Smart home automation with a unique door monitoring system for old age people using Python, OpenCV, Android and Raspberry pi

Bhaumik Vaidya
Research Scholar,
GTU, Ahmedabad

Ankit Patel
Student,
SCET, Surat

Anand Panchal
Student,
SCET, Surat

Rangat Mehta
Student,
SCET, Surat

Krish Mehta
Student,
SCET, Surat

Parth Vaghasiya
Student,
SCET,Surat

***Abstract* — In this paper, smart home automation system particularly for old age people is proposed based on python, OpenCV, raspberry pi and android application. The appliances are controlled by the Raspberry pi server, which operates according to the user command (touch or voice) received from the mobile phone. A unique door monitoring system is designed based on face detection and recognition from a camera installed outside the main door, which can be accessed from the phone using android application. One interesting feature that has been added is that, all the appliances can also be controlled through the voice of user. For energy efficiency user can analyze the usage of each appliance from their phone. Moreover, user can also control the intensity of light as well as the speed of the fan. With all this features incorporated in a single system with good and simple user interface, this system is cost effective and perfect for old age people living alone in their houses.**

***Keywords*—Raspberry pi; Android; Python; OpenCV; Wi-Fi; USB; camera.**

I. INTRODUCTION

Home automation is one of the major growing field that can change the way people live. Some of these home automation systems target those seeking luxury and sophisticated home automation platforms; others target those with special needs like the elderly and the disabled. Home automation refers to domestic environment that improves the quality of the resident's life by facilitating a flexible, comfortable, healthy, and safe environment. [1]

In Home, automation systems there are collections of interconnected devices for controlling various functions within a house. Mobile devices are ideal in providing a user interface in a home automation system, due to their portability and their wide range of capabilities. Within the house, the user might not want to go to a central control panel, or not even to the laptop, but use the phone that is usually placed in closer proximity to the user. When far from the house, the user might want to check its status or even schedule actions for his return.

The motivation for the proposed wireless Home Automation System is to provide those with special needs with a system that can respond to voice commands and control the appliances. Now a day, Elderly people leaving alone faces big threat from thieves attacking their houses. The proposed system has a unique door monitoring system based on face detection and recognition algorithms that will help elderly and disabled people from this kind of attacks.

When system is designed for elderly or disabled persons it should be reasonably cheap, easy to configure, and easy to run with a good user interface. So, in this paper, the system proposed is relatively simple to implement with friendly User interface.

In this paper, first the problem has been defined, and then a cost-effective solution to that problem using Raspberry Pi has been proposed. The existing solutions for home automation based on other platforms is discussed in Section-II. In section-III block diagram and implementation of proposed system is discussed. In section IV implementation of door monitoring system with its results is discussed.

II. LITERATURE SURVEY

The most available home automation systems in the literature uses different wireless communication standards like IR, RF, Bluetooth, ZigBee, Wi-Fi, and Global System for Mobile Communication (GSM) to exchange data and signaling between their components. Wireless home automation systems decrease installation cost and effort, and enhance system flexibility and scalability. [4]

A few examples of home automation system in literature are GSM based Home Automation using SMS [2,3,6,7], IR Remote based Home Automation System [10], Bluetooth Based Home Automation System [8], RF and Zig-bee based Home Automation System [12], Wi-Fi based Home Automation System, Java-(Web) Based Home Automation System. [11]

Even if many varieties of home automation systems are available, current systems have number of limitations. Currently home automation systems are implemented with a large amount of hardware. The installation and maintenance of the systems is a difficult task. It also imposes a huge installation cost on the user or consumer. Current home automation systems are inefficient in security. In Infrared (IR) remote based Home automation requires line of sight communication. [10] Radio Frequency (RF) based home

automation required high power consumption. They are also very poor in bandwidth utilization.
In case of ZigBee, the bandwidth is too low and in case of GSM, it is too high. [12] The java web based home automation is very poor in security as it uses web pages to access and control the appliances. [11] Bluetooth have limited communication range. [8] MS based and GSM based home automation is costly for the consumer as it becomes expensive to communicate via SMS. [2, 3]

To overcome all this limitation system based on Raspberry Pi and Android operating system has been proposed. Using concept of android-based home automation systems, users can be provided with simple, secure and easily configurable home automation system. Raspberry Pi is a credit card sized computer. It's basically a small PC which provides all the basic functions that are provided by a desktop PC. For example, it provides functions like word processing, gaming and playing audio/video. [9]

III. PROPOSED SYSTEM

The block diagram of proposed home automation system is shown in Fig 1. The system is built around Raspberri pi and Android plateform to control multiple home appliances like tube light and fan as shown in figure.

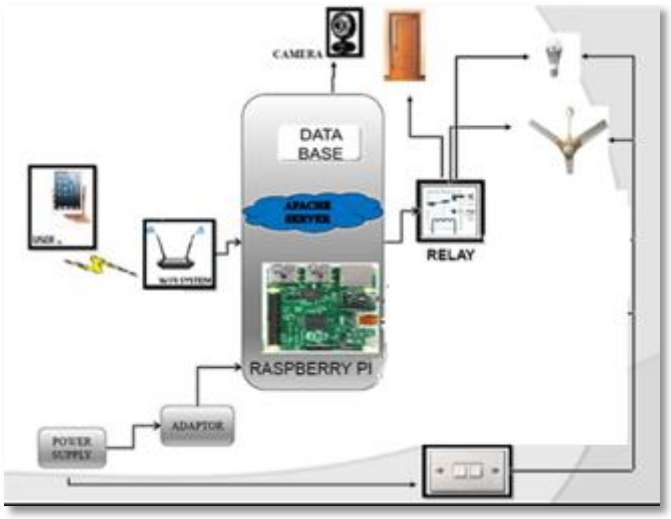

Fig 1 Block diagram of Proposed System

The home appliances are controlled by Raspberry Pi through user command in form of touch or voice received from the mobile phone. For wireless connection, Wi-Fi router is used that is connected with raspberry pi though Wi-Pi dongle and phone with Wi-Fi (IEEE 802.11 protocol) connection. One will control different appliances from the android application by giving command to the raspberry pi and according to command Raspberry pi will give signal to relay switching circuit to turn ON/OFF particular Electrical appliance. In door monitoring system, there is one camera installed on the main door, which is connected to raspberry pi and can be accessed from the phone using android application. The detail of door monitoring system is discussed in the next section. One interesting feature that has been added is that, all the appliances can also be controlled through user's voice. The voice command given by the user will be matched with the code stored in raspberry-Pi data base system of a particular user and accordingly particular device will be turned ON/OFF.

One can analyze the usage of each appliance from their phone. Moreover, user will also be able to control the intensity of light as well as the speed of the fan.
The System has following Main components.

1. Raspberry Pi:
   It is the central core part of whole proposed system. It is used to get command from either android tablet or PC and according to the command, control the appliances connected to it on the output port. It is connected to android tablet or phone via a router by using Wi-Fi or Ethernet cable. It is also used as a webserver to store to status of appliances in the database and give it to the php web application to display on the webpage.

2. Android Devices:
   These devices are used to control the appliances connected to it from the remote places. It is connected to raspberry pi via a router by Ethernet cable or Wi-Fi. Application uses the TCP protocol to communicate with Raspberry Pi.

3. Pi Camera:
   It is connected to raspberry pi for monitoring the door. When there is someone on the door, by using Android application and intelligent face recognition software, one can help in providing security to home.

The home automation system is built around Raspberry Pi 3, USB camera and android phone. Implementation results are discussed one by one.

The first part is to control appliances using Android device. In this, relay drivers and X-OR gate has been used so that appliances can be controlled via application and it can be controlled manually also via switches. Switch sensing circuit is used to sense the current status of switch. The block diagram of the connections is shown below in Fig 2.

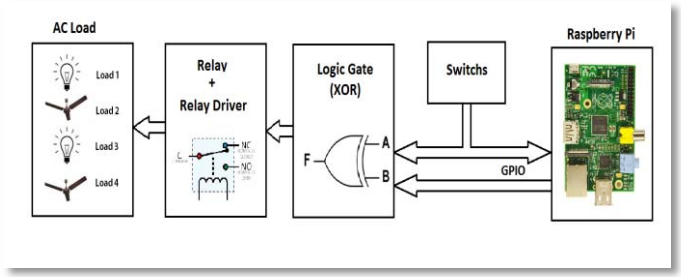

Fig 2 Block diagram of Appliances control [5]

After implementing circuit on the hardware, android application is made to control appliances that are connected to

Raspberry Pi. The communication is made using TCP/IP protocol. Here local area network is used so Raspberry pi and android phone should be connected via same wi-fi router. Although giving a global IP to the router and then via port forwarding appliances can be controlled from anywhere in the world. Fig 3 indicates results of controlling appliances via Android application. Current status of appliances can also be view in application via pressing the refresh button.

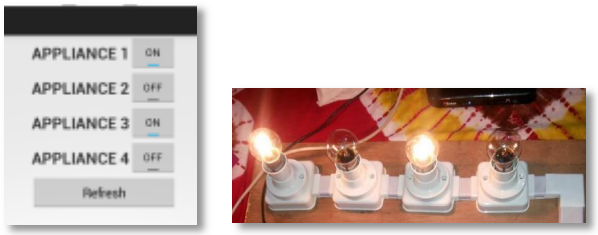

Fig 3 Results of Appliances control via Android application

A more complicated thing is to generate AC or PWM output from Raspberry pi. This can be used to control intensity of light, speed of fan, position of curtain etc. Fig 4 shows the hardware implantation result for controlling intensity of light using PWM output from Raspberry Pi.

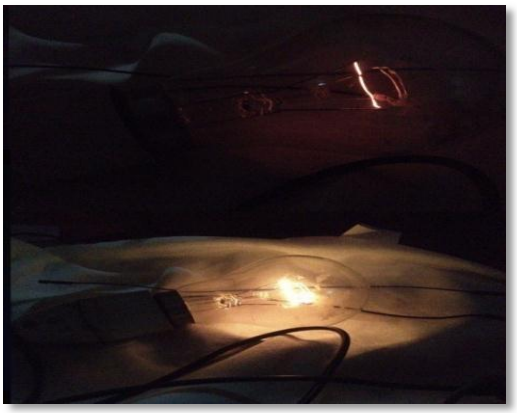

Fig 4 Result of Light dimmer in hardware

The status of appliances are periodically stored in the database. So from the database usage information and energy consumption for a month can be calculated that will help in calculating electric bill and prediction of future energy consumption.

IV Proposed Door monitoring System

For Door monitoring system a camera is interfaced with Raspberry pi. Web camera is interfaced with Raspberry pi via a USB cable. Door lock is also connected to raspberry pi and it can only be opened through command given to raspberry pi via Android phone or manually by having key. Whenever door is opened manually or via mobile, notification is sent to the owner on Android application. The flowchart of whole workflow for automatic door monitoring system is shown in Fig 5. It will work automatically without manual intervention from user when someone is at the door.

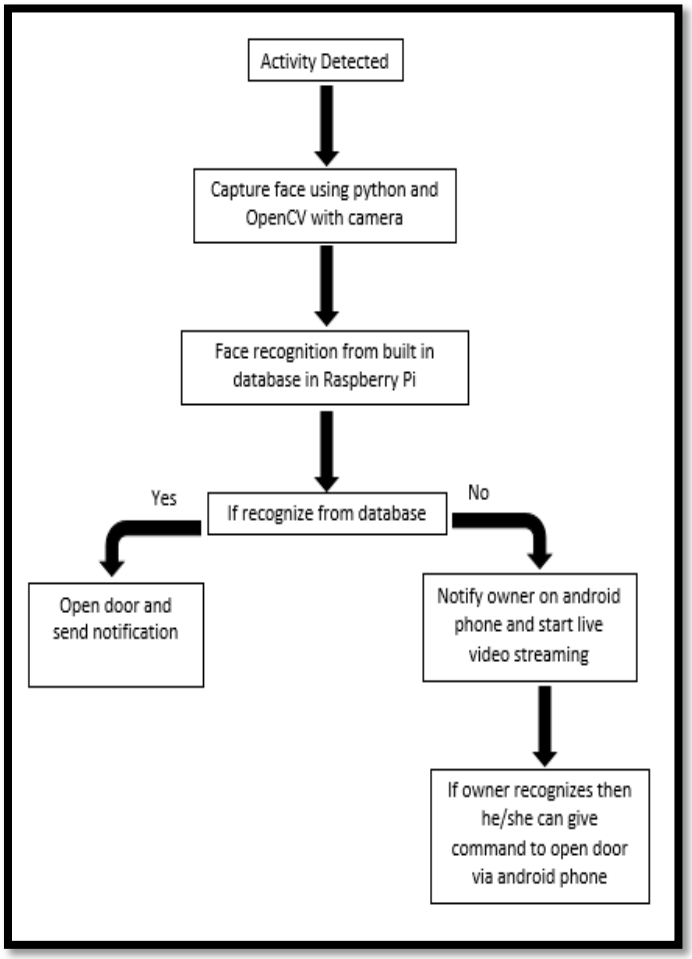

Fig 5 Flowchart for Automatic Door monitoring System

When somebody will press the doorbell or when camera will detect abnormal activity then it will capture the image using software code written in Python and OpenCV for activity detection. Background subtraction algorithm is used to implement activity detection. [14] After capturing image face is detected and segmented from the image using Haar features using python and OpenCV code. [15] Segmented face is given to face recognition code for recognizing faces from the known faces stored in the database. Principal component Analysis (PCA) algorithm and Support vector machine (SVM) is used for face recognition [16] and it is implemented in Python and OpenCV.

If face is recognized, Raspberry pi will open the door and notify the owner via Android application about who has entered the house. If face is not recognized then owner will get notification about some unknown person waiting on the door

and live video streaming will start on the phone. If owner recognizes the person and wants to open the door, it can give command via Android phone to Raspberry pi for opening the door. If owner can't recognize a person and wants to inform police he can do it by pressing the other button. This system will be particularly helpful for elderly or disabled persons living alone in their houses in big cities where possibility of thieves attacking their houses is large.

The result of captured image by camera when somebody has pressed the doorbell is shown in the Fig 6.

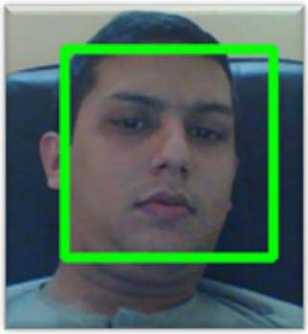

Fig 6 Result of captured image by camera when someone is at door

For face recognition using PCA and SVM apart from synthesized dataset, Yale database is used to test the results for face recognition. [17] Different features from a training set and testing set is extracted using PCA. Using these features SVM classifier is trained. Fig 7 indicates face recognition result for sample image from Yale database.

Fig 7 Result of face recognition using PCA

Important parameters for performance analysis of face recognition system are False Acceptance rate (FAR) and False Rejection Ratio (FRR). A system's FAR typically is stated as the ratio of the number of false acceptances divided by the number of identification attempt and system's FRR typically is stated as the ratio of the number of false rejections divided by the number of identification attempt. The value of FAR and FRR should be as low as possible and there is a trade off in balancing values of FAR and FRR according to the application. The values of FAR and FRR changes according to of number of features used and classification threshold. For this application FAR should be as low as possible because no unauthorized person should come inside the house. FRR can be moderate as there is second chance for authorized person to enter house by authentication from the owner. So in this paper optimal value for FAR and FRR was arrived at by varying threshold value and number of features. After comparison it was found that at 60% threshold and 30 features FAR and FRR was optimal at 1.4% and 53% respectively for this particular application for door monitoring.

In future, this system can be extended to predict Energy utilization in the household. Also the status of appliances can be monitored if the webpages are hosted using public IPs.

CONCLUSION:

In this paper, home automation system has been proposed using Raspberry Pi module and operated using Android Application. AC Appliances like Bulb, Fan, etc. are controlled via Android application via touch or voice command.

Dedicated Application is developed through which devices can be operated and status can be seen. An automatic door monitoring system using USB camera, python, OpenCV, raspberry pi and android device is proposed for monitoring and security purpose. It can particularly help elderly and disable people living alone in their houses. The database for status of appliances at a particular time has been developed. The system proposed is reasonably cheap, easy to configure, and easy to run.

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