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Optimized Surveillance Solution for Unattended Baggage Recognition

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***Abstract*—The system automatically recognize activities around protected area to improve safety and security by multiplexing hundreds of video streams in real time. Object tracking method has important role in real time environment because it enables applications such as Security and surveillance to recognize people and to provide better sense of security using visual information. A novel algorithm for unattended baggage detection based on image segmentation is proposed by using segmentation results of successive frames. An adaptive background subtraction technique is used to handle illumination changes and sudden change in backgrounds.**

Index Terms* -*Real time object tracking; Real time object detection; surveillance system and background subtraction.

I. Introduction

Video Analytics is enabling a rapidly growing number of embedded video products such as smart cameras and intelligent digital video recorders (DVRs) with automated capabilities that just a few years ago would have required human monitoring. Broadly, video analytics is the extraction of meaningful and relevant information from digital video. Smart cameras with analytics continuously analyze video and can detect the presence of people and vehicles and interpret their activities. Suspicious activities such as unattended baggage in crowded area can be recognized and forwarded to the security personals.

Video analytics applications comprise a series of processing steps as shown in Fig.1. These processing steps provide increasingly detailed information about the activities in the scene.

Fig. 1. Video Analytics Processing Pipeline.

The Segmentation is the process of detecting changes and extracting relevant changes for further analysis and qualification. Pixels that have changed are referred to as "Foreground Pixels"; those that do not change are called "Background Pixels". Therefore, segmentation is also called "Background Subtraction". Pixels remaining after the background has been subtracted are the foreground pixels. The degree of change which is used to identify foreground pixels is a key factor in segmentation and can vary depending on the application. The result of segmentation is one or more foreground blobs, a blob being a collection of connected pixels. Classification is the process of qualifying each blob and assigning a class label to it Classification may be done on a single frame or may use information over multiple frames. Tracking of classified foreground blobs takes place over multiple frames as objects move through the field of view. Tracking is a problem of blob association; for each blob in a starting frame, the position of that blob in successive frames needs to be identified. Activity Recognition is the final step that combines the results of classification and tracking, correlating the tracks of multiple blobs to infer the activity occurring in the video.

The structure of the paper is organized as follows. Section 2 presents a brief overview of previous related work. Section 3 explains the implementing method. In section 4, experimental results are shown. Discussions and conclusions are provided in Section 5.

II. Related work

To detect and track the objects in a video sequence and live video streaming is studied. Background subtraction is the simplest method to detect the object. This section presents the through study on different tracking algorithms as well as on the use of cameras for capturing the video data set.

A. Background subraction

Object detection can be achieved by building a representation of the scene called background model and then finding deviations from the model for each incoming frame. Any significant change in an image region from the background model signifies a moving object. The pixels constituting the regions undergoing change are marked for further processing. This process is referred to as the background subtraction. However, background subtraction [4] became popular following the work of

Wren et al. In order to learn gradual changes in time, Wren et al. propose modeling the color of each pixel, I (*x*, *y*), of a stationary background with a single 3D (Y, U, and V color space)

Gaussian, I $(x, y) \sim N(\mu(x, y), \_(x, y))$ (1)

The model parameters, the mean $\mu(x, y)$ and the covariance (x, y), are learned from the color observations in several consecutive frames. Once the background model is derived, for every pixel (x, y) in the input frame, the likelihood of its color coming from N $(\mu(x, y), (x, y))$ is computed, and the pixels that deviate from the background model are labeled as the foreground pixels. However, a single Gaussian is not a good model for outdoor scenes since multiple colors can be observed at a certain location due to repetitive object motion, shadows, or reflectance. A substantial improvement in background modeling is achieved by using multimodal statistical models to describe per-pixel background color. For instance, Stauffer and Grimson[4] use a mixture of Gaussians to model the pixel color. In this method, a pixel in the current frame is checked against the background model by comparing it with every Gaussian in the model until a matching Gaussian is found. If a match is found, the mean and variance of the matched Gaussian is updated, otherwise a new Gaussian with the mean equal to the current pixel color and some initial variance is introduced into the mixture.

B. Segmentation

The aim of image segmentation algorithms is to partition the image into perceptually similar regions. Every segmentation algorithm addresses two problems, the criteria for a good partition and the method for achieving efficient partitioning. In this section, the recent segmentation techniques that are relevant to object tracking discussed.

Mean-Shift Clustering :

For the image segmentation problem, Comaniciu and Meer [3] propose the mean-shift approach to find clusters in the joint spatial + color space, [*l* , *u*, *v*, *x*, *y*], where [*l* , *u*, *v*] represents the color and [*x*, *y*] represents the spatial location. Given an image, the algorithm is initialized with a large number of hypothesized cluster centre's randomly chosen from the data. Then, each cluster centre is moved to the mean of the data lying inside the multidimensional ellipsoid centered on the cluster centre. The vector defined by the old and the new cluster centres are called as the mean-shift vector. Image segmentation can also be formulated as a graph partitioning problem, where the vertices (pixels), V = {*u*, *v*, . . .}, of a graph (image), G, are partitioned into *N* disjoint sub graphs (regions), by pruning the weighted edges of the graph.

$$A_i,\ U^{N}_{i=1}A_i=V,\ A_i \cap A_j=\phi,\ i\neq j; \quad (2)$$

The total weight of the pruned edges between two sub graphs is called a *cut.* The weight is typically computed by color, brightness, or texture similarity between the nodes. One limitation of minimum cut is its bias toward over segmenting the image. This effect is due to the increase in cost of a cut with the number of edges going across the two partitioned segments.

Active Contours:

In an active contour framework, object segmentation is achieved by evolving a closed contour to the object's boundary, such that the contour tightly encloses the object region. Evolution of the contour is governed by an energy functional which defines the fitness of the contour to the hypothesized object region.

Energy functional for contour evolution has the following common form:

$$E(\Gamma) = \int_0^1 E_{\text{int}}(V) + E_{im}(V) + E_{ext}(V)ds, \quad (3)$$

Where *s* is the arc-length of the contour Γ, E_{int} includes regularization constraints, E_{im} includes appearance-based energy, and E_{ext} specifies additional constraints. E_{int} usually includes a curvature term, first-order (∇V) or second-order (∇V^2) continuity terms to find the shortest contour. Image-based energy, *Eim*, can be computed locally or globally.

C. Object detection:

Every tracking method requires an object detection mechanism either in every frame or when the object first appears in the video. A common approach for object detection is to use information in a single frame. However, some object detection methods make use of the temporal information computed from a sequence of frames to reduce the number of false detections. This temporal information is usually in the form of frame differencing, which highlights changing regions in consecutive frames. Given the object regions in the image, it is then the tracker's task to perform object correspondence from one frame to the next to generate the tracks. Although the object detection itself requires a survey of its own, here outline of the popular methods in the context of object tracking for the sake of completeness.

III. IMPLEMENTING METHOD

This section describes the implementation of real time object detection and tracking algorithm in simulation software MATLAB. The system model is divided into three main parts they are video decoding, processing and encoding the processed output to required format as shown in Fig.2. The video decoder is used to convert the analog video from the camera to digital format and the algorithm is processed in Simulation software MATLAB.

In this system we use adaptive background technique for tackling sudden changes in background. Generally the background images in static surveillance cameras are fixed

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and changes are made by manual operators or the first frame when the camera is starting operation will be considered as Background image. This process will reduce the efficiency of the system to avoid this we use adaptive background technique, in this method the background image is changed frequently when the change in the pixel ratio of the subtracted image is high.

Fig.2. Implementing System Model.

Algorithm flow:

The flow of algorithm is shown in Fig.3 as a flow chart and the process is explained in steps,

1) The video input received from the Analog Camera is converted into frames.
2) Object detection is done by using frame difference method.
3) Post processing is done to enhance the segmented image in order to improve the required result.
4) Feature Selection is based on Centroid of an object to plot the location of non-rigid body (objects) with frame to frame.
5) The Object Representation is done by rectangular shape to cover the object boundary to represent the object.

A. Generating Frames:

Here we have presented the algorithm to generate the image frames from video sequence.

Steps are given as:

a) Read the video file using aviread ( ) for audio video interlaced file format or mmread ( ) for other supported file format.

b) Convert the video into frames using frame2im ( ).

c) Write the converted frame on to the storage disk.

B. Object Detection:

Object detection is the process of finding out the area of interest as per user's requirement. Here the algorithm for object detection using frame difference method is proposed (One of the background subtraction algorithms).
Steps are given as:

Read all the image frames generated from the video, which are stored on a variable or storage medium. The images are converted from colored image to gray scale. Calculate the difference as | frame i – frame i-1| > Th. If the difference is greater than a threshold Th, then the value is considered to be the part of foreground otherwise background. Update the value of i by incrementing with one. Repeat the steps up to the last image frame.

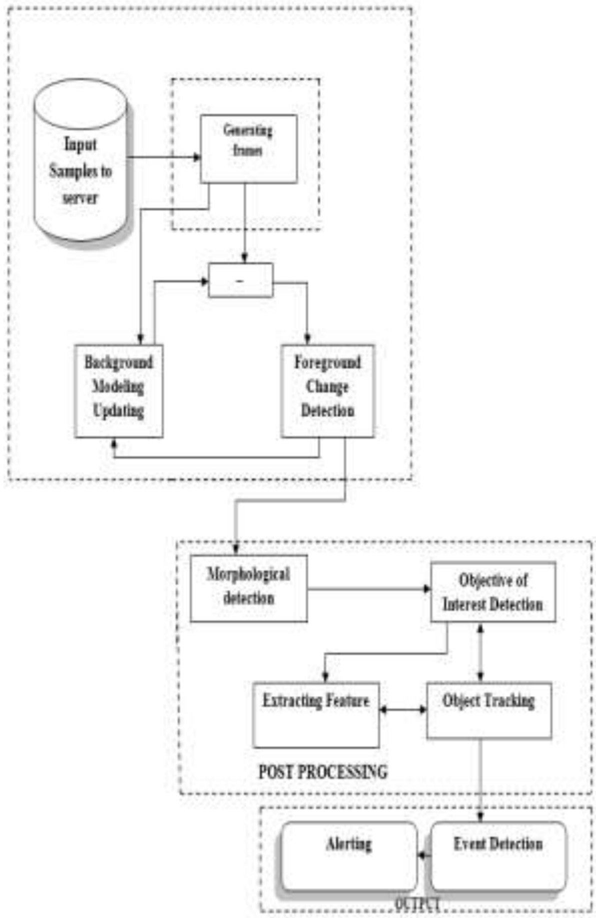

Fig.3. Flow Chart of Implementing Method.

Post Processing:

The detected object in the previous phase may lead to have a problem of connectivity and it may also have some holes which may be useless for object representation. Some post processing methods are needed, which will reduce the problem of handling holes and the connectivity of pixels within object region. Mathematical morphological analysis is one of post processing approach which leads to enhance the segmented image in order to improve the required result. By using the erosion and dilation iteratively in the proposed method an object will clearly appear in foreground while the rest useless blobs will be removed. Morphological operations are useful to obtain the useful components from the image. These components may be the object boundary, region, shape and skeleton etc.

C. *Feature Selection:*

It is based on Centroid of an object and feature to be calculated through which it is easy to plot the location of non rigid body (objects) with frame to frame. The proposed method evaluates the centroid of detected object in each frame. It is assumed that after the morphological operations there will not be any false (misdetection) object. And then a centroid of the object in two dimensional frames can be calculated as the average of the pixels in x and y coordinates belonging to the object

$$Cx = \sum_{1=1}^{N} Xi \,/\, N \qquad (4)$$

$$Cy = \sum_{1=1}^{N} Yi \,/\, N \qquad (5)$$

Here N is the number of pixels in the object.

D. Object Representation:

The centroid and the rectangular shape are used to cover the object boundary to represent the object. After calculating the centroid, find the Width Wi and Height Hi of the object by extracting the positions of pixels Px(max) and Px(min) which has the maximum and minimum values of X Coordinate related to the object. Similarly, for the Y coordinates, Calculate Py(max) and Py(min). Calculation of width and height of a particular object as i^{th} segment in t^{th} frame.

E. *Trajectory Plot:*

After the process of object detection using frame differencing method, the detected components are given as input to the tracking process to plot the trajectory. The frame differencing algorithm will give all the pixel values of the detected object. The centroid of the objects is calculated by using the equation 4 and 5. The trajectory plot function process the input video frame and calculate the centroid, height and width of the object to draw the the trajectory plot.

IV RESULTS

Initially the moving objects in video images are tracked based on image segmentation, background subtraction and object detection techniques. The video is converted in to frames and snapshots of input video frames are taken and shown in Fig5. The Fig 6 shows the output of the video frames where the unattended baggage is detected by red colored block.

The input video is captured in a home environment where the first frame is taken as background image Fig 4. In this video frame a book is considered as baggage carried by a person left in the room. Once the baggage left the algorithm detects it and show to the security personal by covering the left baggage in red blocks.

Fig 4. Background image

V CONCLUSION

The object tracking algorithm based on image segmentation of the segmented objects between frames in a simple feature space is proposed . The results for frame sequences with video sequences verify the suitability of the algorithm for reliable detection of unattended baggage. The algorithm works very well for more complicated video pictures including crowded area and rapid change in background. The algorithm is verified with various video samples to verify its stability and furthermore the algorithm can be implemented using Digital Signal Processor to develop as a standalone device.

Fig.5. Input Frames of Video Sequence

Fig.6: Output Video Sequence of Unattended Baggage Detection.

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