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A Cost-Effective Ambient Assisted Living for Golden-Agers with IoT based Smart Security Surveillance System using Raspberry Pi

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ABSTRACT

Building a secure home for elders is an expensive affair in India with even simple home security systems costing anywhere from thousands of rupees to lakhs. But where there is a will, there is a way definitely. Tech-loving people with a little bit knowledge in Python programming can now create their own inexpensive security systems with the tiny supercomputer called the Raspberry Pi. With the huge increase in threats to old people living alone at homes, it might be wise to invest in a Raspberry Pi-controlled security system for our elders at home. Also such systems allow our elders to lead a nearly normal and independent life with dignity at reduced risks to their property and themselves. Their kith and kin may also work and live at peace knowing that their elderly relatives are safe and if anything out of ordinary occurs they shall be informed immediately. Such Raspberry Pi-controlled security systems can be built with little expertise, while at the same time being customizable, easily extendable at the same time easy on the pocket too.

Keywords – Assisted Living; Home Security system; Internet of Things; Raspberry pi

I. INTRODUCTION

Today security and safety is becoming more and more important since nowadays theft is very much on the rise. So there are increasing endeavors to build a security system which will effectively manage this issue keeping a user free from fear about home security in all cases and especially when golden-agers are left alone at home. Whenever the user is away from his home leaving the elders at home alone for some reason, often he is left unconnected with the home. This situation can be overcome now with the advent of Internet of Things (IoT). IoT is an ecosystem of connected physical objects that are accessible through the Internet. Internet of Things can connect devices embedded in various systems to the Internet. When devices/objects can represent themselves digitally, they can be controlled from anywhere. The connectivity then helps us capture more data from more places, ensuring more ways of increasing efficiency and improving safety and IoT security. It enables

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devices/objects to observe, identify and understand a situation or the surroundings without being dependent on human help.

One of the biggest changes that the IoT has brought to our homes is the ability to control our home while we are away or while elderly persons are alone at home. For instance if a burglar enters our home, instantly we could receive a message on our phone, that tells us someone has entered our home. We can then check our e-mail and see who is in our home and also sound the alarm if need arises. The possibilities are endless, and the low cost involved in setting up these types of protections will allow the majority of households to set up powerful home security systems in the future.

The rest of the paper is organized as follows: Section 2 explains some of the related works and Section 3 gives an overview of the proposed approach. Our implementation details are provided in Section 4. Finally, conclusion and future work are presented in Section 5.

II. Literature Survey

Visa and Asogwa [1] proposed a better security system for cars with the help of GSM. The proposed framework operates with Dual Tone Multi Frequency (DTMF) and a GSM to provide security against cart thefts by text message to the owner, create a sound alert and demobilize the car whenever a threat is detected.Jayashri and Aravind [2] proposed a home security system with a camera to capture motion and give an alert via audio and also send an SMS using GSM-GPS module. They used an Atmega644p microcontroller, sensors, relays and buzzers to create this security system.Sathya Narayan and Gayathri [3] proposed an intelligent home automation system using PIC microcontroller, ZigBee wireless communication technology, speech recognition technique and GSM technology. The system was mainly designed to control electrical devices at home and in office through speech.

Sanjana et al [4] proposed a home security system for capturing information and transmitting it via a 3G Dongle to a Smart phone using a web application. They used Raspberry pi to remotely control motion detectors and video cameras for surveillance.Shaju et al [5] proposed a system for controlling home appliances using a Raspberry Pi server, android phones and WiFi communication protocol. The user interface of the system is designed to fit the android mobile display size and is used to control the home appliances remotely.

Vigneswari et al [6] proposed a system to create alerts whenever a person enters a room. IR sensors were used to detect persons entering a room and Raspberry Pi board was used for processing this information and sending alerts to the user in the form of SMS. A GSM modem was used for sending SMS to the users.Rajendra et al [7] proposed a secure home automation system by creating a web application that interacts with a Raspberry Pi device. The security was provided by integrating cameras, motion detectors, buzzers, temperature and moisture sensors with Raspberry Pi which processes the information from the sensors and sends mails to the user whenever necessary. Also the user is able to control the components at home remotely with the help of the web application.

III. Proposed System Architecture

Overall block diagram of the proposed system is shown in Figure 1. The Ultrasonic sensor detects the presence of intruders in the area being monitored and triggers the Raspberry Pi (RPi). The RPi notifies the user using SMS message and sends the image captured by the camera through email. Also an alarm sound (audio message) is generated for alerting the neighbors when the sensor detects the intruder. After checking the email and the attached image, user can decide upon further actions to be taken for the safety of the golden-agers at home. The Ultrasonic sensor and USB camera can be installed at the front door of our home and interfaced with the RPi. When the ultra sonic sensor is triggered by the intruders, the USB camera captures the image of the intruder and sends a mail to the registered owner and

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also an alert message to the owner's mobile number. The speaker is used to provide a voice alarm message to the neighbors for immediate action.

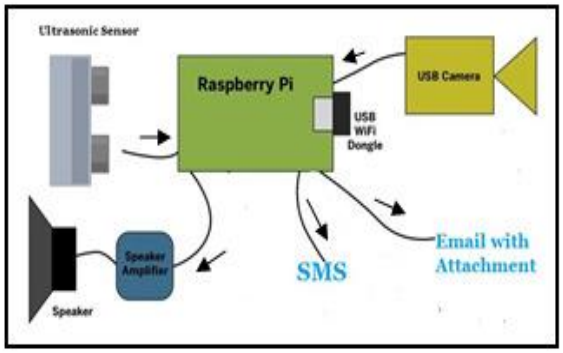

Figure 1: Proposed System Architecture

3.1 System Components / Hardware

The hardware components needed for building the home security system include a Raspberry Pi model 3 (with in-built USB Wifi dongle), HC-SR04 ultrasonic distance sensor, an USB 2.0 PC camera with 8.0 mega pixels, a small passive speaker that does not need an external power source to work on an RPi, resistors, and connecting wires. The major components are explained below.

3.1.1 Raspberry Pi 3 Model B

The RPi is a small, affordable single-board credit-card sized computer that can be used to design and develop a smart home security system. The RPi works with a variety of input/output devices using HDMI, USB, and Ethernet to communicate with the outside world. The RPi 3 is the third generation Raspberry Pi. Any language which will compile for ARMv8 processor can be used with the RPi, though Python is the most popular language used. Figure 2 illustrates the Raspberry Pi 3 kit.

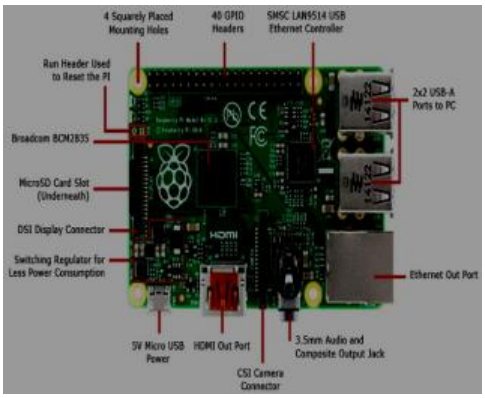

Figure 2: Raspberry Pi Model 3

The specifications of RPi 3 model is given in Table 1.

Model	Specifications
RPi 3 Model B	• CPU: 1.2GHz 64-bit quad-core ARMv8 • RAM: 1GB • USB: 4 ports • Connectivity: Ethernet, Wi-Fi, Bluetooth • 40 GPIO pins • Full HDMI port • Combined 3.5mm audio jack and composite video • Camera interface (CSI) • Display interface (DSI) • Micro SD card slot (now push-pull rather than push-push) • VideoCore IV 3D graphics core

TABLE 1: RPi 3 SPECIFICATION

The RPi 3 has an identical form factor to the previous RPi 2 . Table 2 lists the ports on the RPi board and some of their uses. The ports may also be used for other purposes than listed below.

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USB	Mainly used for peripherals like Keyboard, mouse and a Wi-Fi Adapter. A powered USB hub can be connected and be expanded
HDMI	This is the High Definition Multimedia Interface [HDMI] and is used to connect to a display unit like TV or Monitor or sometimes a Projector
Stereo Audio	Audio connections using a 3.5 mm jack
SD Card	SD card is used as a boot device and also persistent storage. More storage can be attached to the USB
Micro USB	The micro USB port is used for supplying power to the unit
CSI Connector	CSI [Camera Serial Interface] is used for connecting a camera to the unit
Ethernet	Used for connecting to a network using a network cable
DSI Connector	DSI [Digital Serial Interface] is used for connecting a LCD to the unit

TABLE 2: RPi PORTS AND THEIR PURPOSE

One powerful feature of the Raspberry Pi is the row of GPIO (General Purpose Input/Output) pins available along the top edge of the board. These pins are a physical interface between the Pi and the outside world. At the simplest level, we can think of them as switches that we can turn on or off (input) or that the Pi can turn on or off (output). Of the 40 pins, 26 are GPIO pins and the others are power or ground pins plus two ID EEPROM pins. Figure 3 illustrates the GPIO pin diagram.

Figure 3: GPIO Pins

3.1.2 Other Components

Ultrasonic Sensor

The Ultrasonic Sensor is used to measure the distance to an obstacle with high accuracy and stable readings. It can measure distance from 2cm to 400cm or from 1 inch to 13 feet. It emits an ultrasound wave at the frequency of 40 KHz in the air and if any obstacle comes in its way, then the wave will bounce back to the sensor. By using the time that the wave takes to strike the object and come back, the distance between the sensor and the intruding object can be calculated. The HC-SR04 Ultrasonic Sensor used for the home security system is shown in Figure 4.

Figure 4: Ultrasonic Sensor

Camera and Speaker

We are using a standard USB 2.0 PC camera of 8.0 mega pixel with Raspberry Pi to capture the image of the intruders. A small passive speaker is plugged into the Raspberry Pi to produce a voice alert in case of the detection of intruders. Figure 5 shows the camera and speaker used for the implementation.

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Figure 5: Camera and Speaker

IV. IMPLEMENTATION

An ultrasonic sensor is used to detect the presence of any person and a Pi Camera is used to capture the images when their presence is detected. Whenever an intruder comes into the specified range of the ultrasonic sensor, the Pi Camera is triggered through RPi. RPi sends commands to the Pi camera to capture the face of the intruder and save it in a specified location under a specified name. Then the RPi creates a mail and sends it to a specified mail address with the recently clicked images as attachments. The mail contains a message and picture of intruder as attachment. Here we have used the message "Alert!!! Someone has entered the house. Please see the attachment". The pictures are saved in RPi with the name specifying the date and time of intrusion, which helps in proper identification and necessary action to be taken by the receiver. Usage of ultrasonic sensor provides us the flexibility to adjust the intrusion detection range or distance of the security system. An alternate feature is also included in case the receiver is in a place without Internet facility and is unable to receive the mail sent by the RPi. The alternative is to send an SMS alert to the receiver's mobile immediately when the sensor detects the intruder. As an added facility, a voice alert is also generated to notify the event of intrusion for timely action by the neighbors. For all the above implementation, Python coding is used as it is the preferred language for RPi.

4.1 Hardware Configuration

In this Smart Security Surveillance System, we need to connect Pi Camera module and ultra sonic sensor to Raspberry Pi 3. Pi camera is connected at the camera slot of the RPi and ultra sonic sensor is connected to the GPIO pins. Also the speaker is connected to the appropriate slot (Stereo audio port) in the RPi.

4.2 Software Configuration and Python Coding

Whenever anyone comes in the path/range of Ultrasonic Sensor, RPi detects the distance of intruder from the sensor and if the object is in the defined range, it sends the High signal which triggers three actions in our system, namely, sending a mail with an image attachment, sending SMS and triggering the speaker which starts broadcasting the specified text message loudly for alerting the neighbors.

Before coding, user needs to configure Raspberry Pi. After successfully installing Raspbian Jessie OS on Raspberry Pi, we should install the required libraries for the proper functioning of the various components connected to the Raspberry Pi. The packages are installed by executing the following command at the Pi terminal

sudo apt-get install <required-package/library>

Then user needs to reboot Raspberry Pi, so that the new setting can become active.

Camera

To make sure that the Raspberry Pi recognizes the camera, we should enable Raspberry Pi Camera (Figure 6) by using the Raspberry Pi Software Configuration Tool, *raspi-config*.

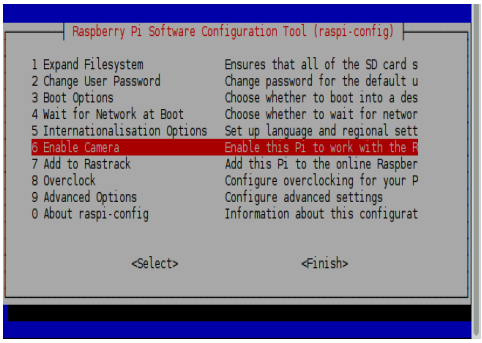

Figure 6: Camera Configuration Screen

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Now our Pi camera is ready to use. The following command is then issued to capture the image and store it in the specified location: for example, "/home/pi/security" under the name "intruder.jpg" in our Python script.

fswebcam -r 1280x720 /home/pi/security/intruder.jpg

Sending Email

Now after setting up the Pi Camera, we will install software for sending the mail. Here we are using ssmtp which is an easy and good solution for sending mail using command line or using Python Script. Here we have tried with a Gmail account. Gmail has made some security change recently. So we have to allow "less secure apps" on the account. Otherwise, we won't be able to connect to it with our python script. There's a native library in Python to send emails: *smtplib*. Import the required libraries. After this, the user needs to open *ssmtp.conf* file and edit this configuration file. To configure the email, the file */etc/ssmtp/ssmtp.conf* is edited to include the appropriate information.

Once the configurations are done, the image captured by the camera can be sent as attachment along with appropriate subject to the required user using the following statement in the Python script.

server.sendmail(FROM, TO, msg.as_string())

Sending SMS

Even when users are in a location with lack of internet connectivity, our system provides security by sending SMS to the required user. This implementation is tried through Way2SMS. Initially an account is created in the Way2SMS text messaging service, which offers free messaging. After this initial step, the Python script is written to send SMS to the required user. The script contains statements for user login, sending SMS as shown below.

```
url = 'http://site24.way2sms.com/Login1.action?'
data = 'username='+username + '&password=' +
passwd + '&Submit=Sign+in'
sms_sent_page = opener.open(sms_url, sms_data)
```

Sound Alert

A simple method to get some immediate attention by the neighbors about the intruder is achieved using the Raspberry Pi's Text To Speech (TTS) facility and a speaker. For this the espeak text to speech synthesizer is installed in RPi. In the *raspi-config* panel, choose: *Advanced Options, Audio, Force 3.5mm headphone jack* and select Finish as shown in Figure 7.

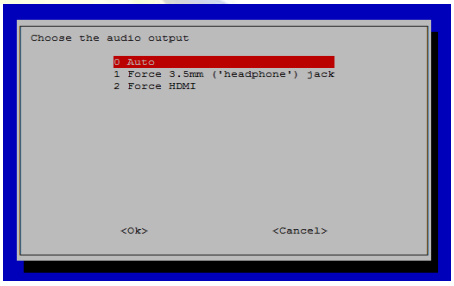

Figure 7: Audio Configuration Screen

Once the required configurations are done, Python script can be written to convert a text to speech. A part of the code is given below.

```
text = '"Attention Intruder inside the house"'
subprocess.call('espeak '+text, shell=True)
```

Ultrasonic Sensor

The sensor consists of 4 pins, which are connected using the GPIO pins of the RPi. (PIN 1- VCC or +5V, PIN 2- TRIGGER, PIN 3- ECHO and PIN 4- GROUND).

A snippet of the Python script is given below

```
TRIG = 20
ECHO = 21
GPIO.setup(TRIG,GPIO.OUT)
GPIO.setup(ECHO,GPIO.IN)
…
pulse_duration = pulse_end - pulse_start
distance = pulse_duration*17150
```

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To summarize, the overall steps carried out using Python script is given below.

1. Send trigger to sensor
2. Record start and stop time of pulse output from sensor.
3. Calculate the distance by using START and STOP time.
4. Trigger camera to capture image if distance is less than the specified intrusion range
5. Send mail with captured image as attachment
6. Send SMS to specified mobile number
7. Activate speaker and announce the specified text message

V. Conclusion and Future Scope

Building a customizable, secure home for our golden agers at affordable cost using the credit-card sized single board computer called RPi has been achieved. With the Raspberry Pi, attempts at illegal entry into the houses of old people is detected through round the clock surveillance but at a nominal price when compared to the existing surveillance systems available in market at present. In addition to alerting the authorities through mails and/or SMS, selected care takers, guardians or neighbors can also be alerted through the same mails and/or SMS without any additional cost. This ensures quick help to our golden agers and also ensures that the relatives can rest assured that immediate help will be available to their elders at any time in case of illegal entry into their homes. Additional security in the form of audio alert through speakers is also implemented which provides security not only to the golden agers but also their neighbors as the presence of intruders is informed to the entire neighborhood through the speakers immediately.

In future, this security system could be extended to take care of the health issues of the golden agers. Motion sensors attached to the beds of elderly people can help to detect emergencies like heart attacks or other health problems and inform the same through alarms, mails or SMS to the family doctors, nearby hospitals, ambulance services, neighbors and relatives all at the same time. Also additional security can be provided by enabling main electricity supply of the house to be turned on or off from a remote location in case of emergencies like fire. Lights can be turned on or off remotely giving an impression that there are more people at home even when the elders are alone thus providing additional means of foiling attempts at theft. Creating a safe but independent living environment for the golden agers of our nation has thus become possible with the advent of RPi and IoT at affordable costs.

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