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RESEARCH ARTICLE

Automated Gun Security System

*** Shoaib Mughal, Tahir Qadri, M.Tayyab, M. Shiraz Alam Khan and Zia Mohy Uddin**
Department of Electronic Engineering, Sir Syed University of Engineering & Technology, Pakistan

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***Corresponding Author**

Shoaib Mughal,

Abstract

The aim of this work is to design the automated security system in order to detect, track and destroy the target for surveillance operations. The system can be operated in two modes, in which the target can be tracked automatically by using microcontroller based system. On other hand, the system can also be controlled manually in which the user has right to select the target and performs shooting if necessary. The image processing algorithms are implemented in Matlab. The process starts by processing the video signal on computer by using the video camera, then the target is selected which can be tracked further by using different image processing techniques. After the selection of target, the micro-controller unit takes the decision to shoot any unauthorized person or activity within its range. The gun is mounted on a tripod stand and its movement is controlled by using the stepper motor. Once the target is selected it can be tracked by moving the camera and gun.

Introduction

In these days security is the major issue for all over the world. Security is very important in order to protect vulnerable and valuable assets such as a person, dwelling, community and nation from any harm. International security issues are also very important, especially border and coast security to any country. The people of national security agencies, maritime security organization, military forces and other forces sacrifice their lives to protect their country people. The lives of forces are also very precious like other lives. So by using advance technologies, the forces can protect their nation superiorly with minimum life losses.

In this modern era, computer base security equipments are very popular among forces because they are more advance and safe for themselves. For example drone technology the "unmanned aerial vehicle" which is controlled automatically by computer is very popular these days. In this technology, the target is selected and hit by using computer based algorithms including image processing techniques.

Real time image and video processing for object detection and tracking has many important applications in the field of computer vision (B. Coifman et al., 1998), such as video surveillance, military purposes etc. The availability of high quality and inexpensive video cameras and the increasing need for automated video analysis has generated a great deal of interest in the areas of motion detection, object tracking and object targeted (A. Yilmaz et al., 2006) Thus on a very high level, it is possible to identify three key steps in video analysis: detection of interesting moving objects, tracking of the detected objects from frame to frame, and analysis of the object tracks to recognize their behavior and targeted object accordingly.

Another existing example of automatically aimed weapon is the sentry gun which aims and fires the targets which is selected by its sensors (http://en.wikipedia.org/wiki/Sentry_gun). The earliest military sentry guns were used in "Close-in Weapon" systems in which the target is detected and it also destroys enemy aircrafts and short range incoming missiles (P. Croom et al., 2010). Another existing application is "Air Defense Gun" which is mounted on the device at the top of the army tank which automatically tracks and shoots low flying armored vehicles.

Object detection with a camera is a revolution in image processing which itself has applications in various civilian and military fields. These applications include air traffic control, navigation system, error tolerant systems, judgment problems, inspection, target analyze, command and control, sensor management and weapon assistance.

Our system is a combination of sentry guns and drone technology but the difference is that, it is used on earth and it is implemented by gun not on an aircraft. The gun that automatically aimed and fired at the targets which are detected by using image processing algorithms. We first select the object, and then the gun starts the tracking process according to the movement of camera. Once it aimed the tracked object then the gun fires automatically at targeted object. This operation can also be controlled manually.
This paper focuses mainly on the problem of robust foreground segmentation of moving objects. This paper is organized in as follow: Section 2 describes the image processing techniques and section 3 describes the tracking system.

System Model

The work is divided into 4 parts. The first part is to process the video signal using Matlab in computer. The second part is to select the target. The third part consists of microcontroller based control unit which is used to control the stepper motor. Finally, the last part is to control the movement of gun. The overall block diagram of the proposed system is illustrated below.

Processing of Video Signal

The first step is the processing of video signal by using Matlab software. The computer takes the video from the camera, process the video signal and then displays its contents on the LCD or monitor. The digital video is then converted into the composite video format. This raw digital data is further processed to produce the YCbCr (luminosity and chrominance) components of each frame. It is also introduced to change the pixels consequently to show it on VGA (Video Graphics Array). The next part explains the procedure to select the target.

Target Selection

The target selection starts with the motion detection, which is used as pre-processing algorithm in most of the object tracking applications (J. S. Lai et al., 2008). There are different algorithms used for motion analysis but here we used background subtraction to estimate the amount of motion in each frame. Background subtraction is conducted by using background estimation process (A. Mittal et al., 2004) which starts with the grey scaling and smoothing techniques in order to remove noise and improve sharpness.

To produce delay between present and forthcoming frames, a buffer is used to store the reference image for 30 seconds. Meantime another image is captured from upcoming frame and both are subtracted with each other in order to estimate the background and foreground motions. The difference of both frames is a raw foreground image which is refined further. The raw foreground image is then converted from intensity image to binary format by applying the threshold value. By performing many experiments we selected the threshold value as ‘0.2’, which means that in binary image if the value is greater than 0.2, it will be treated as ‘1’ otherwise ‘0’. The threshold process is explained in figure below.

The threshold image after the background subtraction process is illustrated in figure 4. The foreground is represented by ‘1’ white pixels and background as ‘0’, black areas.

The binary image is then further processed by using morphological operations. The morphological operation is a process of image dilation and erosion techniques. The steps include the scanning of pixels from left to right direction and analyzing all pixels which are connected with foreground and background orientations. Those pixels whose neighbors are connected with foreground are considered as a part of foreground and those connected with background are considered as background pixels. A four by four (3x3) matrix is used to analyze the connected pixels. This 3x3 matrix is compared with each 3x3 pixels of the binary image. If the neighboring pixel is ‘1’ then the other four pixels will also be treated as ‘1’ and if the neighboring pixel is ‘0’ then the corresponding four pixels will be considered as ‘0’. The process of dilation and erosion is explained in figure 5 below.

After the noise removal and image enhancement by using dilation and erosion processes the binary image from figure 4 is converted as in figure 6.

In order to differentiate the detected objects with each other, we labeled them as object ‘1’ or object ‘2’ by giving different values to them as explained in table below.

Then we applied blob analysis to connect all part of the object by filling the empty spaces inside the object. A 4x4 matrix of ‘1s’ is used as the blob factor which was put on the labeled matrix previously. Then the neighbor of the foreground will be marked as ‘1’ and the neighbor of background will be marked as ‘0’ as shown in figure 8.

After tracking the location and shape of the objects as discussed above, the next step is to track the movement of objects by using the micro-controller unit, which is explained in next section.

Micro-Controller Unit

The heart of the controlling unit is the PIC18F442 micro-controller. As explained in the above section, the location of the suspected object is determined by the image processing algorithm. When the object is detected, the micro-controller performs two functions. First is to activate the peripheral devices such as alarm, hooter and spotlight to indicate the presence of the object. It is achieved by using relays. Secondly, to take the decision in order to control the movement of the gun, which is also achieved by using relays. The relays are connected to the micro-controller unit, when the object is detected; the micro-controller unit sends the high signal to the relay which activates the peripheral devices. To control the movement of the gun, we extracted the X and Y co-ordinates and forward it serially to the Matlab for further processing. Then the controller takes the decision according to the coordinates, how much the gun should rotate. The decision to shoot the object is also made by the microcontroller. We also applied two modes of controlling. The first is automated control mode and the second is the manual control mode. In automated control mode, the system works automatically and it will take self-decision (either shoot the person who is detected or not). There is no need of any one to monitor or to supervise in this mode. The system is also trained in order to recognize the person. In automated mode, it will shoot only that person which has an unauthorized entry to that point. Whereas, in manual mode, the decision to shoot will be taken by the person who is monitoring the system. The next section explains the controlling of stepper motor to control the movement of the gun.

Stepper Motor Controlling Gun

After the detection of any unauthorized object, the gun starts tracking that object. The co-ordinates of the object are already sent to the computer earlier which tracks the co-ordinates of the target and send the new location to the micro-controller unit. Then the micro-controller unit controls the movement of the gun through the stepper motor. To track the object, the gun is able to move in x-y plane which is achieved by mounting the gun on tripod stand. We used two stepper motors having the power rating of 5.6 watts with the step angle of 0.02 degree. One controls the movement of gun in horizontal direction and the other for vertical orientation.

To move the gun to the desired position on the x-y plane, the current position of the gun is very necessary to be known, so encoders are used to find the current position of the gun. On the basis of the current position, the microcontroller sends the information to the stepper motor about the position of the object. The main function of the motor is to rotate the gun according to the object. If object moves left side than motor moves anti-clock wise until the position of gun comes to centre of the detected object and if object moves right side than motor moves clock wise until position of gun comes to centre of the detected object.

Working of the System

This system is designed to track the suspected object in real time and provide security by means of peripherals attached to this system. The working of the system consists of several steps which includes the processing of video signal from camera. The video is first converted into the raw digital format and then its luminance part is extracted by applying image processing algorithms. Then each frame is compared with the previous frame in order to detect the motion in the current frame. It is done by using background subtraction method. In this work, we applied scaling and smoothing techniques to remove noise and to improve the sharpness of the image. Then we calculated the difference image by subtracting the background information. Then the resultant raw binary image is further processed by using morphological operations which results in the detection of multiple objects. Then we applied blob analysis to connect all parts of the detected image. The next step was to determine the coordinates of the selected target which is achieved by sending the information to the micro-controller based system which compares the coordinates of the current frame with the previous one. Micro-controller then performs two functions; one is to activate the peripheral devices and the second is to take the decision in order to move the gun to the desired location.

Once the target is selected, the microcontroller controls the movement of the gun by using the stepper motor. After the object is tracked, the decision to shoot the target is achieved manually or automatically by using microcontroller based system.

Conclusion and Future Work

The theme of the work is to design the automated security system for surveillance operations. The system is designed by using image processing algorithms in order to select, track and hit the target. In this work, the image processing algorithms are designed and implemented in computer based system whereas for future development, we can use digital signal processors (DSP) in order to make the system working in standalone mode. Another advantage of using DSP processors is to reduce the processing time as DSP processors are efficient and faster in performance. The performance of the system can also be improved by using high resolution cameras with night vision provision. The work can also be expanded for traffic control or military purposes.

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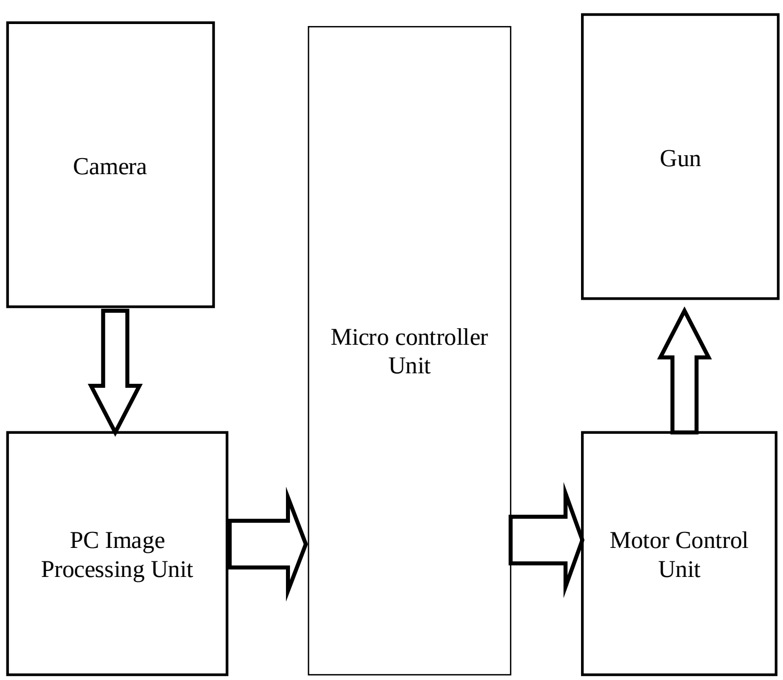


Fig 1. Block diagram of the proposed model

Fig 2: Converting the image into intensity and eliminating noise by applying median filter.

3	5	0	0
0	2	0	6
7	0	8	0

1	1	0	0
0	1	0	1
1	0	1	0

Fig. 3 (a) Intensity image, (b) Binary image

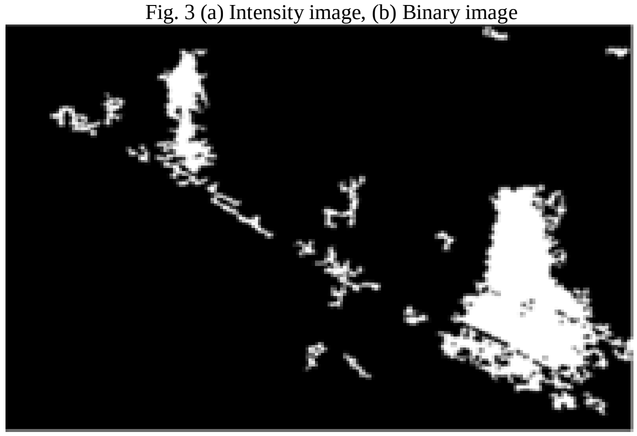
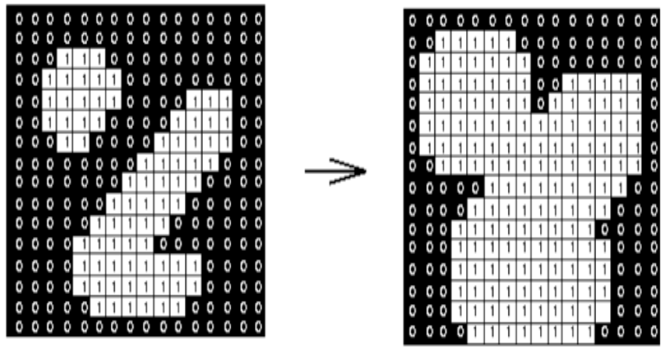
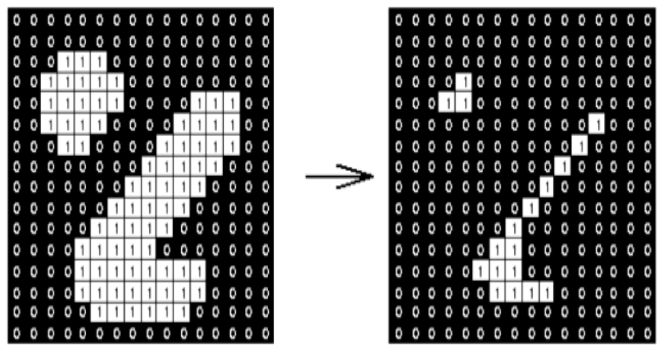


Fig 4. Image expressing background and foreground areas. Foreground is represented



Effect of dilation using a 3×3 square structuring element



Effect of erosion using a 3×3 square structuring element

Fig 5. Morphological operation

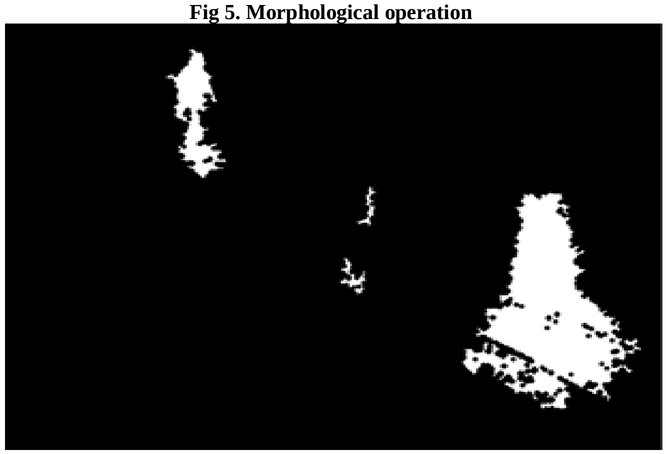


Fig 6. Enhanced and de-noised version of the binary image.

1	1	0	0	0
1	1	0	1	1
0	0	0	1	1
0	0	0	0	0

1	1	0	0	0
1	1	0	2	2
0	0	0	2	2
0	0	0	0	0

Fig 7 (a) Before labeling (b) After labeling

0	0	0	2	2	0	4
1	1	0	2	2	0	0
1	1	0	0	2	0	4
1	0	0	0	0	0	4
0	0	3	3	0	3	0

1	1	0	2	2	0	4
1	1	0	2	2	0	4
1	1	0	2	2	0	4
1	1	0	0	0	0	4
1	1	3	3	3	3	3

Fig 8 (a) Labeled image (b) After blob analysis