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An Algorithm on Alert Generation for Proximity Sensing in Real Time Video Streams

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ABSTRACT

This research work presents a framework for computer vision based surveillance system to generate an alert if any moving body is localized within a defined sensitive area. This is done by using a proximity operation. The approach that is used here is based on detection of a sensitive area at first and then on unique identification of the paths of all of the objects entering at a standoff distance of that sensitive area. After identifying the sensitive area while doing the path identification phase, a catalog is maintained and that consists of the co-ordinates of the already entered objects as well as the newly entering objects. The work also generates an alert with the help of a relative study of those cataloged data with respect to that of a predefined reference frame. The proposed algorithm is validated using real time video taken by CCTV footage and as well as using an animated video which consists of all types of possible test cases.

Key words : Proximity sensing, Reference frame, Current frame, Filter, Morphological filter, Path plotting.

1. INTRODUCTION

Any kind of sensitive area requires a continuous surveillance system. Computer vision is a low cost model since it can imitate human vision and also this can give us a much reliable document. In this paper, a computer vision based proximity sensing system has been proposed and the system can generate an alert when any unauthorized object enters within a defined sensitive area. A combination of a camera and such software is able to sense the proximity of any object, where a camera is used to acquire a real time video and a computer processor is used to extract some meaningful information for the surveillance of any sensitive area. Video surveillance system is a major area of research interest in video tracking domain and researches were carried in [12][13].

Proximity, that is the nearness of any object, can be sensed or calculated in many ways. It can be a photoelectric proximity or an acoustic proximity or a capacitive proximity. In the first case, a light beam generator is used where as in the second case, a sensor with an oscillator is used which generates a pulsed signal, having a frequency somewhat above the range of human hearing like a sonar. In the third case a radio frequency is used for the proximity calculation. But in this paper unlike these traditional procedures, a new approach, where a camera and a computer processor work in a pair to calculate the proximity of any object from the sensitive area, has been proposed.

In this paper the extracted video is tracked as a sequence of images to maintain the dynamism of any real time video. For the identification of the objects, pixel based identification has been used since it has given fruitful result in many case studies. A new object is assumed to enter if any rapid change is encountered in a relative study of any frame with a reference frame. This procedure is repeated for the whole series of frames and the changes are cataloged. From the collected data, it is possible to identify the paths of the moving objects. Assuming that the sequence of the entering objects do not changes, their unique paths have been obtained and also if it enters any predefined sensitive zone an alert can be generated and also an email can be sent to the concerned user's email id.

The rest of this paper is organized as follows: Section 2 summarizes the review of the past work, section 3 deals with work description and section 4 describes detailed designing of the algorithm of the entire work. Section 5 presents implementation of the work and the experimental results are given in section 6 and finally, conclusion and future work are discussed in section 7 followed by references.

2. RELATED STUDY

A lot of research has been done in the field of video processing and tracking of objects in a video system. A comparative study on this aspect has been done in [2]. In some cases, the work has failed to detect multiple objects form a video and in some other cases, shadows could not be completely removed from the videos. Discussions on object identification and tracking

from a real time video were done in [3][4][5][6]. Almost all the researches which have been done in his area have heavily been dependent on then 'background subtraction' method which separates objects in a video frame. But the real challenge of identifying multiple objects and tracking their path yet remains untracked. When any changes in some pixels are spotted in any frame with respect to the reference frame, it is logically conclusive that an object has been identified and hence a graphical plot can be generated using a bounding box. A research work regarding this has been mentioned in [2]. Whenever a box or a collection of pixels is identified, the algorithm will plot the cancroids [2]. The work which has been done in [2] has been able to identify the objects separately but failed to track their movements. In the field of object tracking, research proposals were put forward in [7][8][11] using different approaches like Kalman filter, wavelet transformation. In the present paper, the proposed algorithm has been successfully used to track various objects in a video clip using different colors. The background subtraction method forms the basis of the algorithm proposed here. In this work, the frames have been captured from the video clip and the entire video has been accessed as a combination of frames. Some predefined methods have been used for extracting the objects from the foreground image and for color conversion [9] [10]. The objects have been identified using the number of pixels they contain and the relative location of the objects in the reference frames. The movements of the objects have then been tracked using the bounding box and different colors have been used to track the path of motion of each object separately. A research work has already been done in [1] to identify different objects separately and to identify their paths of different objects with different colours. In the present paper, the method that is used for object identification, has taken help of foreground subtraction. For path identification of the objects, more specifically the co-ordinates of the objects have been identified and have been plotted accordingly. In this process, the sensitive areas have been marked and any co-ordinate found within the range of the co-ordinate of that sensitive area has been identified separately and accordingly, an alert is generated and sent to the concerned user's mobile phone.

3. WORK DESCRIPTION

The algorithm starts with capturing a video as a combination of frames and converting the RGB images to corresponding grey scale images. This grey scale conversion makes the calculation simpler since the grey scale image needs at most eight bits to represent an image and also makes the whole procedure simpler for calculation. Our intention is to identify the objects and hence it is necessary and sufficient to use the grey scale image for better calculation and also it does not create any ambiguity like binary image also.

Then the sensitive area is defined with the co-ordinates of the vertices of the convex hull of the particular sensitive area. A rectangular area has been considered in the process for the simplicity of the definition of the co-ordinates of the outer bound of the sensitive area. The first image frame has been taken to be the reference frame.

Then the morphological filter has been applied to each and every image using Laplacian filter to remove the small regions and isolated bunch of pixels. Basic function of this filter is to highlight the region of high intensity and thus this filter also identifies edges of the bunched pixel and hence helps to identify an object uniquely.

Then the foreground subtraction method has been used to all the captured frames with respect to the first image which has been previously defined as the reference image. With the help of this, the excess part of the foreground layer can be separated and this is the new frame if the absolute value after the subtraction is taken and this subtracted value is compared with a threshold value. If the same procedure is applied on every frame then the sequence of changing of the positions of every bunch of pixels can be identified. If the sequence of the objects to be maintained is considered then the path of every object can be separately identified. With this, the process of the objects identification is concluded. For the path identification phase, when any object is identified, that is separated with a rectangular outbound. Then a stack is maintained to store the values of the x and y co-ordinates of the positions of the objects already entered and the new objects that are entering as well. This stack can be used to locate the objects later. The path identification part ends with plotting the cataloged point in a single graph. Then for the proximity sensing part, at first, the co-ordinates of the vertices of the rectangular sensitive area are defined. Then from the cataloged data he difference of the coordinates of the sensitive region can be obtained. If it is found that the co-ordinate of the newly entered object is within the region of the sensitive area then the alert generation procedure is invoked.

An alert generating image is generated at that particular device which is processing the image and at the same time an email is sent to the user with the information that an unauthorized entry at the sensitive zone has occurred. If the user has any phone with internet facility then the phone network connection can be synchronized so that the user can get the notification of the message from anywhere. To send the message it is required to change some settings of gmail service and the process have also taken help of Google group to interface MATLAB with Gmail. The details procedure is described afterwards.

4. DESIGN OF THE ALGORITHM

The whole procedure can be divided into some major modules. The first module contains the image acquisition process. The second part consists of RGB to grey scale image conversion. The third major part is used to enlarge and to rectify the image which would be easier for the calculation and object identification. In the next module the path identification has been done and the proximity sensing has been detected. In the last part the module, a method has been

designed to send an alert to the user on the basis of the output of the previous steps. From the next paragraph, all these modules are discussed separately.

4.1 Image Acquisition

This part is basically functioning of the web camera attached at any area under observation. The part consists of capturing the video. For any video tracking system it is necessary to convert the video file to a sequence of image frames so that the images can be analyzed afterwards. This algorithm is based on a procedure where the frames have been taken at a speed of 25 frames per second.

4.2 RGB to Grey Scale Image Conversion

Since any real time video consists of colored images, the output of the image acquisition is an RGB image. An RGB image is more complex to handle because it has three 2-dimentional matrices and on the other hand gray scale image is easier for calculation since it takes at most eight bits to represent a single pixel and also does not create any kind of ambiguity like any binary image and hence conversion from RGB image to gray scale image is done using NTSC format. The following expression has been used for the conversion process:

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.274 & -0.322 \\ 0.211 & -0.523 & 0.312 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

where **Y** = Luminance, **I** = Hue and **Q** = Saturation

4.3 Application of Laplacian Filter

The video that is supposed to use in such surveillance system must be with a lot of noise and also the light may not be proper and there may be other problems as well because naturally any video footage of any close circuit camera contains such errors. Hence, a Laplacian filter has been used in the work. This filter is a 2-dimentional isotropic measure or second order derivative of an image which highlights the area of rapid intensity. The Laplacian L(x,y) of an image with pixel intensity values I(x,y) is as follows:

$$L(x,y) = \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2}$$

4.4 Path Plotting and Proximity Sensing

The steps of the proposed algorithm to design this method are described below:

Step 1:- To read the video.

Step 2:- To define the sensitive area by a rectangle ABCD where A = (Xa,Ya), B = (Xb,Yb), C = (Xc,Yc), D = (Xd,Yd). Now Xl = Minimum of (Xa,Xb,Xc,Xd), Xr= Maximum of (Xa,Xb,Xc,Xd), Yb = Minimum of (Ya,Yb,Yc,Yd) and Yt = Maximum of (Ya,Yb,Yc,Yd).

Step 3:- Let the reference frame be IR where moving objects are not present and IC be any other frame of that video clip where moving objects are present but background is same with the reference frame.

Step 4:- The image of reference frame IR is converted from RGB to grayscale.

Step 5:- Laplacian filter is applied on that grayscale image to enhance the image. The result is stored as I1.

Step 6:- For each frame IC the following steps are executed, until no more new frames in the video frame set is found:

a) The current frame IC is read.
b) The current frame image IC is converted from RGB to grayscale.
c) Laplacian filter is applied on that grayscale image to enhance the image and the result is stored as I2.
d) After applying the Laplacian filter that current image I2 is subtracted from the reference frame image I1 pixel by pixel i.e. the operation (I1 - I2) is performed.
e) After subtraction, the resultant image is converted into its equivalent binary form. Let the new image be Ig2b.
f) Very small unnecessary structures called noise are removed from Ig2b and the result is stored as I3.
g) The area and centroid of each remaining structure in I3 are computed.
h) If the area is not empty then it identifies the presence of one or more than one moving objects in that video frame. Thus, the detection process is completed.
i) On the basis of the result obtained, it stores the number of objects in mxob and compares it with every IC dynamically.
j) Each detected moving object is then identified and tracked separately by green bounding box.
k) It is checked whether the object is crossing the sensitive zone or not. If Xc >=Xl and Xc <=Xr and Yc >=Yb and Yc <=Yt where centroid of the object is (Xc,Yc), then the flag variable is set i.e. it tries to identify if the object is entering within the sensitive area.
l) The centre co-ordinate of each tracked object is computed and stored in a vector named XY.
m) The color of the path changes with increasing value of mxob.

Step 7:- The discrete points that are stored in XY vector are plotted at the end. So, finally the path of the moving objects from the different frames is identified and the path of every object is identified with a separate color.

Step 8:- Then the value of the flag variable is checked. If flag is equal to one i.e. flag = 1 then an alert message is sent to the specified email id using Gmail feature.

Step 9:- The entire process is stopped.

4.5 Interfacing Gmail with MATLAB

On the basis of the output obtained at step 6, an alert message is to be sent to the user and hence the following steps are executed if after step 6 of section 4.4, flag = 1. For the Gmail alert generation part, the following modifications are needed to to interface MATLAB with Gmail –

1. To open 'Groupmail' and to go to 'Tool' menu, then to click on 'Account', a new window will open.
2. To click on 'New Account', a new window will open.
3. On the 'New Account' window, to fill up the form entering the required details.
4. To click on 'Next', after filling up the form. Then the Group Mail will try to automatically configure the SMTP server settings based on those details.
5. To enter a 'descriptive name' for the account.
6. To click on 'Finish'.
7. To select the account from tool window and to click on 'modify'.
8. To select 'Manual Account Setup-Enter your own server details' option.
9. To click on 'Next' and to fill up all the details.
10. To click on 'Delivery option' tab and to make 'Connection' option 'Standard' and to give 'SMTP server address' as 'smtp.gmail.com'.
11. To enable 'Require Authentication option' and to click on 'Setup'. A new window will open.
12. To enable 'Use SMTP Authentication(outbound)' option and to fill up 'Type', 'Username' and 'Password' combo box with correct and valid information and to click on 'Ok'.
13. To click on 'Advanced'.
14. To set 'SMTP Port' and 'Pop3 port', 587 and 995 respectively at Advanced Email Settings.
15. To make 'Server requires an SSL connection' enable and to select 'STATRTLS(default)' option in the corresponding combo box and to make 'SMTP Domain' as 'Use system default'.
16. To click on 'Ok'.

5. IMPLEMENTATION

The entire procedure has some modules to complete the whole work. Hence the process has been divided into several stages.

5.1 Assumption

Some assumptions have been made for the simplicity of calculation. It is assumed that the sequence of the objects will remain unchanged throughout the video and the velocity of the objects will vary within a small range.

5.2 Used Hardware Platform and Software Platform

An animated video has been used to have all the possible test cases and the validation of the experiment has also been checked on any CCTV footage. The proposed algorithm has been implemented using Windows 7 operating system and 2013a version of MATLAB. The required help regarding MATLAB has been taken from [14]. A basic smart phone model is required for the alert delivery system directly to the user. Otherwise a processor is enough to send the email to the user of the software.

5.3 Functional Design

A video stream is given as an input file and the output of the process is a polychromatic path which consists of all the paths of the objects which have been entered within a standoff region of a defined sensitive area, a path which consists only the paths of those objects which have been entered the sensitive area and a Gmail alert to aware the user that an unauthorized entry has been occurred.

5.4 Algorithm development

In this stage the implementation of the algorithm is done and the steps are chosen in such a way that the complexity is much less and also each step must be taken in such a way that they should be optimistic and feasible.

5.5 Coding

The software that has been used to implement is MATLAB 2013a and it has given a fruitful result for every step of the algorithm.

6. EXPERIMENTAL RESULTS

The experiment related to the proposed algorithm has been validated using an animated video of three balls, where the balls are entering from three different sides having a collision between each other and then the balls return back in a different path. The initial blank frame has no objects it only has the sensitive area.

Figure 1 in the next page shows a series of figures to demonstrate the process. The first frame or the initial frame, shown in fig-1 (frame 1 of video stream) consists of only the background image. The next frames are to be subtracted from this image for the foreground subtraction. Fig-2 (frame 15 of video stream) depicts the entry of three objects and the objects are identified uniquely and have been separated by bounding boxes. Fig-3 (frame 28 of the video stream) shows the collision of two objects and it has been shown that the objects are identified separately in spite of being very much close to each other. Fig-5 shows that the object enters the sensitive area but it has not fully entered in that area and the centroid is outside the sensitive region. Fig-6 shows that the object has fully entered and hence an alert is generated and fig-7 shows the mail giving the information of the unauthorized entry of

the object. Finally, fig-8 shows the path of objects with different color.

7. Conclusion and Future Prospect

The research work that has been depicted in the paper on the object identification from a video stream mainly address a proximity sensing approach on the basis of a polychromatic

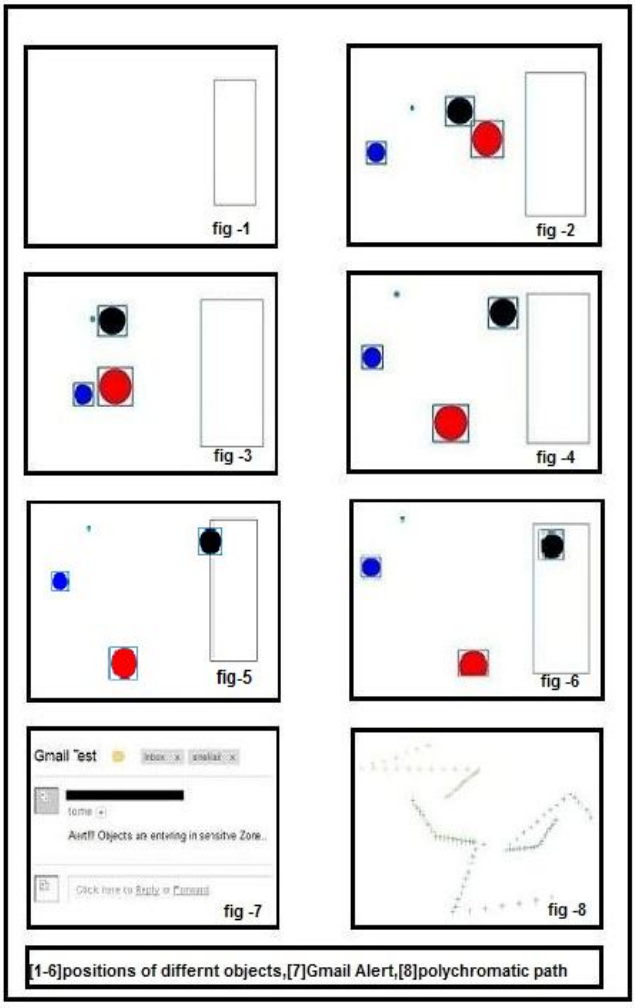

Figure 1: Animations showing the results of the experiment

path to sense whether any unauthorized entry has been occurred or not. The methods which have been used are not much complex and a software group mail has been installed to interface the algorithm with Gmail. The software is also very user-friendly. From the observations of different experiments on different real time videos it has been seen that it can successfully generate an alert and can be successfully used in any surveillance system.

But still there are some constraints present in this algorithm which can be removed in future. The present work gives fruitful result on 2-dimentional images. But in real time video when a 3-dimentional video is projected on a 2-dimentional view port, a situation may arise where the camera may fail to capture some important objects and hence the algorithm needs a few improvements and multiple cameras can be synchronized to remove such errors. Moreover it has been assumed that the sequence of the objects will remain unchanged throughout the entire video clip but in practical situations there is a huge possibility of the objects to change their sequences.

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