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Real time active surveillance system with night vision capability using OpenCV and Raspberry pi

SABIHA MOHAMMED SABIULLAH[1], CH HARIPRASAD[2]
M.Tech Student, ECE Department, GNITS, Hyderabad, India
Assistant Professor, ECE Department, GNITS, Hyderabad, India
[1]sabiham94@gmail.com., [2]chindam.prasad@gmail.com

ABSTRACT

Surveillance of the public using CCTV is particularly common in many areas around the world. In order to make CCTV technology independent and reduce human labour, this system is proposed. Design and implementation of real time surveillance system with night vision capability using high speed processor board Raspberry pi and computer vision is done. Raspberry pi is a series of credit card-sized single board computers and OpenCV is open source software for real time computer vision. This system controls the image processing, voice alerts and sends captured images to users email via Wi-Fi. An alarm system will play recorded sounds like "human detected" or "explosive detected". A regular webcam in presence of infrared light emitting diode array (IR-LED) with the aid of light dependent resistor (LDR) is used for night vision.

Keywords: *Open- computer-vision, Integral image, Raspberry pi*

1. INTRODUCTION

CCTV system has become an inevitable device and is found everywhere, almost every corner of the street. It performs real-time monitoring, gives video footage, and helps the users to have evidences against crime. Though CCTV camera records video and aids in determining the cause of an incident, it cannot do anything to stop the crime or get hold of the invaders at the time of occurrence of incident. Hence, there is a need of a system which will be able to detect the invaders and harmful objects detected in a particular area. The proposed system not only records the video but also alerts the owner if any suspicious activity is found. With the help of OpenCV functions, the system is made capable of recognizing whether the moving body is a human being or not. Also, it will identify if the person is carrying any harmful weapons which may cause potential threats.

2. SYSTEM BLOCK DIAGRAM

In this system, Image processing will be used for detection purpose with the help of a strong computer vision library known as Open CV. Below is the block diagram of the proposed system

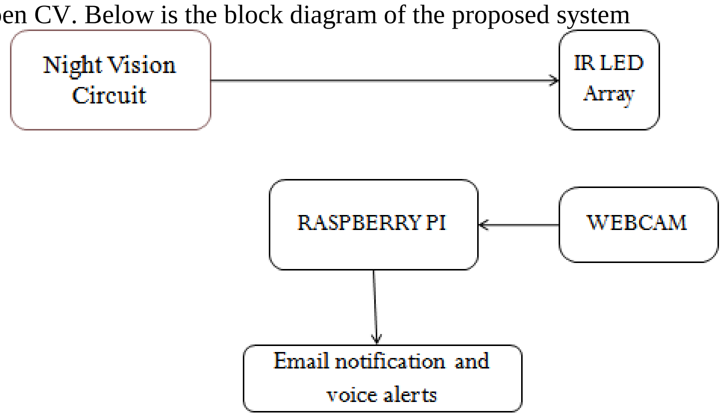

Figure (1): System Block Diagram

Raspberry Pi is the central processing unit of the system. The camera will be monitoring the scene continuously and if there is any movement it will start the system process. In absence of light, Night vision circuit will trigger the IR LED array and it will turn ON and emit Infrared light. The infrared light from the array serves as light source to the camera. The IR light is visible to camera and not to the human being and hence the system will be functioning even at the night time. The email notification will be sent to user via Wi-Fi. APR33A processor based voice circuit will be used to record and play designated voice. The aPR33A series are powerful audio processor along with high performance analog-to-digital converters (ADCs) and digital-to-analog converters (DACs). For different types of detection a specific voice will be played.

3. NIGHT VISION SETUP

Night vision setup mainly consists of light dependent resistor (LDR), potentiometer, voltage comparator and IR LED Array. The block diagram of the night vision set up is as follows:

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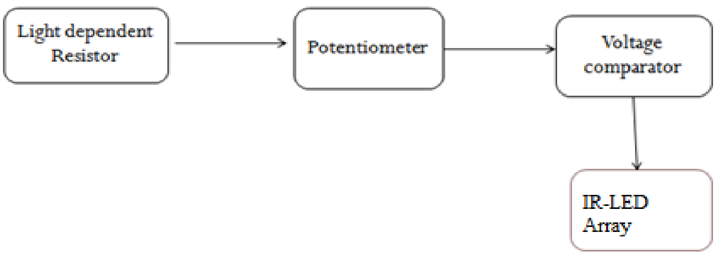
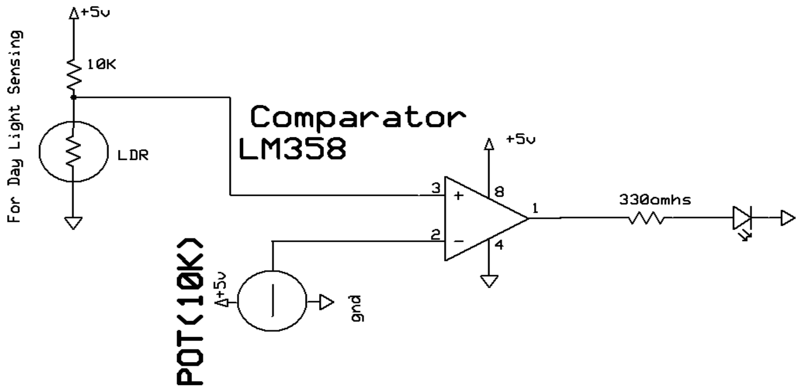


Figure (2): Block diagram of Night vision set up

The circuit for night vision consists of a Light dependent resistor (LDR), LM358 comparator, potentiometer to adjust resistance and a LED array



Figure(3):Diagram of night vision circuit

Light dependent resistors (LDR's) exhibit a property wherein the resistance of the LDR increases when light falls on it. With the help of potentiometer, resistance is given to the inverting terminal of the comparator and the LDR's resistance is given to the non inverting terminal of the voltage comparator. The output voltage is

$$V_o = V_{in} \times \frac{R_2}{R_{LDR} + R_2}$$

(Voltage division rule)

V_o is compared with V_{cc} and the resultant voltage is given to the LED and it starts to glow hence providing the required illumination. The light intensity of the LED can be controlled with the help of potentiometer.

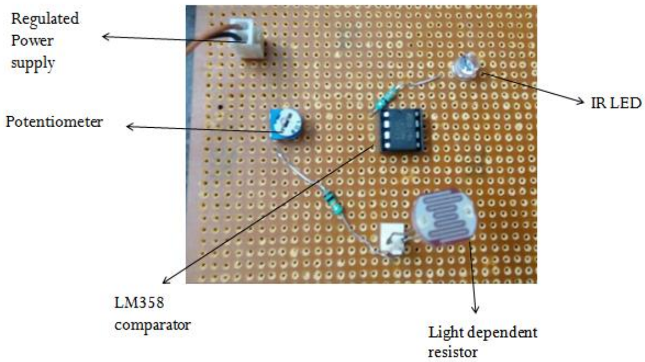


Figure (4): Hardware implementation of Night vision circuit

4. SYSTEM FLOW

The system process is divided into three parts which are motion detection, human detection and hazard detection. If there is no movement detected, the program will not go to human detection and hazard detection algorithm. Otherwise, if movement is detected, the current frame of detected motion will be given as input to human detection algorithm. If the moving object is identified as nonhuman object, then the hazard detection algorithm will be run.

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If there is a detection of either human or hazard, alarm, IR-LED array and email interface function will be turned on. For motion detection, the concept of background subtraction is used here since we are going to deal with simple backgrounds.

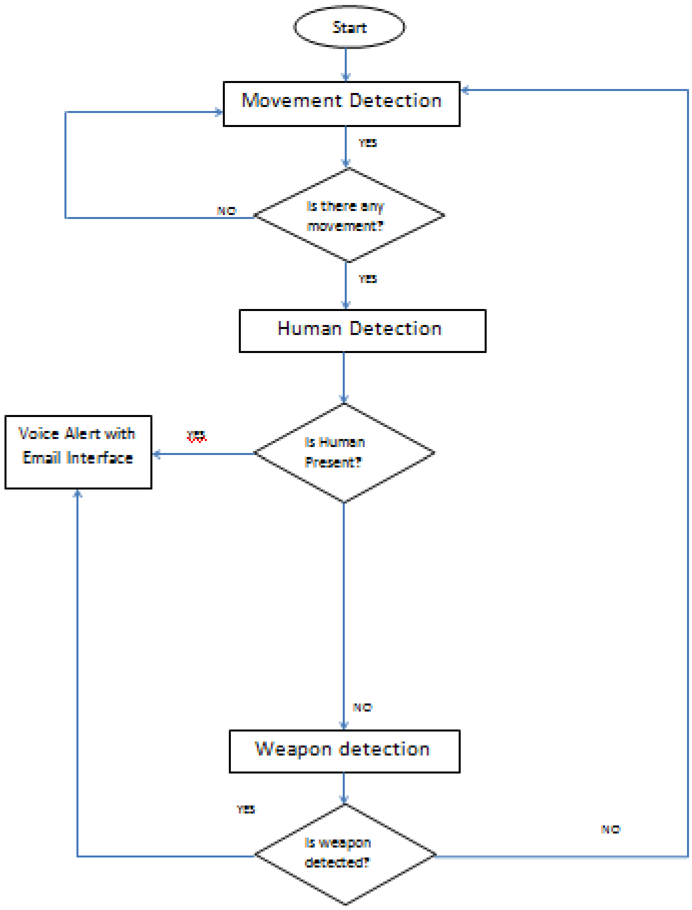

Figure (5):System Flow

4.1 Motion detection using Background Subtraction

A motion detection process begins with the segmentation part where foreground or moving object are extracted from the background. The easiest way to implement this is to select on image as background and take the frames obtained at time t and is represented by I (t) to compare with the background image which is represented as B. For calculating the background, a series of previous images are averaged. Here using simple mathematical calculations, we can separate out the objects by using image subtraction. For each pixels in current image, take the pixel value indicated as P[I(t)] and subtract it with the respective pixels at the same position on the background image denoted as P[B].In equation form, it is written as:

$$P\,[F\,(t)] = P\,[I\,(t)] - P\,[(B)]$$

The background is the frame at time *t*. This difference image would only show little intensity for the pixel positions which have changed in the two frames.

4.2 Omega Model for Human detection

Remarkable research has been devoted to detecting people in images and videos. Human being detection is a demanding classification problem which has several applications in the field of computer vision. The main challenges in detecting human beings are due to the variations in pose, body shape, and clothing, illumination, moving cameras, occlusion and changing background. Therefore the ultimatum is to find a set of unique features that characterizes human being in a scene, while remaining resistant to the above mentioned problems.It considers the head-neck-shoulder based descriptors for the recognition of human body. As the head-neck-shoulder resembles the symbol omega this is also referred as “Omega Model”

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4.3 Weapon detection using SIFT

Weapon here refers to harmful objects like explosives and sharp objects. Scale-invariant feature transform is an algorithm in computer vision to recognize and describe local features in images. Applications of SIFT include object recognition, navigation of images, images stitching, gesture recognition, video tracking, individual identification of wildlife and match moving. For any object in an image, unique points on the object can be obtained to provide a "feature description" of the object. This descriptor, obtained from a test image, can then be used to identify the object when attempting to recognize the object in a test image containing many other different objects. It can identify objects even among clutter and under partial occlusion, because the SIFT feature descriptor is invariant to uniform scaling, orientation, and partially invariant to affine distortion and illumination changes. Keypoints of objects are first extracted from a set of test images and stored in a database.
A mask can be passed if we want to search only a part of image. Each keypoint is a unique structure which has many attributes like its (x, y) coordinates, size of the corresponding neighborhood, angle which specifies the orientation, response that indicates strength of keypoints etc.

5 .HARDWARE IMPLEMENTATION

The circuit diagram of the system is developed using a software known as PCB express anf then implemented on the PCB. The working of night vision circuit is tested first by using a single LED and if it is glowing then the array of IR LED is connected.
Figure (6) shows the integrated system which consists of IR-LED array which serves as illuminator during night time and Raspberry Pi which is the heart of the system uses SMTP protocol to send mails. The e-mail through which mails are received as alerts should be created and the username and password are feeded in the code. Whenever recognition is completed the Raspberry Pi itself logs in to the mail attaches the captured image in the email with subject as “Human detected” for human being. Similarly for others objects the same process takesplace. Weapon detection using SIFT captures and sends the image to the user’s mail in presence of hazardous object. In this project the objects considered are Toy gun, Cutting plier and a phone battery. If atleast any one of it is present in the scene monitored, mail is received along with the name of the object.

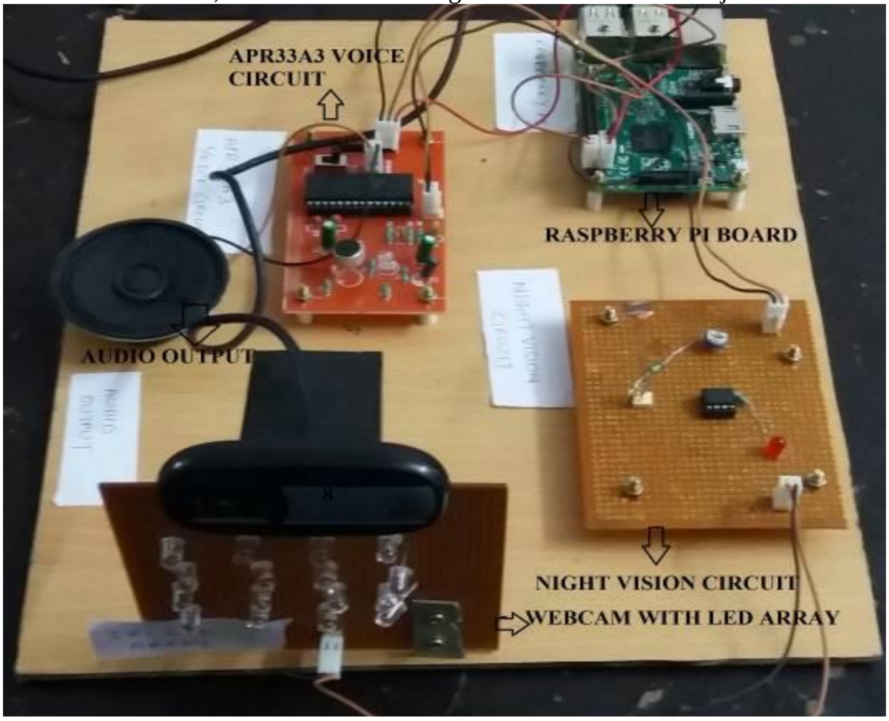

Figure (6): Hardware Implementation of the system

6. RESULTS AND DISCUSSIONS

6.1 Results of motion detection

When no motion is present it just converts the image into grayscale image. When some movement is observed, the image is captured and contour of the image is developed for further processing. Following is the experimental analysis of motion detection using background subtraction. Figure (6) indicates motion detection process. In Figure 6(a) when no motion is detected the image is just converted into greyscale image. Figure6 (b) indicates the

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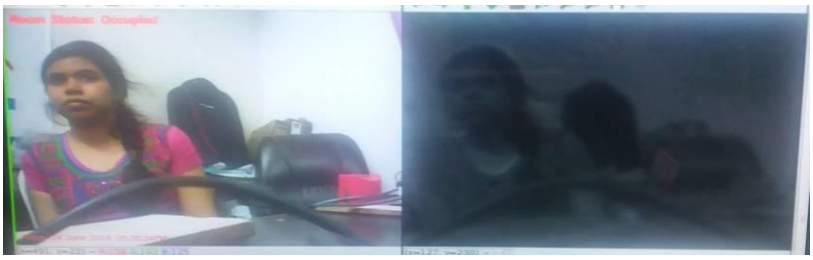
formation of contour due to motion and Figure 6(c) shows the obtained contour which is sent for further processing.



6(a): No movement is detected

6 (b): Contour is obtained due to motion

6(c): Final contour for further processing

6.2 Results of Human detection

7(a): Human detection at day time

7(b): Human detection at night time

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6.3 Results of Weapon detection

Figure 8: Database Image

Figure 9:Object identification using SIFT at Day time

Figure 10:Object identification using SIFT at Night time

TABLE 1: HUMAN DETECTION RESULTS FOR 10 VIDEO SAMPLES

Trials	True positive	True Negative	False positive	False Negative	Accuracy (%)	Sensitivity (%)
1(Day)	9	1	2	0	83.3	90.0
2(Day)	8	2	0	1	90.09	80
3(Day)	4	3	0	2	77.7	90
4(Day)	5	2	0	0	100	87.5
5(Day)	8	2	1	0	90.9	85.7
1(Night)	7	2	1	1	77.4	77.7
2(Night)	7	1	1	3	83.3	87.5
3(Night)	7	2	2	2	69.2	77.7
4(Night)	7	0	1	1	87.5	100
5(Night)	6	1	2	1	70.0	85.7

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TABLE 2.OBJECT RECOGNITION RESULTS FOR 10 VIDEO SAMPLES

Trials	True Positive	True Negative	False positive	False Negative	Accuracy (%)	Sensitivity (%)
1(Day)	4	0	0	0	100	100
2(Day)	4	0	0	0	100	0
3(Day)	0	4	0	0	100	0
4(Day)	3	0	0	1	75	100
5(Day)	4	0	0	0	100	100
1(Night)	2	0	1	1	50	100
2(Night)	2	0	2	0	50	0
3(Night)	3	0	1	0	75	100
4(Night)	3	0	0	1	75	100
5(Night)	2	0	1	1	50	100

7. CONCLUSION

Real active surveillance system with human and weapon detection with night vision capability was designed. The accuracy of human detection was 82.9% and weapon detection was 77.5% respectively. High speed processors can be used instead of Raspberry Pi board in order to reduce response time but at a higher cost. While this system operates at a rate of 30 frames per second, advances in digital signal processing and consumer graphics hardware has made high-speed image acquisition, processing, and display possible for real-time systems on the order of hundreds to thousands of frames per second. When combined with a high-speed projector, fast image acquisition allows 3D measurement and feature tracking to be realized. Vision processing units are emerging as a new class of processor, to complement CPUs and GPUs in this role

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