Implementation of Real Time Human Intruder Monitoring System using Arduino Microcontroller

Su Thae Swe, Su Wai Hlaing

Abstract— **Video surveillance is a very active research area in computer vision. The use of this concept in surveillance for security fights against terrorism and crime. In real time, video surveillance captured images to detect human or other is important. This paper is proposed for implementation of real time human intruder monitoring system using Arduino Microcontroller. In this system, the incoming video frames are firstly filtered with median filter to remove noise. Then, background subtraction method is applied to detect motion objects. After detecting motion objects, Histogram of Oriented Gradients (HOG) feature are extracted .In human detection step, Support Vector Machine (SVM) is employed to check whether human or other. If the system detected the human intruder, the system is sent SMS message via Arduino microcontroller to the owner. In this way, the system is to develop a system that monitors the area in which it is being deployed and provide the security against any misdeed. The system is implemented with MATLAB programming language. According to the experimental results, the proposed framework is able to efficiently detect the human intruder from real time video scenes and then sent SMS message via Arduino to the owner.**

Index Terms— Arduino Microcontroller, Background Subtraction, HOG Features, SVM,

1) INTRODUCTION

Security has been becoming an important issue everywhere. Surveillance is the monitoring of the behavior, activities, or other changing Information, usually of people for the purpose of influencing, managing, directing or protecting them. Surveillance is very useful to governments and law enforcement to maintain social control, recognize and monitor threats, and prevent/investigate criminal activity. Nowadays the possibilities of intrusion are increasing day by day.

Human detection is particularly difficult, mainly because of the high variability of appearances and possible situations. The problem is to find a representation of a human that is both sufficiently generic to cover all types of situations, and sufficiently discriminative for humans. For this, an intermediate representation based on the computation of one or more features and taken from the information contained in the only values of the image pixels.

This paper describes a method for classifying moving objects as either a human or not and if human is detected then sent SMS message via Arduino to the owner. The work includes four steps. Firstly, motion regions are detected. Secondly, the HOG features are extracted from motion region. Thirdly, human can be detected by SVM classifier. And, if the proposed system detected the human intruder, the system will sent SMS message via Arduio Microcontroller to the owner.

The paper is organized as follows: Section 1 describes the research situation of human detection. Section 2 describes related works in human detection system. Section 3 describes the overview of the proposed system. Section 4 presents research method of the proposed system. Experimental results in real time are demonstrated in Section 5. Finally, conclusion for the paper is expressed in section 6.

2) RELATED WORKS

A number of researchers have been conducted on human detection systems. N.Dalal and B.Triggs [4] presented a human detection algorithm with excellent detection results. Their algorithm uses a dense grid of Histograms of Oriented Gradients (HOG) to represent a detection window. The Histogram of Oriented Gradient (HOG) descriptors provide better performance than other existing feature sets. Each stage of the HOG computation has much influence on performance, concluding that fine-scale gradients, fine orientation binning, relatively coarse spatial binning, and high-quality local contrast normalization in overlapping descriptor blocks are all important for good results.

Tudor Barbu [6] proposed an automatic cell detection system. He performed a proper HOG based feature extraction, and then he applied a non-linear SVM-based algorithm, using a quadratic kernel function, in the classification stage. The main purpose of this paper was proved that the HOG characteristics and the SVMs, used mainly in human detection domain, work satisfactory for other classes of objects too.

Yahia Said, Mohamed Atri and Rached Tourki [3] proposed a method for human detection in video sequence. The Histogram of Oriented Gradients (HOG) descriptors show experimentally significantly out-performs existing feature sets for human detection. Because of HOG computation influence on performance, they finally choose a more better HOG descriptor to extract human feature from

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visible spectrum images based on OpenCv and MS VC++. The image descriptor based on Integral Histograms of Oriented Gradients (HOG), associated with a Support Vector Machine (SVM) classifier was realized and evaluate its efficiency.

Ruchita R. Katkamwar , Divya V. Dhanaskar, Pragati D. Pawar, Atul N. Shire [1] proposed implementation of security system on Arduino. They are providing enough security to satisfy the needs. The user would be prompted to enter a password to unlock the application. After successful password entry, the application would unlocks for a specified amount of time enabling and anyone to store or restore anyone's valuables, if the user entered an invalid password then it would intimate that the password is incorrect corresponding equivalent message would be displayed.

Viraj Mali, Ankit Gorasia, Meghana Patil, Prof. P.S.Wawage [2] proposed home automation and security using Arduino microcontroller. The system is aimed to develop a low-cost means of home security system using sensors like motion sensor, PIR sensor etc. This system also deals with the OTP (One Time Password) generation which would be used as entry password for user. Data from all these sensors is continually received and processed by Arduino Uno board which acted as a microcontroller unit. In case of untoward situations, the Arduino would trigger an alarm and alert messages would be sent to user's mobile via GSM. Thus the system ensured home safety as well as security.

3) THE OVERVIEW OF THE PROPOSED SYSTEM

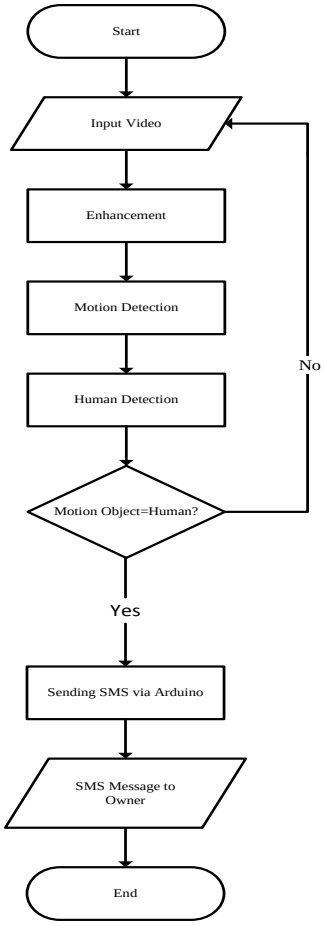


Figure 1. The overview of the proposed system design

The paper is intended for security areas to monitor the human intruder in real time. In this section, the overall procedure of the real time human monitoring system is shown in Fig. 1 where each module is explained in Section 4.A-D, Fig. 1.

4) RESEARCH METHOD OF THE PROPOSED SYSTEM

In this section, the detail of the real time human intruder monitoring system will be described.

(A) Image Enhancement

In the system, the incoming color video frames from security web cam are firstly converted into gray scale image. And the grey scale image is filtered with median filtering to remove noise. The system is based on real time, so various noises can cause in real time condition. The median filter can remove noise from an image without significantly reducing the sharpness of the image.

(B) Motion Detection

After filtering the gray scale frame with median filter, the next step in the human intruder monitoring system is to detect moving objects of each frame in a real time video scene. In the motion detection step, background subtraction method is employed to extract moving object regions. The background subtraction (1) is used to recognize the pixel intensity of foreground which is obtained by the difference between the current image, $C(x,y)$ and the background image, $B(x,y)$. In this system, the incoming first 5^{th} frame is assumed as background model. After obtaining the initial background model, the subtraction between the current frame and the reference frame is done for the moving object detected, M_0. The subtraction will be done pixel by pixel of the both frames.

$$M_0 = \begin{cases} 1 & if\ |C(x,y) - B(x,y)| > T \\ 0 & otherwise \end{cases} \quad (1)$$

In this background subtraction method, thresholding, T, plays a vital role to detect motion object. In this system, dynamic thresholding is calculated based on statistical decision theory to minimize the missing moving objects. Dynamic thresholding algorithm is summarized as follows:

1) Select and convert the incoming frame to gray scale image and enhance the incoming gray scale image with median filter.

2) Calculate the absolute difference between the incoming 5^{th} frame and the incoming first to 10^{th} frames.

3) Sum the total absolute difference from 1 to 10^{th}.

4) Calculate the average threshold by dividing the total absolute difference with 10.

5) Calculate the threshold by multiplying the average threshold with 2.

Threshold= (average threshold * 2) (2)

(C) Human Detection

After detecting the moving objects from the incoming video scene, the next step is to determine motion object is human or not. In human detection step, support vector machine (SVM) classifier is used based on Histogram of oriented gradients (HOG) features. The histogram of oriented gradients (HOG) is a feature descriptor used in computer vision and image processing for the purpose of object detection. It uses gradients magnitude and direction to describe all parts of an image. It can be combined with SVM detector for human detection purpose. HOG Human detector has the following steps [5]:

1) Input Image Acquisition

The motion detection stage generates the moving object frame. This frame is resized to a dimension of 64x128 pixel size.

2) Gradient Computation

The Gradients in the motion object frame were computed using the simple the 1-D point derivatives G_x and G_y in x and y direction by convolving the gradient masks D_x and D_y with the raw image I.

$$G_x = D_x * I \qquad D_x = \begin{bmatrix} -1 & 0 & 1 \end{bmatrix} \tag{3}$$

$$G_y = D_y * I \qquad D_y = \begin{bmatrix} 1 \\ 0 \\ -1 \end{bmatrix} \tag{4}$$

The magnitude of the gradient is

$$|G(x,y)| = \sqrt{G_x(x,y)^2 + G_y(x,y)^2} \tag{5}$$

The orientation of the gradient is

$$\theta(x,y) = \arctan\left(\frac{G_x(x,y)}{G_y(x,y)}\right) \tag{6}$$

3) Histogram Mapping and Binning into Cells

After calculating the gradient for the target frame, the target frame is divided into multiple regions of fixed rectangular size called a cell. A histogram of gradient direction is computed for each cell, weighted by the gradient strength. In the human detection system, a cell size of 8x8 pixels is taken resulting in 8 cells width wise and 16 cells height wise. Histograms of Gradients are computed over each cell, generating a 9 component feature vector.

4) Overall Block Definition and Feature Vector Extraction

Local contrast normalization of the gradient values is desired to reduce the effect of illumination variations in the image. Normalization is achieved by spatially grouping the histogram cells into overlapping blocks. A single block consists of 2x2 cells and any two neighboring blocks have 2 cells in common due to block overlap. Each block consists of 4 Histogram of Gradient vectors, one from each of the four cells; resulting in a 36 Dimension feature vector. A 64x128 pixel image will consist of 7 blocks width wise and 15 blocks height wise, generating a 3780 Dimension feature vector.

5) Classification using Support Vector Machine

In classifying persons for the motion object, SVM is used "training sets" as its reference. A training set is a set of images that are already labeled as positive or negative in containing a person in them. The HOG features from the training sets are used to train the SVM for person detection. When the test sets are inputted, its HOG features are now compared to the features in the trained SVM to determine if the corresponding image contains a person or not.

(D) Arduino Microcontroller

In proposed system, Arduino Uno and GSM SIM 900A are used. By connection all connection correctly applies a simple C or C++ code on Arduino senses the motion so that it will get alert to user.

1) Software Requirement

Arduino Environment ARDUINO 1.8.0:

It is the open source software (IDE) makes it easy to write code and upload it on the micro-controller board. It runs on various platforms like Windows, Mac OS and Linux. Arduino programs are written in C/C++.

2) Hardware Requirement

i) Arduino UNO

The Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller simply connect it to computer with a USB cable or power it with AC to-DC adapter or battery to get started.

Figure 2. Arduino UNO

ii) GSM SIM 900A Module

GSM is an international standard for mobile telephones. It is an acronym that stands for Global system for mobile communications. SIM 900A module is a GSM module that functions like phone. It can send message, call a phone number and use GPRS to send data. The inserted SIM card something referred to as 2G, as it is second-generation

cellular network. This is a very low cost and simple Arduino GSM-Shield.

Figure 3. GSM SIM 900A Module

5) Experimental Evaluation

In this section, the real time human intruder monitoring system is implemented. The human intruder monitoring system is tested in real time with various scenes. For real time testing, it is not necessary to use all input sequence frames come from web cam in order to gain processing time efficiency. So, one frame per second is used to get the required frame for processing. In Fig.4 and Fig. 5, (a) represents the background frame and (b) is input frame for detecting the people. (c) is subtracted result for motion detection and if there is motion detection in incoming frame, detecting people is carried out using HOG operator. As seen in (d) of Fig. 4 and Fig. 5, human is detected correctly with a significant matching value. When the human is detected in input frame, the detected human is bounded with yellow rectangle by using bounding boxes which are obtained from the result of HOG operator. The detection can be done even in the illuminated natural scene; this can be clearly seen in Fig. 5.

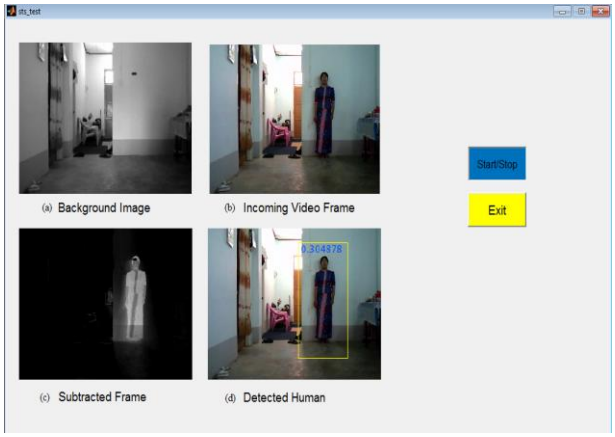
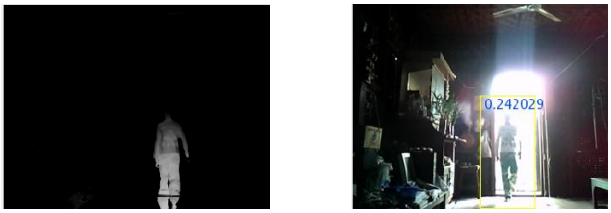


Figure 4. Test (1) in room (a) Background Frame (b) Incoming Video Frame (c)Motion Detection Result (d) Detected Human Result

(a) (b)

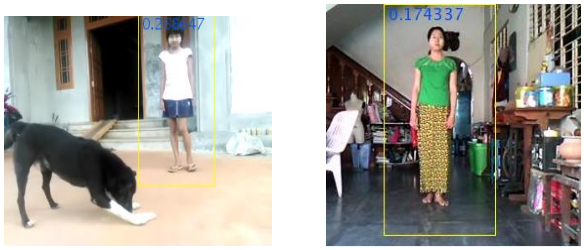


(c) (d)

Figure 5. Test (2) in natural scene(a) Background Frame (b) Incoming Video Frame (c)Motion Detection Result (d) Human Detection Result

(a) (b)

Figure 6. Test (3) Only Human Detection Results



(a) (b)

Figure 7. Test (4) Only Human Detection Results

Moreover, the system is designed to detect only the human beings. Fig. 6 (a) and (b) prove that the system can detect not only adult but also the children. In Fig.7 (a), although there are two motion objects, a girl and a dog, only the girl is detected by the HOG. Fig 7 (a) is obtained from testing 3. In this testing, the girl and the dog are included in 55 frames. The number of motion dog frames is about 22 and the number of motion girl frames is 33. The dog is not completely detected in this testing because the dog features and human features are totally different. According to the HOG operator is robust as it can detect the any standing position of human being, faced to the camera, backed to the camera, sided to the camera for both directions. As seen in Fig. 7 (b), the system can handle the complex scene for human intruder detection. When intruder is detected, it is recorded for surveillance.

TABLE I. Accuracy Of The Proposed System

	Nos of Frame	Nos of Motion Objects	Nos of Actual Human	Nos of Detected Human	Precision %
Testing 1	250	50	50	47	94%
Testing 2	200	40	40	32	80%
Testing 3	260	55	33	31	94%
Testing 4	240	58	58	55	95%
Avg	238	51	46	42	91%

To prove the effectiveness of the proposed system, the performance accuracy of this system is described in Table I. The performance evaluation is carried out by using the following equation.

$$\text{Precision} = \frac{\text{Nos of Human Correctly Detected}}{\text{Total Nos of Actual Human}} \quad (7)$$

There are 250 frames sequences in testing 1, and motion object is included in 50 frames. Among them, human object is detected by HOG in 47 frames. So its precision is just about 94%. The other three testing are also performed and their precisions are listed in table 1. The average precision, 91% is acceptable in the area of video surveillance system.

After detecting human intruder, the proposed system sent SMS message via Arduino and GSM module to the owner's phone. In sending message step, signal from the detected human is continually received and processed by Arduino Uno board which as microcontroller unit. Then, Arduino sent message to owner's mobile phone via GSM module.

Arduino uses serial ports to load program from the Arduino IDE.

TABLE II. PIN ASSIGNMENT

Arduino Uno	GSM SIM 900A Module
GND	GND
5V	VCC
D5	5VT
D6	5VR

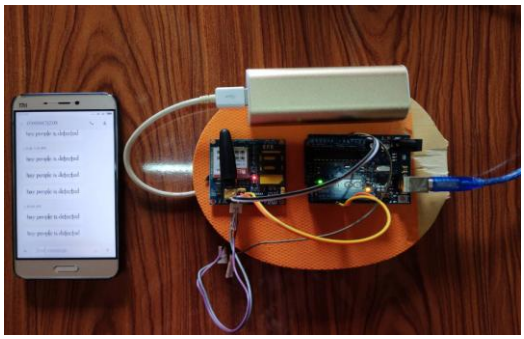


Figure 8. Experimental Result with Circuit

6) CONCLUSION

The paper is proposed to monitor human intruder for security areas in the real time. In this system, there are three main stages which are motion detection and human detection and sending message. In motion detection stage, the background subtraction and dynamic threshold are used to detect the moving objects. In human detection stage, HOG features and SVM is employed to classify whether the moving object is human or other. In sending message stage, Arduino sent message to owner's mobile phone via GSM module. The proposed system can handle even in the complex scene and illuminated natural scene for human intruder detection and monitors the security area against any misdeed. In this proposed system, GSM module is a very important part for communication between mobile phone and microcontroller GSM module required the SIM card, due to range fluctuation or busy network sometimes GSM module will not work properly. The proposed system can detect any standing position of human being and depend on the kind of cameras and its setting. In future, the proposed system will be added face recognition to be more human positions and situations for improvement authenticate person or not and combined with embedded system can phone call to the owner after detecting the human.

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