

# Smart Surveillance Security & Monitoring System Using Raspberry Pi and PIR Sensor

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**Abstract**— This paper deals with the design and implementation of Smart surveillance monitoring system using Raspberry pi and PIR sensor for mobile devices. It increases the usage of mobile technology to provide essential security to our homes and for other control applications . It has human detection and smoke detection capability that can provide precaution to potential crimes and potential fire. The credit card size Raspberry Pi (RPI) with Open Source Computer Vision (OpenCV) software handles the image processing, control algorithms for the alarms and sends captured pictures to user's email via Wi-Fi. As part of its alarm system, it will play the recorded sounds: "intruder" or "smoke detected" when there is a detection. The system uses ordinary webcam but its IR filter was removed in order to have night vision capability. The proposed home security system captures information and transmits it via a 3G Dongle to a Smart phone using web application. Raspberry pi operates and controls motion detectors and video cameras for remote sensing and surveillance, streams live video and records it for future playback. It can also find the number of persons located with the help of the Infrared sensor.. For example , when motion is detected, The cameras automatically initiate recording and the Raspberry pi device alerts the owner of the possible intrusion having a smart phone. Raspberry - Pi has two main components interacting with each other: one is the Web Application that executes on the mobile device's browser and server -side scripts that run in a cloud which will be operated by the Raspberry Pi Hardware tool component

**Keywords**— USB cameras , PIR sensor ,Raspberry Pi, Relay,3G dongle, Smart phone

## I. INTRODUCTION

Raspberry pi is a credit- card sized computer .It functions almost as a computer . There are various surveillance systems such as camera ,CCTV etc.,In these types of surveillance systems, the person who is stationary and is located in that particular area can only view what is happening in that place .Whereas, here ,even if the user is moving from one place to another ,he/she can keep track of what is happening in that particular place. Also another advantage is that it offers privacy on both sides since it is being viewed by only one person .The other major advantage is that it is a simple circuit .the operating system used here is

Raspbian OS.Raspbian OS has to be installed so that the image can be transmitted to the smartphone Closed-circuit television monitoring system has now become an indispensable device in today's society. Supermarkets, factories, hospitals, hotels, schools, and companies are having their own CCTV system for 24/7 monitoring. It gives real-time monitoring, provides surveillance footage, and allows the authorities have evidences against illegal activities. Although surveillance camera records video and helps the authorities to identify the cause of an incident such as crime or accident, it is just a passive monitoring device. The researchers developed an active surveillance camera that has the capability of identifying the context of the scene being monitored and able to give notification or alarm as the event happens.

## II. THEORETICAL FRAMEWORK & DESIGN CONSIDERATION

### A. Top Level Design

Figure 1 shows the block diagram of the whole system. The heart of the system is a single board credit card size computer known as Raspberry Pi (RPI). It is the central platform for image processing and signal alerting. An ordinary webcam with its IR filter removed captures the scene to be processed by the RPI. A dark activate switch triggers IR LED illuminator circuit during night time to enhance night vision mode. The system has the capability of detecting motion of an object by the background subtraction algorithm. When the moving object is detected, the system can classify it as human or smoke. If there is detection, the system sends out alerting signal in the form of sound and email to indicate fire or unauthorized invasion.

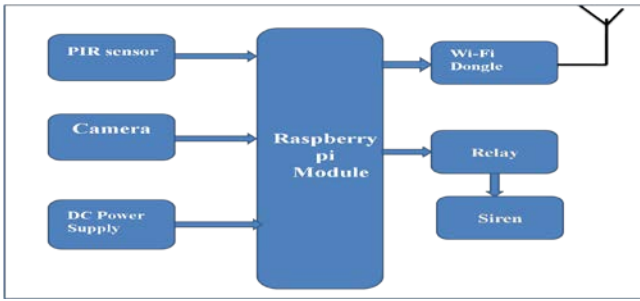


Fig. 1. System Block Diagram

### III. FUNCTIONAL DESCRIPTION

The functions of the various components are given below:

#### A. USB Camera:

USB Camera captures the image and sends it to the USB port of the Raspberry Pi board. The camera model used here is USB Camera model 2.0.

#### B. Raspberry Pi:

Raspberry pi is a small credit-card sized computer capable of performing various functionalities such as in surveillance systems, military applications, etc. The various functionalities of the components are given below. The various components of Raspberry- Pi are

- *SD Card Slot* is used to install OS/booting/long term storage. The total memory of the SD card is about 8GB.
- *Micro USB Power Port* provides 700mA at 5A.
- *RCA Video Out* is connected to display if HDMI output is not used. It is mainly used to carry audio and video signals. They are otherwise called as A/V jacks.
- *Audio Out* Digital audio is obtained if HDMI is used to obtain stereo audio. Here analogue RCA connection is used.
- *Ethernet Port* is used to connect to the Internet. It also plays a role in updating, getting new software easier.
- *HDMI OUT(High Definition Multimedia Interface)* is used with HDTVs and monitors with HDMI input. Also HDMI-HDMI is used here.
- *BROADCOM BCM 2835*: It is otherwise defined as System on chip. It is a 700 MHz Processor. It has a Video core IV GPU.

*GPIO* allows us to control and interact with real world

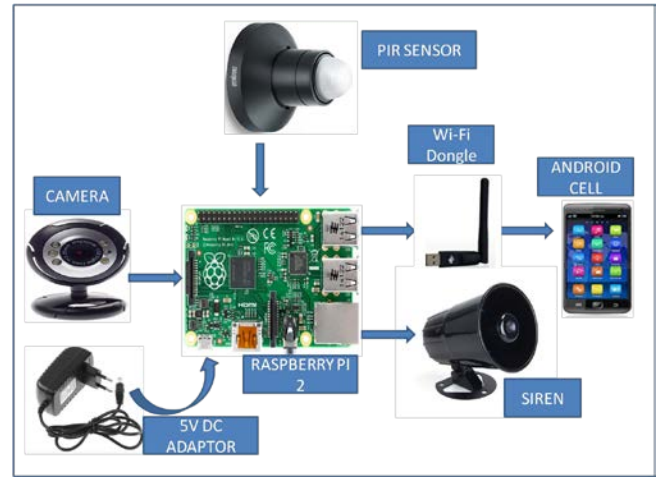


Fig 2 : System Design

### IV.. GENERAL SYSTEM FLOW CHART

To optimize the algorithm, the researchers separate the algorithm into three parts which are motion detection, human detection and smoke detection. If there is no motion detected, the program will not go to human detection and smoke detection algorithm. Otherwise, if motion is detected, the current frame of detected motion will be processed by human detection algorithm. If the moving object is identified as non-human object, the smoke detection algorithm will be activated. If there is a detection of either human or smoke, alarm, LED indicators and email interface function will be activated. General system flowchart is shown in Figure 3

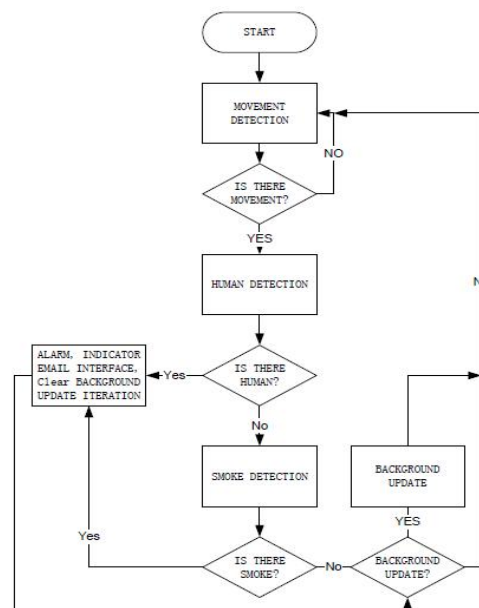


Fig. 3. General System Flowchart

## V.HARDWARE ARCHITECTURE

In the figure 1,Raspberry Pi is connected to the USB camera with the help of USB port .In the PC ,Raspbian operating system is installed. Raspberry-pi works only on Raspbian operating system ,Linux., Raspbian is a free operating system based on Debian optimized for the Raspberry Pi hardware. An operating system is the set of basic programs and utilities that make your Raspberry Pi run. However, Raspbian provides more than a pure OS: it comes with over 35,000 packages, pre-compiled software bundled in a nice format for easy installation on your Raspberry Pi.



Fig 4: Connection Of USB Camera With Raspberry Pi

Putty configuration and VNC viewer are needed to install Raspbian OS . Putty configuration is SSH and Telnet client .It is a open source software that is available with source code. Virtual network computing is a Graphical desktop sharing system that allows us to remotely control the desktop interface of one computer from another.

The Raspberry Pi primarily uses Linux kernel-based operating systems (it is not possible to run Windows on the Raspberry Pi). The ARM11 is based on version 6 of the ARM on which several popular versions of Linux no longer run (in current releases), including Ubuntu. The install manager for Raspberry Pi is NOOBS. The OSs included with NOOBS are:

Arch linux  
 ARM Open  
 ELEC

Pidora (Fedora Remix) Raspbmc and the XBMC

open source digital media center

RISC OS – The operating system of the first ARM-based computer  
 Raspbian (recommended) – Maintained independently of the Foundation; based on the ARM hard-float(armhf) Debian 7 'Wheezy' architecture port originally designed for ARMv7 and later processors (with Jazelle RCT/ThumbEE, VFPv3, and NEON SIMD extensions), compiled for the more limited ARMv6 instruction set of the Raspberry Pi. A minimum size of 2 GB SD card is required, but a 4 GB SD card or above is recommended. There is a Pi Store for exchanging programs.

- o The Raspbian Server Edition is a stripped version with other software packages bundled as compared to the usual desktop computer oriented Raspbian.

The Wayland display server protocol enable the efficient use of the GPU for hardware accelerated GUI drawing functions Raspbian for Robots - A fork of Raspbian for robotics projects with LEGO, Grove, and Arduino

## VI. i .STEPS FOR THE PuTTY CONFIGURATION

1. Obtain a copy of PuTTY pre-configured for use at Columbia from the PuTTY download page.
2. Save the installer file to your download directory or desktop.  
**Important: Exit all applications before you begin the installation process.**
3. Double-click on the file PuTTY-install.exe to begin the installation.
4. At the **Choose Destination** screen, Click **Next** to accept the recommended default destination location for installing PuTTY.
5. Click **Next on the Select Program Folder** screen to select PuTTY as the recommended Program Folder name (**PuTTY** should already be displayed in the Program Folders text box).
6. Click **Finish** on the final screen to complete the installation.

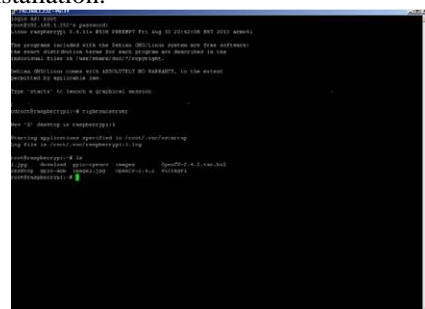


Fig 5:PuTTY configuratio

## ii. STEPS TO INSTALL RASPBIAN OS

In order to install Raspbian OS, first next out of box software (NOOBS) has to be installed.

1. First step is to allocate the drive for installing OS
2. SD adaptor can also be used for this purpose
3. Download WINDISK 32 utility from source forge project which is a zip file
4. Extract and run the zip file
5. Select the file and click run as administrator
6. Select the image file which was extracted above
7. Select the drive letter of the SD card in the device box
8. Click write and wait for write process to complete
9. Exit the image and eject the SD card

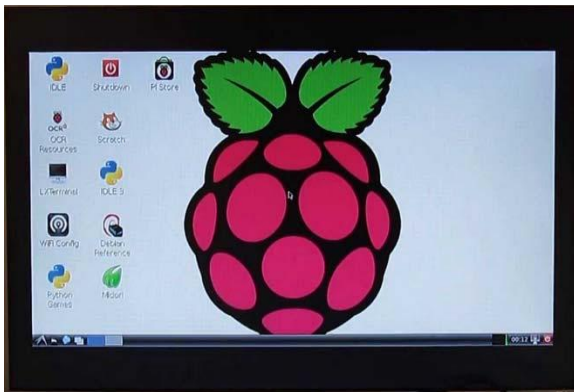


Fig 6: Installed Raspbian OS

## iii. INSTALLATION OF VNC VIEWER

Once you have an operating system running here are the required steps to install a VNC server:

1. Open LX terminal
2. In LX terminal type in "sudo apt-get update" to update the operating system to the latest version
3. When prompted to update type in "y" and press enter.
4. After updating is complete type in "sudo install tight vncserver". Press "y" and hit enter when prompted
5. Once tight VNC server has completed installation you can start it by typing in "vncserver:1"
6. It will prompt you to create a password. Keep in mind passwords can be at MOST 8 characters long.
7. Enter a password. The VNC server is now running in the background of your Raspberry Pi's operating system. We use any computer on your network with a VNC client to remotely access the Raspberry Pi

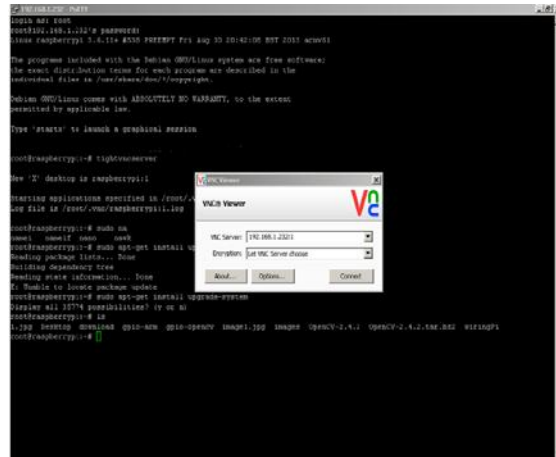


Fig 7: VNC Viewer Installed

## VII. BACKGROUND SUBTRACTION FOR MOTION DETECTION

Since the camera used is monitoring at a fixed location, background subtraction algorithm can be used in detecting motion by the concept of frame differencing. Moving objects within a given background can be deduced from the difference of the current frame and a reference frame, often called the "background image" [2].

There are several algorithms that can be used for motion detection like optical flow and edge analysis. One of the simplest forms of motion detection is using background subtraction. There are different types of background subtraction based from the different journals. The challenges in most of these algorithms are the illumination changes and processing speed. In choosing the type of background subtraction that will be used in the system, the researchers considered the place where the system will be placed and also the processing speed of the RPI. According to one comparative study, the basic background subtraction has the lowest processing speed requirement but it can't be implemented in a complex background environment [3]. The researchers finally choose the basic background subtraction for motion detection due to its low computational requirement. Figure 8 is the block diagram of the simple background subtraction algorithm which can be implemented using equation (1).

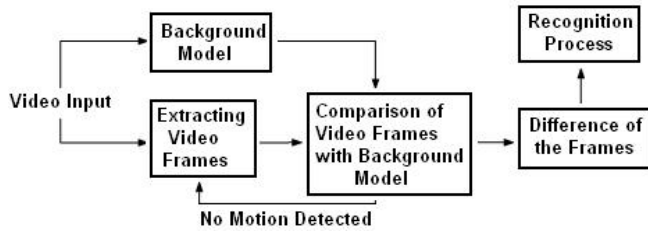


Fig. 8. Block Diagram of Background Subtraction

In the equation 1, each pixel that occurs in the coordinate(x,y) of the current image(t) is subtracted by the previous image(t-1). If their difference reached a threshold value (Th), the motion is detected.

### VIII. Human Detection

Human detection part fully depends on the program of background subtraction. If there is no motion detected, LED indicator will not light up; then the program will start to update the background. On the other hand, if motion detected, that particular frame will be the input frame to the human detection process and indicator for motion detect will light up. The program will immediately convert the captured image to gray scale, improve the contrast of the image and store it in the memory (this is necessary in order to improve the processing speed of the program). The converted image will be process through Haar Classifier Stages. If head and shoulder feature is not detected, the program considers it as non-human object and will move to smoke detection; otherwise, the program will send the captured image to the user’s email and triggers the sound alarm and LED indicator.

Haar like features [4] is one of the common ways used for object detection. Just like the human detection method presented in [4], the researchers used head and shoulder feature as the shape or “region of interest” (ROI) rather than using the typical face detection. It is because basic shape like face in an image can occur in varying scale, position and orientation. In detecting human, the task becomes more challenging owing to the largely varying size, shape, posture and clothing. That is why the researchers considered head and shoulder to be the more

appropriate since it is the most unvarying part of human body [5]. Fortunately, OpenCV has available haar cascade file “haarcascade\_mcs\_upperbody.xml” covering head and shoulder which is used in this study. The range of monitoring in this study is up to five meters. If face detection is used, it is difficult to detect face at a long distance since the face will be small and blurry. On the other hand, head and shoulder is still quite viewable when the object is 5 meters away from the camera. Table 1 shows the different types of motion sensing classifiers [6].

TABLE I. DIFFERENT TYPES OF CLASSIFIERS [6]

Paper	Human Model	Classifier
Cutler and Davis [2000]	Periodic Motion	Motion Similarity
Utsumi and Tetsutani [2002]	Geom. Pix. Val.	Distance
Gavrila and Giebel [2002]	Shape template	Chamfer Dist.
Viola et al. [2003]	Shape + Motion	Adaboost Cascade
Sidenbladh [2004]	Optical Flow	SVM (RBF)
Dalal and Triggs [2005]	HOG	SVM (Linear)

Cutler and Davis show a technique on detecting periodic motions. Utsumi and Tetsutani show a method that is based on the fact that the relative positions of various body parts are common to all humans, despite the unstable factors like illumination. Gavrila and Giebel’s paper focus on the scenario of a moving camera mounted on a vehicle. Viola’s method is probably the most familiar classifier, it is able to detect human base on shape and motion features. Sidenbladh’s technique is made by collecting several samples of human and non-human motion and computing optical flow. Dalal and Triggs’s method uses the fact that the shape of an object can be well represented by a distribution of local intensity gradients or edge directions. [6]

Paul Viola and Michael Jones’s [4] research papers have a significant improvement on image processing. On their paper entitled “Rapid object detection using boosted cascade of simple features” in 2001, they introduced a method that can accurately detect object using Haar feature-based cascade classifiers. These features use the change in contrast values between adjacent rectangular groups of pixels. The relative light and dark areas are being determined by the contrast variances between the pixel groups. Two or three adjacent groups with a relative

contrast variance form a Haar-like feature. Equation 2 and 3 are used for computing integral areas needed for developing Haar Classifier [7].

## IX. DISCUSSION

Raspberry Pi has enough power for HD video and image manipulation, and can be connected to the Arduino board. Connected to Raspberry Pi, Arduino can be used as a control unit while Raspberry Pi processes video images. Raspberry Pi features include Bluetooth and Wi-Fi wireless technologies and this is the shortcut to display images directly on the Android device.

Video images are displayed at high FPS and are in colors

### Transmission Of Video /Image Via A 3G Dongle To A Smartphone



Fig 6: Final Image/Video

## X. FUTURE WORK

.It is advantageous as it offers reliability and privacy on both sides. It is authenticated and encrypted on the receiver side, hence it offers only the person concerned to view the details. Necessary action can be taken in short span of time in the case of emergency conditions such as elderly person falling sick, military areas, smart homes, offices, industries etc. Future work is to locate the number of persons located exactly on that area and their position so that accurate information can be obtained on the receiver side.

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