Smart Home Security using IoT and Face Recognition

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***Abstract*— The Internet of Things(IoT) has made it possible to set up a smart home security through which you can decide who can enter your home using your smartphone and web application. It's also made it simple and relatively affordable to monitor your home anytime and anywhere. the key issue in a traditional home security system is, it is easily breakable and quite outdated. This in turns, results in the robbery and also needs installation of the costly security system. To tackle this problem, we propose a smart home security system, which is IoT as well as face recognition enabled. In our system, the web camera is used which is connected to the raspberry pi accompanied by sensors such as Passive Infrared(Pir) and Ultrasonic sensor. On motion detection camera captures an image of the person in front of the door then real-time face recognition is done using local binary pattern (LBP). If person's image matches with one of the home members then the door will unlock, else doorbell will ring. if an intruder tries to break door then an alarm will be raised at the same time SMS and Email containing image of the intruder will be sent to the homeowner. Face recognition works well in multi-face recognition and stranger identification, which meet the requirement of home security. This system is battery powered in case of power failure. Furthermore, the house owner can keep track of activity happening in the house using android and web application connected to the raspberry pi using the internet. Using Android application or web application owner can also add new person's faces into the databases eg., guests.**

***Keywords*— Smart Home Security; IoT; Face Recognition; Raspberry Pi; LBP.**

I. INTRODUCTION

A home security system means to protect your home and keep safe valuables, and to keep your family safe from potential break-ins by burglars and thief. In the United States, there is a home related burglary that takes place every 13 seconds, 4 burglaries a minute, 240 an hour and nearly 6,000 a day! some of the statistics are 88% of all burglaries are residential in nature, 77% of all crimes are property crimes, 38% of all robberies are committed with guns, identity theft is the fastest growing crime in the U.S.,Canada and UK. 3 out of 4 homes in the U.S. Will be broken within the next 20 years [13].

Our proposed system deliver a cost and energy efficient solution for home security by using IoT and face recognition. IoT will enable sensing and triggers system on motion detection using sensors such as Pir(Passive Infrared) for motion detection and Ultrasonic for distance measurement used to calculate position of person in front of camera because face detection module has good performance in some conditions such as distance between the person and the camera should be less than 240 cm, person doesn't use accessories that cover part of face. LBP based Face recognition system has 80% of accuracy when it is tested using real time images [2][8][9]. Person should stand in front of the camera. a camera will recognize the face and compares with the faces stored in the home member database stored in raspberry pi. If the face matches found, the door will be automatically unlock else it will remains lock.

II. LITERATURE REVIEW

Varieties of other latest technologies available are RFID card technologies, biometric protected systems, OTP based, cryptography-based and many more. each system is applicable for different application zones depending upon their technology usage. Also, there are systems that use some of this techniques for security, yet they don't provide a complete security system as there is only single-factor authentication[10]. Though large numbers of researchers have already addressed the issues of the home security system and also proposed Home Security techniques, quite a few are done on face recognition which really has a very good scope in eliminating these problems.

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In [1], author have proposed a Face Detection and Recognition System for Smart Home Security which captures image and performs image processing using MyRIO 1900 is main controller which contains the software of image acquisition, face detection and face recognition. Personal computer (PC) is applied as user interface, image display and monitoring. Both MyRIO and PC is programmed using LabVIEW which is graphical programming language called 'G' . The major disadvantage here is cost of MYRIO is very high as compared to the raspberry pi.

In[2], A Face Recognition System Based on Local Binary Patterns and Support Vector Machine for Home Security Service Robot by authors Jia Kailin Wang, Jinjin Zheng, Shiwu Zhang, Jijun He, Xiao Liang and Sui Feng explained in detail how does local binary pattern works in face recognition module, but nothing has done in case of power failure.

In[3], Face Recognition System Using IoT by authors Sandesh Kulkarni, et al., the proposed system is very well presented, and the methodology is quite well, explain in detail working of door lock-unlock on face recognition but, use of wifi limits it's area covered as system can not be accessed remotely by homeowner.

Another disadvantage of above-mentioned systems is that they are not interactive so that the person in front of the camera will not able to understand the particular reason for not allowing to get inside the home. this reasons may include that, the system is not able to recognize the face or a person is not authorized individual or any other technical issue. there are many such issues so, a person should be aware of that.

TABLE I. Literature Survey table

Title	Advantages	Disadvantages
"Design of Face Detection and Recognition System for Smart Home Security Application"[1]	1)Use of Face detection and recognition systems. 2)Easy programming ie., LabVIEW makes use of graphical language called 'G'.	1)Cost of MYRIO 1990 is too high. 2) Only wifi use make its area coverage limited.
"A Face Recognition System Based on Local Binary Patterns and Support Vector Machine for Home Security Service Robot[2]"	1)Detail Explanation of LBP and working of face recognition. 2)Very flexible and mobile due to use of robot.	1)Power requirement is must for this system. 2)No explanation for hardware and flow of system. 3)Additional cost for robotic components.
"Face Recognition System Using IoT[3]"	1)Detailed explanation of each module. 2)Easy modification.	1)No use of android application. 2)No power Backup.
"IoT Based Smart Security and Home Automation System[9]"	1)home automation with home security. 2)works well with traditional keyboard phones.	1)User involvement is must to work system properly. 2)No remote access. 3)Cost of TI CC3200 Launchpad board too high.

III. NEED OF IMPROVISING CURRENT SYSTEM

Home security becomes one of the important things that must be considered by the community as well as in the smart home systems. The major drawbacks of currently used conventional home security system, that is a security with a mechanical system that requires user to always use key to open or close door but chances of losing or duplication of keys are more[1], other example includes password security at doorstep which uses radio frequency signal sent between door and windows to control panel but which can also be cracked easily using advanced technologies such as by intercepting data, decipher commands and play them back to control panel at will. This signals can also be jammed to prevent them from tipping an alarm by sending radio noise to prevent the signal from getting through from sensors to the control panel[14].

In the present situation of the modern digitizing world, everything is equipped with modern technology and internet to ease our work and gain more efficiency. But the current system lacks it, the major problems with security that our system targets are:

1. Today's security system is from 90's that is, key-lock based.
2. In case of power failure security system stops working.
3. High-level security system comes with high cost and maintenance.
4. Homeowners are not aware of their own security system, how does it work because of their complex nature.

IV. PROPOSED SYSTEM

in order to overcome problems in existing securities system, our proposed system will consist of raspberry pi as a main controller which is inexpensive and has embedded sensors which enable sensing helps in reducing power consumption by avoiding unnecessary loss of energy which is pir for motion detection and ultrasonic sensors for distance measurement. the stepper motor will help in door locking mechanism controlled by raspberry pi which consists of face recognition algorithm. android and web application will help

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in remote access to the system with help of internet. This proposed system is broadly divided into the three parts:

A. Data Generation Unit
B. Data Processing Unit
C. Application Unit

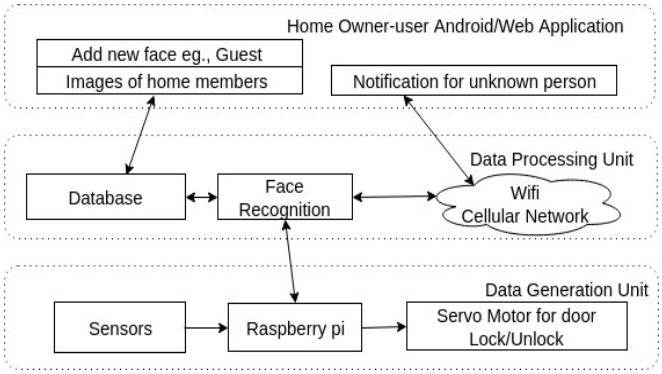

Fig. 1. Component Diagram

A. Data Generation Unit

Data generation unit will consist of sensors such as PIR (passive infrared sensor) and HC SR04 ultrasonic sensor connected to the raspberry pi model B+ and another hardware component includes Stepper motor, Doorbell, Alarm, Camera, 5V Battery.

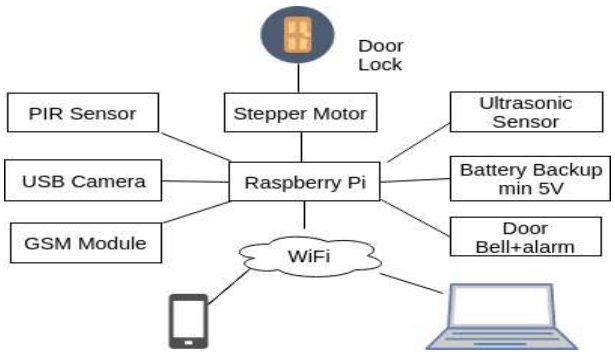

Fig. 2. Proposed System Hardware structure

- Pir Sensor

Pir(Passive Infrared Sensor) sensor is small, cheap, low-power, easy to use, low maintenance and don't wear out, used for motion detection, on motion detection USB camera connected to raspberry pi captures an image of a person in front of a camera. Here Pir sensor will be tuned in such a way that it will neglect motion detected from pets.

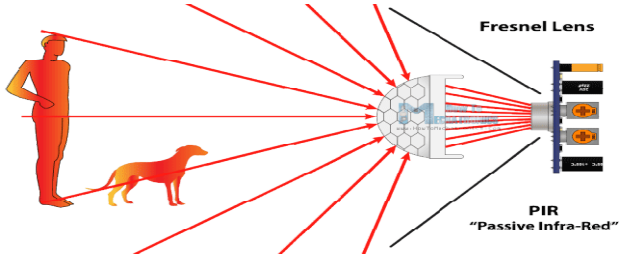

Fig. 3. Pir Sensor

- Ultrasonic Sensor

Ultrasonic sensors are intended to detect proximity or range utilizing ultrasound reflection, to compute the time it takes to reflect ultrasound waves between the sensor and any object. Ultrasound is chiefly utilized on the grounds that it's indistinct to the human ear and is generally precise inside short separations. Here it is used for distance measurement between camera and person because it is essential for better output by face recognition module.

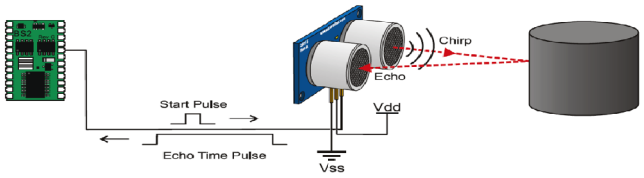

Fig. 4. HC SR04 Ultrasonic Sensor

- Stepper Motor

A stepper motor is brushless and can be both synchronous and in addition non-concurring electrical motor. Because of this the motor can change over computerized beats into mechanical turns this pivots can be utilized to open entryway controlled by raspberry pi. if proprietor is at home doorbell will be used else notification to the proprietor will be sent. if intruder breaks stepper motor that is door lock then high volume alarm will be raised and alert will be sent to the homeowner.

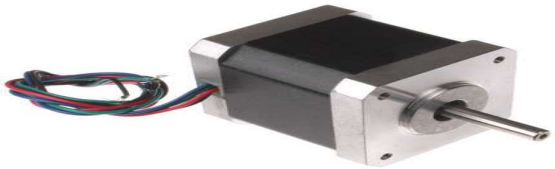

Fig. 5.Stepper Motor

The combination with a password is needed in order to increase the security level as it is applied in real smart home security systems, it also adds an extra layer of security[10].

B. Data Processing Unit

Data processing Unit will consist of Raspberry Pi 3 model B+ which has Face Recognition algorithm to detect faces in images captured by the camera. Some of the key features of raspberry pi are mentioned below[11]:

- Bluetooth: 4.1
- Peripherals: 17 GPIO plus specific functions
- Weight: 45g.
- GPU: 400MHz VideoCore IV multimedia
- USB ports: 4 ports
- Size: 85.60mm × 56.5mm
- Video outputs: HDMI
- Network: 10/100Mbps Ethernet and 802.11n Wireless LAN
- Memory: 1GB LPDDR2-900 SDRAM (i.e. 900MHz)

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- Power source: 5V via MicroUSB
- CPU: Quad-core 64-bit ARM Cortex A53 clocked at 1.2 GHz.

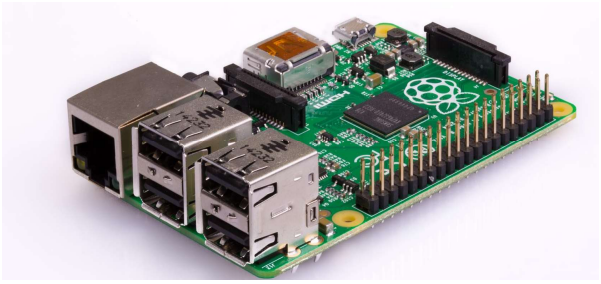

Fig. 6. Raspberry pi 3 Model B+

- Local Binary pattern(LBP)

The captured image will undergo image processing for face recognition, Local Binary Pattern(LBP) has been implemented using Python and OpenCV[12]. face recognition considers both shape and texture information to represent face images based on Local Binary Patterns, steps involved in LBP algorithm are as follow[8]:

A. Crop face(using face detector) and align the face images in order.
B. Convert all images into the same size.
C. fix the dimension of the cell size where the LBP will be calculated.
D. Run an LBP algorithm on the face images. Concatenate LBPs extracted from the image to form a unique face feature vector.
E. The feature vector for each face image can be used to recognize the person in the face image. This feature vector forms an efficient representation of the face and is used to estimate similarities between images[2][8].

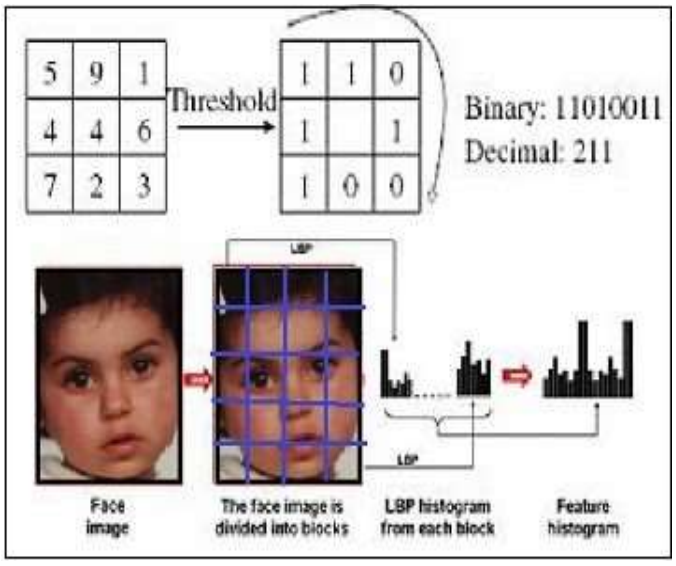

Fig. 7. LBP Feature Extraction procedure

After Face recognition, If system unable to found a face, it will alert the person that it is not able to recognize face using LED display and door remains lock.

C. Application Unit

All these activities and images of home members are stores into the database and can be accessible by the homeowner using Android and web application. Urgent notification of intruder alert can be view on a smartphone. In case of power failure system will make use of the cellular network to communicate with a smartphone using GSM module. the smartphone can be used to remove, update or add a new face to the database quickly. Android Application will auto refresh in 15 min time interval. use of android application makes our system more flexible.

V. METHODOLOGY

Our proposed system improves the current scenario, by bringing all the data on the internet so that systems operate more efficiently. This is an IoT based system and hence can be made automated. By using Raspberry Pi, the system becomes scalable, flexible and cheaper. Low power requirement make system affordable, minimum 5V required by raspberry pi to work efficiently. The system can be modified easily without disturbing the other components in the system such as replace defective sensor without interrupting other modules. The flow of the system is described in detail below.

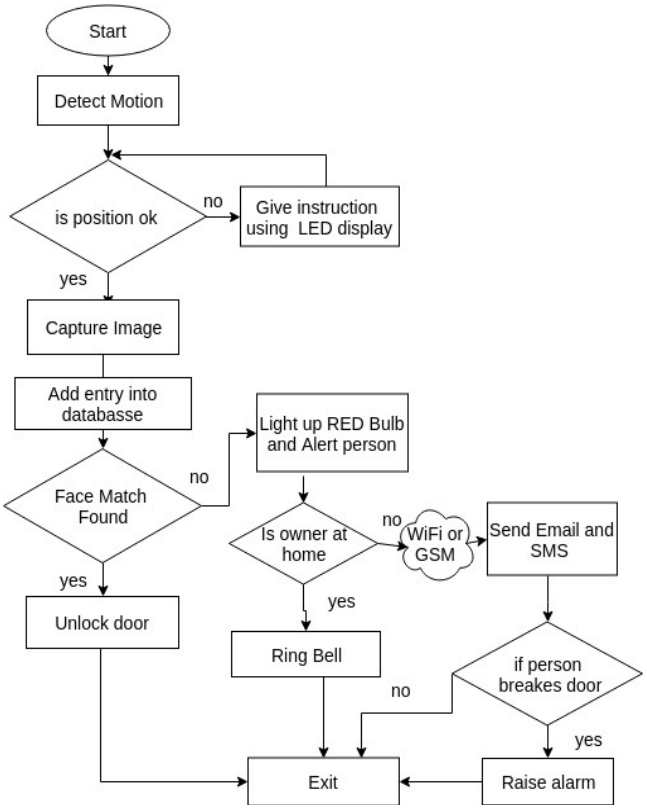

Fig. 8. System flow Diagram

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Steps involved in proposed system are discussed in detail-

1) System will work if there is some motion detected using Pir sensor else it will go into the hibernation to save energy.

2) After detecting motion, the system will check for the position of person ie., the distance between person and camera (at most 240cm) here ultrasonic sensor will be used, lighting condition. In order to satisfy this conditions system will give instructions to the person present in front of the camera.

3) Image will be captured and face recognition will be performed. if face match found door will open else red color bulb will light up, if the owner is at home(specified in android application) then bell will ring else notification will be sent ie., someone is waiting outside your home. All these activities are stored in the database which is in microSD card in raspberry pi and maximum size of SD card is 32GB. These activities can be accessible using android or web application.

4) If intruder breaks locked door then system will raise high volume alarm and indicate same to the homeowner via email and sms.

VI. RESULTS

Face recognition to determine whether person is home member or not is shown in figure 9.

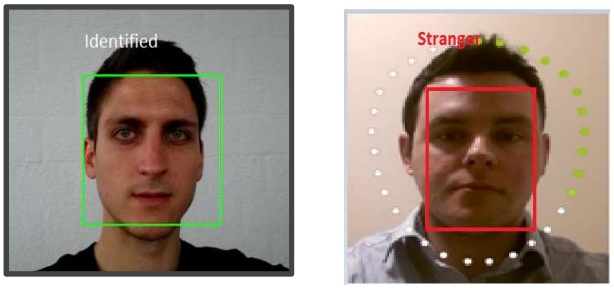

Fig. 9. Face Recognition

After face recognition, person will be determined whether it is stranger or not. In case of stranger led turns red and door will not open shown in figure 10.

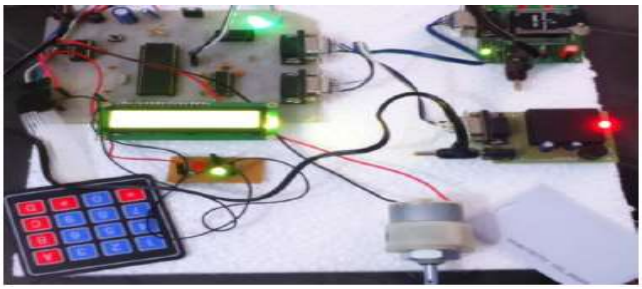

Fig. 10. LED turns Red colour in case of stranger and door remains locked[10].

In case of home member, led turns green and stepper motor rotates (door opens) shown in figure 11.

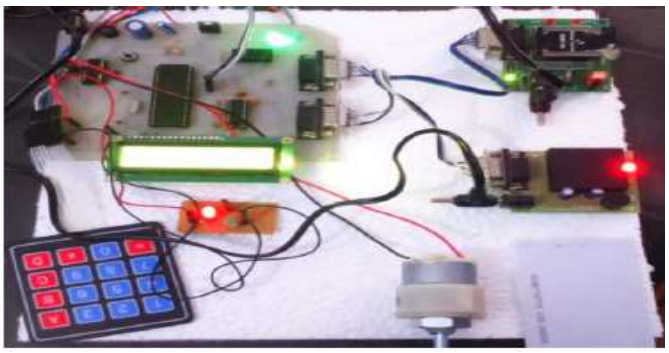

Fig. 11. LED turns Green colored in case of home member determined using facial recognition and door opens[10].

If homeowner is not at home and an intruder breaks door, system will send notification via Gmail with person's image as an attachment and sms too as shown in figure 12 and 13.

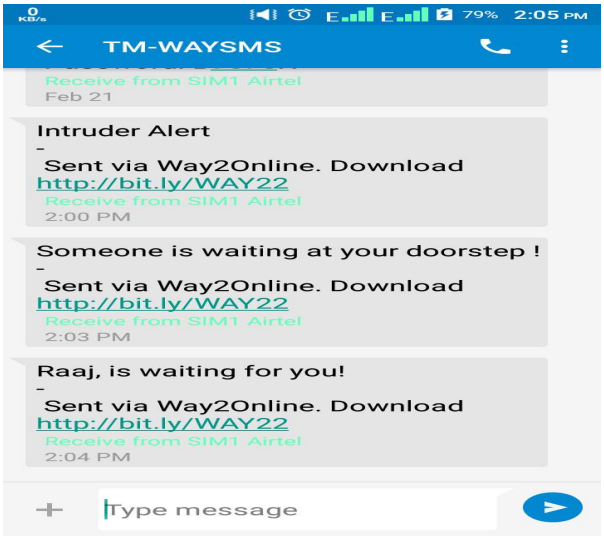

Fig.12.Notification send via Sms

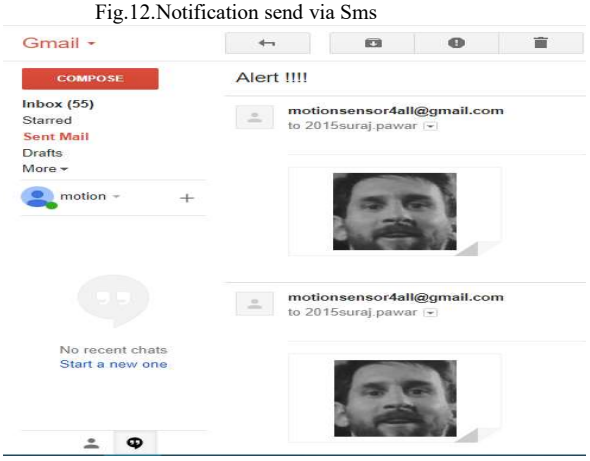

Fig. 13. Notification send via Gmail

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VII. FUTURE SCOPE

In future, a more exact face recognition algorithm can be presented and more accurate and less expensive sensors can be utilized to expand system's precision. Android application will be patched up to make it easier to understand and new highlights will be included, for example, remote entryway control, live streaming will be conceivable to track exercises occurring in the home. Digital assistance will be utilized, developed using artificial intelligence to surveillance the home.

VIII. CONCLUSION

In this paper, we have proposed and demonstrated an optimal smart home security approach with less cost and increased security. Advanced level of security is provided with help of IoT and Face Recognition. The real-time face recognition and face detection used for stranger identification and gives a warning using a LED display and send notification via SMS and email to the homeowner. Both IoT and face recognition are growing rapidly, so much advancement in this field is possible in future. Experimental results, in reality, show that system satisfies requirements of the current smart home security system. Use of android application makes it remotely accessible; a user can keep track of activities happening in the home using a Smartphone.

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