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A Study on Video Surveillance System for Object Detection and Tracking

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***Abstract*- Visual surveillance System is basically used for analysis and explanation of object behaviors. It consists of static and moving object detection, video tracking to understand the events that occur in scene. The most important objective of this survey paper is to determine the various methods in static and moving object detection as well as tracking of moving objects. Any video scene contains objects that can be determined by object detection technique. There are various classes of detected object such as tree, clouds, person and other moving objects. Detection for moving object is a very challenging for any video surveillance system. Object Tracking is used to find the area where objects are available and shape of objects in each frame in higher level application. In this paper, we used different methods such as background subtraction, statistical method, and temporal frame differencing for the detection of moving objects. We also described different tracking methods like Point tracking, Silhouette Tracking and Kernel tracking in our survey paper.**

***Keywords* - Object detection, object tracking, visual surveillance**

I. INTRODUCTION

The word surveillance is the combination of two words first is "sur" that means "from above" and second is "veiller" that means "to watch"[1]. Video surveillance is attractive research area in artificial intelligence, computer vision and digital image processing. Tube cameras were used in 1930-1940 as monitoring system. The Close-Circuit Television (CCTV) – was defective and expensive to observe events that happen in the scenes via visual display. Video surveillance system provides safety and security in public places. The main problem encountered in video surveillance is low resolution quality of the scenes obtained. Surveillance system depends on human operators who detect some useful activities in a video scene. It is difficult to monitor simultaneous events in surveillance displays due to few limitations [2].

There are various technologies like CCD cameras, night vision devices like goggles and thermal imaging cameras. These devices are used in the video surveillance field. An intelligent visual surveillance system extracts information from large scale data set. Visual surveillance system helps to detect as well as to track objects to know the behavior of objects with multiple cameras [3].

Video surveillance system is also used to watch out the sensitive areas like banks, road, shop and borders where different types of incident can take place such as theft and accident etc. The main aim of Video surveillance system is to solve different kinds of problems such as object detection, object tracking [4]. Hence, human motion plays an important role in the area of image classification and machine learning that focuses on the recognition of patterns [5].

Detecting object like humans in surveillance videos is a challenging task due to their different appearances and variety of poses they can adopt [6]. Various features in biometric such as face and style of walking [7] or non-biometric features such as appearance can be used for person recognition in video sequences.

An automated visual surveillance system consists of object detection, object tracking, person identification [3]. Motion and object detection is the important step of any visual surveillance system. Visual surveillance systems that uses single camera can be applied to detect, track and person identification. When the surveillance area is expanded, then the problem of occlusion occurs. To solve this problem Visual surveillance systems using multiple camera can be helpful. If we use single camera for object tracking then it creates ambiguity problem due to occlusion. This problem of ambiguity may be eliminated from another view of camera. When we use multiple cameras then various problems occurs such as camera calibration and object matching. In video surveillance system there are three generations that is given as follows [8]:

1GSS: The first generation surveillance system was related for action of retrieving an image, transmission and processing. But in this generation there were some disadvantages like extraction of event that occur in the system and high bandwidth.

2GSS: The second generation surveillance systems were based on analog and digital sub systems. These systems are used to resolve the problems of bandwidth and filtering out false events etc.

3GSS: In this generation systems provide end-to-end digital systems. A smart system which is used in 3GSS generates real-time alarms for events that occur in system.

Video surveillance system is used for integration of real-time and efficient computer vision algorithms [9]. There are various number of visual surveillance systems.

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- W4 is a real-time video surveillance system [10]. This system monitors object behaviors in the presence of occlusion.
- The vehicle tracking system comes under VIEWS system that is a three dimensional model [11].
- Wren et al. [12] developed The Pfinder system which is used to regain a 3-dimensional description of a person in a vast area.
- Olsen et al.[13] developed TI, which is used as single-person tracking system. It is also used to detect moving objects in indoor scenes.
- The system at CMU [14] is basically used to monitor different types of activities using multiple cameras in a large area.

II. OBJECT DETECTION

The way of finding semantic objects like humans, animals, carriage in video scenes is called object detection. There are various areas of object detection like face recognition and pedestrian detection. Object detection algorithms mainly used to extract features to recognize instances of an object. The various application area of object detection are retrieval of images from many sources, security and vehicle parking systems.

A. Categories

The object detection categorized as follows:

1) Model-Based System

The system tries to match model that is designed for the object to different parts of the image[15].

2) Image Invariance Method

This method is used for a matching of an object on a group of an image patterns relationship like brightness level [16].

3) Example-based learning Method

This method is used to categorize object detection systems in a good manner [17-18]. The main application areas of this method are computer vision and object recognition.

B. Static Object Detection

The various application area of static object detection are detection of vehicles in no parking zone or the detection of abandoned objects [19].To detect static object, each object in the system has 3 attributes:

- Age-Age records the number of frames that object has not moved
- Type –Type represents the status of objects.
- It can be new, matched and occluded.
- If we want to extract the foreground objects from current frame then we will compare those objects with objects from previous frame. There are three criteria for matching such as Similarity in shape and position, Similarity of intensity and Similarity in edges.

If an object from previous frame matches with some object from current frame then it is called matched objects (figure 1). If it does not match well but the major parts of the object overlap with some objects in current frame, it is called occluded object (figure 2). The object from current frame does not match with any objects from previous frame are known as new object (figure 3).

Fig.1. matched static object

The new objects are added into the previous frame before processing the next frame. Any object that has age more than a certain threshold is called static object [20].

Fig.2. Ocluded static object

Fig.3. New static object

C. Moving Object Detection

Object detection in a moving scene is the basic step for analysis of video. An object detection mechanism is applied when moving object appears in video scene. Object detection approach basically uses information in a single frame [21]. Motion detection is very important and difficult task when the camera is itself mobile. Motion detection technique usually depends on pixel level classification scheme exploiting local motion related information such as data flow diagram, Frame Difference or the normal flow. A block diagram of moving object detection is explained in figure 4.

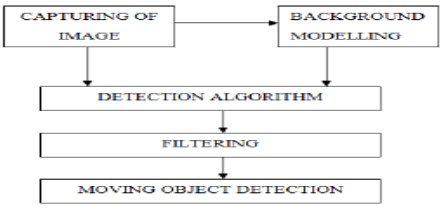

Fig.4. moving object detection block diagram

*1) Frame Differencing (Temporal Differencing):*Moving object in video scene is determined by calculating the

difference between two consecutive images. It is very easy and simple to implement [22]. It is a highly adaptive approach if the changes occur in scene due to motion. When object moves slowly, it is not able to retrieve all needed pixels of a foreground object [23] in this situation. Extraction of pixel that moves in scene is simple and fast in temporal difference technique.

Fig.5. Temporal frame differencing. (a) Present Frame (PF) (b) Previous Frame (Prev) (c) Result = PF – Prev

*2) Optical Flow:*Image optical flow field can be represented by using optical flow method [24]. It is also used for clustering processing. This method is useful to get movement information of an object from the background. Optical flow method is used in those areas that contain the problem of motion of objects in the scene as well as the structure of objects.

Consider a ball is moving from the bottom left to the top right in five-frame clip in a two dimensional plane. Motion of balls can be extracted from the frames sequentially with the help of vectors.

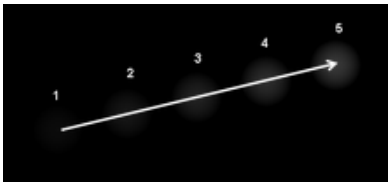

Fig.6. Optical flow vector of moving object in a video

3) Background Subtraction: Background modeling is the first step of background subtraction [25]. We can calculate the difference between current image and background image by using difference method to detect moving objects. If the difference is above a threshold value then the pixel is called foreground pixel.The background subtraction is used where each video sequence is compared with the background. After the comparison this model determines the variation. The variations between current video frames and reference frame signify existence of moving object information in terms of pixels. There are two approaches:

Recursive Algorithm: There is no concept of buffer for background estimation in Recursive algorithm. This technique is used to modify a single background model that depends on each input frame recursively [26]. Less storage is needed in recursive techniques. This algorithm uses various methods such as approximate median, Gaussian mixture etc.

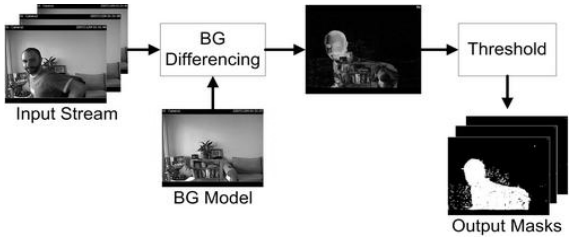

Fig.7. Background Subtraction

Non-Recursive Algorithm: Non-recursive algorithm is highly adaptive rather than recursive techniques. A sliding-window method is used for background estimation in non-recursive algorithm [27]. It stores a buffer of the previous frames in video for estimation of the background image that depends on the variation of each pixel within the buffer.

*4) Statistical Methods:*Statistical Method is used to extract regions that have been changed from background. This statistical method comes from background subtraction methods. The different statistics of background are modified dynamically during processing [28]. Now days this method is more popular because it is very reliable in those video scenes that contain noise, variable illumination [29]. W4 [30] system uses Statistical background model in which each pixel is represented with its minimum and maximum intensity values. If the scene contains no objects in moving position then largest intensity difference is found between any two frames in series observed during initial training period. The current image classifies a pixel as foreground if it satisfies:

$$\left|Min(x,y) - I_t(x,y)\right| > Diff(x,y) \text{ or } \left|Max(x,y) - I_t(x,y)\right| > Diff(x,y)$$

D) Challenges

Images of an object may change when it moves from one frame to another frame. There are three principle sources for this variation. First principle is variation in deformations, the second principle is variation in illumination and third principle is partial or full occlusion of the target [31].

1) *Illumination Changes:* Illumination Changes means that background model accept changes in the appearance of an object. For example the intensity of light varies from time to time during the day.
2) *Dynamic Background***:** Suppose that there is big scenery that may contain movement of object such as a swaying of tree branches, movements of clouds, wave of water etc.
3) *Occlusion:* Full Occlusion or partial occlusion may affect the process of computing the background frame. In real life occlusion can occur anytime in an image. If some part of object in an image is not visible clearly then it called partial occlusion.
4) *Presence of Shadows***:** There are different methods for detection of shadows in an object. Shadows cast by foreground objects often create the problem in background subtraction.

5) Video Noise: In most of cases noise degrades the quality of video signal. Background subtraction or background modeling is used to deal degraded signals due to noise in an environment such as sensor noise.

III. OBJECT TRACKING

Tracking plays an important role of moving object in human motion analysis. With the help of different feature of an object tracking is used to detect foreground objects between a series of frames like velocity, color and texture. Tracking is the process by locating positions of objects from frame to frame in video scene [32]. The appearance model represents the shape of objects that defines the type of motion.

A. Single moving Object Tracking:-

A person that is a single moving object in a room is shown in Fig. 8.The yellow square shows the template matching module and has been superimposed by the tracking module on the original frame.

Fig.8. Tracking of a one person (moving) inside a room

B. Multiple Moving Object Tracking:-

There are three different scenes to represent the moving object tracking. The first two video scenes are shown in Figure 9. A car that is moving and a person who is walking is shown in the first part of figure. In the rest of figure there are three subfigures, two people walking together means merge and then split. After the splitting, the individual persons were identified.

Fig.9. Tracking of multiple moving object (left). Merging and Splitting of two people (right).

Object Tracking Methods

There are Different object tracking methods.

a) Point Tracking: Tracking of vehicles can be done by using point tracking method. This approach requires deterministic methods [33]. Point tracking method is very reliable and robust.

Kernel Tracking: This method requires shape and appearance of the object. Object basically contains various features and any of them is used to track object as kernel. Object tracking can be done easily if we compute the motion of the kernel between more than two frames [34].

Color: There are some physical factors that affect color like spectral power distribution of the illuminant [35]. Color can be represented by RGB (red, green, blue) model.

Edges: Edge detection is basically used to identify changes in image intensities [36]. Illumination changes in edges are less sensitive compared to color features.

Texture: This method generates the descriptors with the help of processing steps and used to identify objects in scenes [37].

Tracking under Occlusion

Tracking is used for the communication purpose between objects across frames. When we are not able to see objects clearly in an image due to some other object that comes in the way of first object, then occlusion occurs. Tracking of object under occlusion is very difficult because the position of an occluded object cannot be determined accurately [38]. There are basically three cases of occlusion:

Inter-object occlusion: Inter-object occlusion occurs, when more than two objects enter the video scene and occluding each other. The main problem is that if foreground region contains various objects like person move in groups, so detecting and resolving particular objects is very difficult.

Occlusion of objects due to thin scene structures: Suppose an object can be breaked into two regions due to poles or trees. This type of condition is raised if two or more objects are occluded one by one by this type of structure.

Occlusion of objects due to large structures: If an object in a scene does not appear again for some time, then this type of occlusion occurs.

Approaches in Object Tracking

Two approaches are used in tracking objects: First approach is based on correspondence matching and other approach depends on distinct tracking [39].

Fig.10. A framework for smart video processing algorithms

Tracking Methodologies

Tracking of moving objects and identify these object such as vehicles in dynamic scene. Tracking methodology locates the position and determines the movements of object between a series of frames in video scene [40]. Tracking [41] can be mainly divided into various types:-

Region Based Tracking: In this tracking scheme first we detect object and then we match the feature of detected object in one image frame to the feature of detected object in the other image frame.

Contour Based Tracking: In this tracking we detect an object by matching the energy of the object boundary in the first

frame with the energy of the boundary of the detected object in the next image frame.

b) 3D Model-Based Tracking Methods: A multi-vehicle tracking system is recommended for different kind of vehicles such as bus, vans, trucks and bikes etc [42]. A 3-dimentional vehicle detection framework depends on a rule based boundary feature [43].This model is very useful in detection and tracking of vehicles.

c) Feature-Based Tracking Methods: Vehicle classification performance can be done in surveillance videos with the help of this method [44].

d) Pattern and color-Based Tracking Methods: YCrCb color space model uses this technique for the background construction, vehicle location and tracking and elimination of shade that presents in object [45].

Multi-Object Tracking System

Multi-object tracking system is divided into three main parts; visual tracking, track management, and online model learning [46].

e) Visual tracking: Object hypotheses are detected using a pre-trained detector and used as an input of the system. The provided detections are associated with existing tracks and existence probabilities of tracks are updated. Then, track states are estimated with the associated detections using particle filtering.

f) Track management: Existing tracks with the low existence probabilities are terminated. Terminated tracks are associated with other tracks or detections to link them. A new track is initialized using observations which are not associated with any tracks.

g) Online model learning: Discriminative appearance, shape and motion models of describing tracked objects are learned by updated tracking results.

IV. CONCLUSION AND FUTURE SCOPE

With the help of some useful information like shape and size video surveillance system is useful to detect a suspicious human behavior. There are various phases of object detection and object tracking that has been described in this survey paper.

There are various methods used for moving object detection such as background subtraction, optical flow and frame difference, and there are various criteria for static object detection such as Similarity in shape and position, Similarity of intensity and Similarity in edges. Background subtraction is a simplest method in compare to frame difference and optical flow for detecting moving objects because it provides complete information about the objects.

This survey paper also describes the concept of object tracking that can be performed using various methods like point tracking, Kernel tracking, color, edges and texture. Two approaches are used in tracking objects: first approach depends on correspondence matching and second approach based on distinct tracking. I have also described about multi-object tracking system that is divided into 3 parts; visual tracking, track management, and online model learning. The proposed research work will attempt to design and develop algorithms for robust object detection and tracking in future. The main limitation of this survey paper is that it is not useful where higher key frames are required for object detection. One another limitation is that it is not suitable to track moving object for denser environments such as crowds of moving people.

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