RXD4/SCL4	21	22	SPI4 CE1 N	GPIO25
GPIO11	SCL5	23	24	SDA4/TXD4	GPIO8
GND	GND	25	26	SCL4/SPI4 SCLK	GPIO7
GPIO0	SPI3 CE0 N/TXD2/SDA6	27	28	SPI3 MISO/SCL6/RXD2	GPIO1
GPIO5	SPI4 MISO/RXD3/SCL3	29	30	GND	GND
GPIO6	SPI4 MOSI/SDA4	31	32	SDA6/SPI5 CEO N/TXD5	GPIO12
GPIO13	SPI5 MISO/RXD5/SCL5	33	34	GND	GND
GPIO19	SPI6 MISO	35	36	SPI1 CE2 N	GPIO16
GPIO26	SPI5 CE1 N	37	38	SPI6 MOSI	GPIO20
GND	GND	39	40	SPI6 SCLK	GPIO21
	I2C			Ground	
	UART			5V Power	
	SPI			3V3 Power	

Figure.10 Raspberry Pi Pin Configuration
(source: https://microcontrollerslab.com/wp-content/uploads/2019/12/Raspberry-Pi-pinout.png

Raspberry Pi Pins Description

The Raspberry Pi 4 can be used in the external embedded system to communicate. It has a total of 40 pins from which 28 are GPIO pins and the rest of them are power pins. GPIO pins don't only perform the simple I/O functions but also UART, SPI, and I^2C communications. These communications are specific to every pin and all their function are discussed below:

Power Supply Pins

Power In: In Raspberry pi, there is two power-in methods, one is from the USB-C power port and the second one is from any 5V pin. The 5-volt pin is directly connected to the USB-C adapter port. The input on the 5V pin should be stable and according to its specifications. In the case of higher voltage, the device could get burned. 5V input pins will bypass any fuse and regulator in case of power input, so the power supply from 5V should according to its specification to avoid any kind of harm. The power input pin of the Raspberry Pi 4 is given below:

- Pin2-6 —> +5V
- Pin6 ——> GND

Power Out: There are two types of power output pin in the Raspberry pi 4 3V3 and 5V. 5V is directly connected to the USB port but 3V3 is connected to through the regulator which gives the stable 3 volts output. All power out pins are given below:

- 3V3 – Pin1, Pin17
- 5V – Pin2, Pin6

Ground: Raspberry Pi 4 has multiple ground pin which is connected internally and any ground pin can be used by the power supply or external device to make the common ground. The list of the ground pins is given below:

- Pin6
- Pin9
- Pin14
- Pin20
- Pin25
- Pin30
- Pin34
- Pin39

Pi Camera

The Pi camera module is a portable light weight camera that supports Raspberry Pi. It communicates with Pi using the MIPI camera serial interface protocol. It is normally used in image processing, machine learning or in surveillance projects. It is commonly used in surveillance drones since the payload of camera is very less. Apart from these modules Pi can also use normal USB webcams that are used along with computer. A typical Pi camera is shown in the below Figure. 10.

Figure. 10 Depiction of typical Pi camera
(source: https://in.element14.com/raspberry-pi/rpi-8mp-camera-board/raspberry-pi-camera-board-v2/dp/3677845)

Pi Camera Features

- 5MP colour camera module for Raspberry Pi
- Supports both Raspberry Pi Model A and B
- MIPI Camera Serial Interface
- Omnivision 5647 Camera module
- Supports 1080p,720p and 480p
- Light weight and portable

GSM

Figure.11 GSM Module
(source: https://nevonexpress.in/wp-content/uploads/2021/10/SIM900A-GSM-Module-Arduino-Compatible-2.jpg)

GSM Module is used for GPRS/GSM communications in embedded systems. It offers GPRS/GSM technology with the use of mobile sim. It uses 900Hz and 1800Hz frequency band. It allows user to send and receive SMS and calls. In this current work, GSM module is used to send SMS alerts to the user, when the captured image is not found in the database.

IV. RESULTS

Pi cam captures the image of faces and the same is stored as database in Raspberry Pi. When a person stands before camera, it captures the image of that person and checks whether any image in the database matches with it or not. The face Id of the image of the person is displayed if the image of that person is found in the database as shown in the Figure.14.

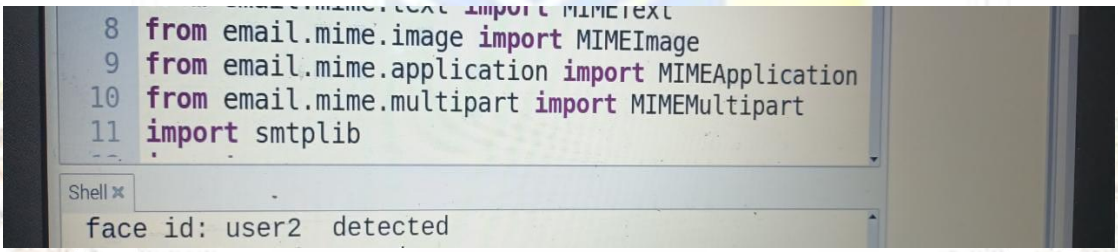


Figure.12 Result when image of person is recognised

If the captured image is not matched with the any image in the database, then the mail and SMS alerts are sent to the user.

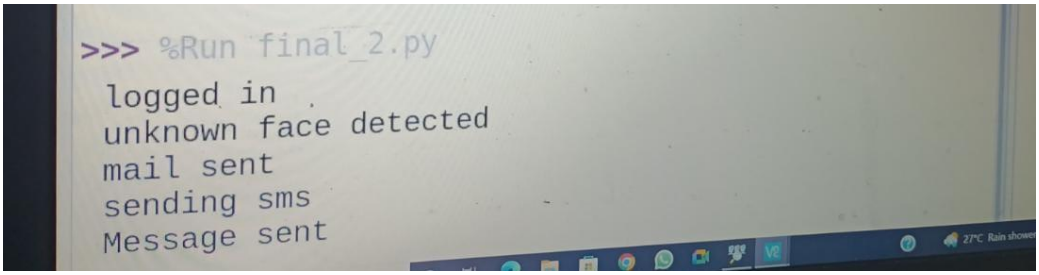


Figure.13 Result when image of person is not recognised

Mail alerts are sent to the one or more than one mail IDs given by the user with captured image as attachment and message " Unknown person trying to enter"

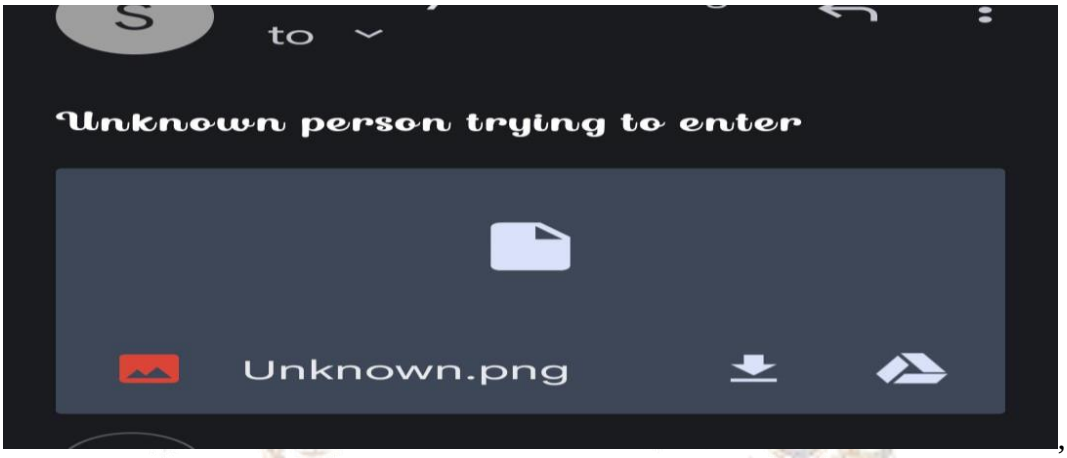


Figure.14 Mail alert

SMS alerts are sent to one or more than one mobile numbers given by the user. SMS alerts are sent with " Unknown Person alert" message.

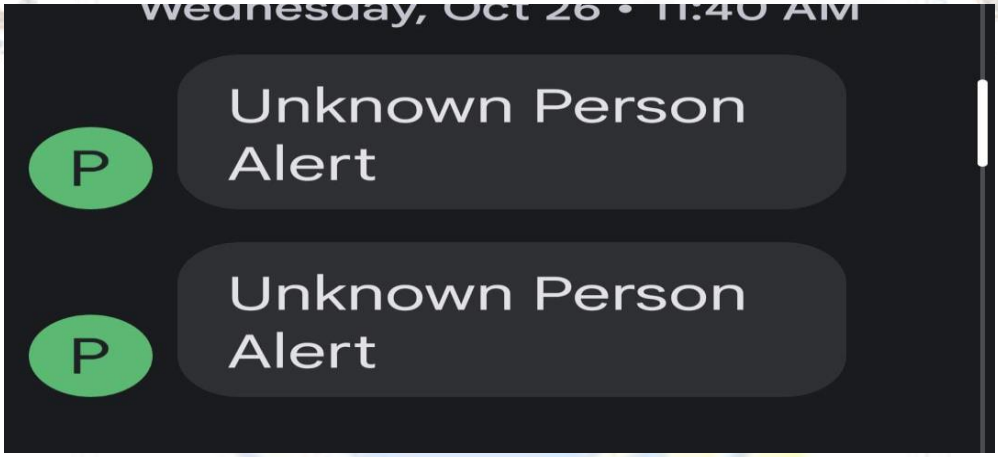


Figure.15 SMS alert

V. CONCLUSION

The system can be used in several places like banks, hospitals, labs and other sophisticated automated systems, which dramatically reduce the hazard of unauthorized entry. Evidence can be given to the security department if any robbery issue occurs. The design of the face recognition system using Raspberry pi can make the smaller, lighter and with lower power consumption, so it is more convenient than the PC-based face recognition system. Because of the open-source code, it is freer to do software development on Python. The efficiency of the system was analyzed in terms of face detection rate. The analysis revealed that the present system shows excellent performance efficiency and can be used for face detection even from poor quality images.

REFERENCES

[1] A. A. Wazwaz, A. O. Herbawi, M. J. Teeti, and S. Y. Hmeed, "Raspberry Pi and computers-based face detection and recognition system," in *2018 4th International Conference on Computer and Technology Applications (ICCTA)*, 2018, pp. 171-174: IEEE.

[2] H. V. Khodaskar and S. J. I. J. A. E. M. S. Mane, "Human face detection & recognition using raspberry Pi," vol. 1, pp. 199-205, 2017.

[3] S. S. A. Abbas, M. Anitha, and X. V. Jaini, "Realization of multiple human head detection and direction movement using Raspberry Pi," in *2017 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET)*, 2017, pp. 1160-1164: IEEE.

[4] N. Mustakim, N. Hossain, M. M. Rahman, N. Islam, Z. H. Sayem, and M. A. Z. Mamun, "Face recognition system based on raspberry Pi platform," in *2019 1st International Conference on Advances in Science, Engineering and Robotics Technology (ICASERT)*, 2019, pp. 1-4: IEEE.

[5] P. Pasumarti, P. P. J. I. R. J. o. E. Sekhar, and Technology, "Classroom attendance using face detection and Raspberry-Pi," vol. 5, no. 03, pp. 167-171, 2018.

[6] M. Karahan, H. Kurt, and C. Kasnakoglu, "Autonomous face detection and tracking using quadrotor UAV," in *2020 4th International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT)*, 2020, pp. 1-4: IEEE.

[7] G. L. Quek, J. Liu-Shuang, V. Goffaux, and B. J. N. Rossion, "Ultra-coarse, single-glance human face detection in a dynamic visual stream," vol. 176, pp. 465-476, 2018.

[8] M. A. Hoque, T. Islam, T. Ahmed, and A. Amin, "Autonomous face detection system from real-time video streaming for ensuring the intelligence security system," in *2020 6th International Conference on Advanced Computing and Communication Systems (ICACCS)*, 2020, pp. 261-265: IEEE.

[9] A. Kumar, M. Kumar, A. J. M. T. Kaur, and Applications, "Face detection in still images under occlusion and non-uniform illumination," vol. 80, no. 10, pp. 14565-14590, 2021.

[10] M. R. Hasan, "Effectiveness of Face Recognition System with Human Face Detection Learning Technique for Students," ed: December, 2020.

[11] A. J. Goldstein, L. D. Harmon, and A. B. J. P. o. t. I. Lesk, "Identification of human faces," vol. 59, no. 5, pp. 748-760, 1971.

[12] M. Kirby, L. J. I. T. o. P. a. Sirovich, and M. intelligence, "Application of the Karhunen-Loeve procedure for the characterization of human faces," vol. 12, no. 1, pp. 103-108, 1990.

[13] J. Lu, K. N. Plataniotis, and A. N. J. I. T. o. N. n. Venetsanopoulos, "Face recognition using LDA-based algorithms," vol. 14, no. 1, pp. 195-200, 2003.

[14] R. D. Lawrence, G. S. Almasi, H. E. J. D. M. Rushmeier, and K. Discovery, "A scalable parallel algorithm for self-organizing maps with applications to sparse data mining problems," vol. 3, no. 2, pp. 171-195, 1999.

[15] D. Kumar, C. Rai, and S. Kumar, "Face recognition using self-organizing map and principal component analysis," in *2005 International Conference on Neural Networks and Brain*, 2005, vol. 3, pp. 1469-1473: IEEE.

[16] Y. Gao, M. K. J. I. t. o. p. a. Leung, and m. intelligence, "Face recognition using line edge map," vol. 24, no. 6, pp. 764-779, 2002.

[17] R. Brunelli, T. J. I. t. o. p. a. Poggio, and m. intelligence, "Face recognition: Features versus templates," vol. 15, no. 10, pp. 1042-1052, 1993.

[18] R. Gottumukkal and V. K. J. P. R. L. Asari, "An improved face recognition technique based on modular PCA approach," vol. 25, no. 4, pp. 429-436, 2004.

[19] A. Borah, A. J. B. J. o. M. Dev, and C. Science, "Face Recognition by Bunch Graph Method Using a Group Based Adaptive Tolerant Neural Network," vol. 1, no. 4, p. 194, 2011.

[20] T. Ahonen, A. Hadid, M. J. I. t. o. p. a. Pietikainen, and m. intelligence, "Face description with local binary patterns: Application to face recognition," vol. 28, no. 12, pp. 2037-2041, 2006.

[21] Y. Gao and Y. J. P. R. Qi, "Robust visual similarity retrieval in single model face databases," vol. 38, no. 7, pp. 1009-1020, 2005.

[22] https://www.ques10.com/p/36738/draw-and-explain-block-diagram-of-embedded-syste-1/

[23] https://towardsdatascience.com/face-recognition-how-lbph-works-90ec258c3d6b

[24] https://www.javatpoint.com/simple-mail-transfer-protocol

[25] https://www.geeksforgeeks.org/simple-mail-transfer-protocol-smtp/

[26] https://iq.opengenus.org/lbph-algorithm-for-face-recognition/

[27] https://medium.com/analytics-vidhya/haar-cascades-explained-38210e57970d

[28]https://mccormickml.com/2013/12/13/adaboosttutorial/#:~:text=AdaBoost%20is%20a%20popular%20boosting,female%20based%20on%20their%20height.