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Overview of Moving Object Detection and Tracking

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***Abstract:** Moving object detection and tracking is one of the critical areas of research for various applications of computer vision and image processing such as pedestrian detection, traffic monitoring, security surveillance and so forth. Object tracking is the key step in video surveillance, public safety, and traffic analysis, remote sensing applications. Though the latest moving object detection methods provide promising results, accurate detection is still tedious task because of various challenges like illumination issues, occlusion, and background objects in an uncontrolled environment. Here going to discuss the most common challenges of accurately detecting moving objects, gives an overview of existing methods for detecting moving objects and tracking.*
***Keywords:** object detection, object tracking.*

I. INTRODUCTION

Videos are sequences of images, displayed in a fast frequency which is compatible to human eyes. Object recognition and tracking reduces human efforts and provides efficiency. Moving objects that should be detected in a video can be people, animals, or vehicles including cars, trucks, ships etc. Most of these objects don’t change their shape. They are so called rigid objects. There are also non-rigid objects, which can change their shape. People and animals constantly change their silhouettes when doing actions and adopting poses. Other objects like waterfalls, hurricanes, clouds, and swaying trees also move, but as a part of the background, they should be considered by a detection algorithm. Representation of objects is important in object detection and tracking. Tracking is the problem of estimating the trajectory of an object in the image plane as it moves around a scene. Cameras are static such as surveillances cameras or moving cameras such as cameras mounted on a mobile robot. Either of them generates video for tracking objects. In tracking [2], an object can be defined as anything that is of interest. Objects can be represented in points, primitive geometric shapes like rectangles, ellipses and by means of silhouette contour. There are some difficulties in object detection such as illumination, positioning, rotation, mirroring, occlusion, scale etc. Object detection identifies objects in the video sequence and cluster pixels of these objects. Classify these objects based on their color, shape, motion, texture is next step.

II. RELATED WORKS

There are few methods for detecting moving object. The first steps in video analysis are detecting target objects and clustering their pixels. This section considers the following approaches to detecting moving objects as Background subtraction, temporal differencing, frame differencing and optical flow.

A. Background Subtraction And Modeling

Background subtraction is also known by foreground detection. Background modeling is the first step of background subtraction which is used to obtain the reference model [1]. It is a technique used in image processing and computer vision where foreground is extracted from the image for object recognition. Here difference between the current video frame and the pervious frame is taken in terms of pixels. Possible variation is determined by comparing this reference model with each video sequence. This method is normally used for segmenting motion in static scenes and for detecting moving objects in videos from static cameras. Regions of interest in image are objects like humans, text, vehicles etc. in the foreground. After image extraction (which may include removing noise from image, morphology etc.) localization of object is required which may make use of this technique. The hypothesis in this approach is detecting the dynamic objects from the difference between the current frame and a reference frame. Often this method is not applicable in real environments, since it is based on static background localization. The indoor scenes, reflections or animated images or motion of objects on screens results to background changes. The technique computes background and then subtracts current frame in which dynamic object is present to detect moving object. The technique finds a thorough difference for each pixel. If the difference is above a certain threshold value then there is a change and the pixel belongs to the object. Moving foreground objects are subtracted pixel by pixel from a static background image using mathematical modelling or probability theory.
Background subtraction algorithms for moving cameras can be classified into Point trajectory-based methods and spatio-temporal segmentation methods. Point trajectory-based methods track points to extract trajectories and cluster them according to motion similarity.

These types of methods include approaches like trajectory classification. Spatio-temporal segmentation methods extend image segmentation to the spatial-temporal domain. Spatial aspect determines semantic similarity over image space and the temporal aspect associates the motion of object pixels over time. Spatio-temporal relationships of pixels need to be consider for detect a moving object.

B. Trajectory Classification

Trajectory classification [6] is a moving object detection method for moving cameras. This method includes such stages as choosing particular points in the first video frame and then forming a trajectory that represents continuous displacements at each point in adjacent frames. At last, clustering is done to classify the trajectories into background and foreground regions where moving objects can be detected.

But clustering approach faces some difficulties in addressing points near the intersection of two subspaces. So region segmentation is applied here labelling by comparing the region trajectories with the point trajectories hence forms regions with points that belong to neither the foreground nor the background. Background subtraction method has mainly two approaches such as recursive and non-recursive algorithm. Recursive algorithm recursively update a single background model based on each input frame so that input frames from distant past could have an effect on the current background model. This technique incorporates various methods such as approximate median, adaptive background, Gaussian of mixture. A non-recursive technique [3] uses a sliding-window approach for background estimation which stores a buffer of the previous L video frames. It then estimates the background image based on the temporal variation of each pixel within the buffer.

C. Temporal Differencing

Temporal differencing [4] is one of another most popular approach for detecting moving objects in video captured with a moving camera. This method detects the moving regions by making use of pixel-wise difference method across successive frames. It is based on the principle of - subtraction of current and background frame pixel wise of two consecutive frames (subtracting current frame from the reference image), but here, previous frame is the reference image (in contradiction with the background method, in which the reference image is fixed). This method uses two adjoining frames to subtract and gets difference images hence it is manageable and smooth to implement. It gives moving target information through the threshold value after the subtraction of image. This is very flexible to the dynamic changes in the scenes; often fails to detect appropriate pixels of some types of dynamic objects.

D. Frame Differencing

Moving objects are detected by calculating the pixel-by-pixel difference of two consecutive frames in a video sequence. The present frame is subtracted from the background frame and difference value is compared with a threshold value to determine whether an object is lying in background or foreground. If each pixel value difference is greater than the threshold value, then that pixel is a part of foreground otherwise it is considered as background. Since it computes only the most recent frames, this method is highly adaptable to dynamic changes in the background. Often it may inaccurately detect objects that move too fast or that suddenly stop which is a challenge to overcome. Because the last frame of the video sequence is treated as the reference, which is subtracted from the current frame. The major demerit of this technique is speed. If the speed of moving object is almost imperceptible then the difference of two values of frames will not be easily identified which will not be able to detect objects properly [4].

E. Optical Flow

This method can be used for real-time moving object detection, but it's very sensitive to noise and may require specialized hardware. A pattern of apparent motion of objects, surfaces and edges in a visual scene caused by relative motion between an observer and a scene which is known as optical flow. A velocity vector is calculated for every pixel which is based on how quickly the pixel is moving across the image and also depending on the direction of object movement. Real time video processing is bit difficult as it needs special hardware support also computation is very complicated. The image optical flow field is [2] calculated by this optical flow method and clustering processing is done based on image optical flow distribution characteristics. Apparent velocity and direction of every pixel in a video frame has to be calculate makes optical flow method time consuming one. It uses the flow vectors to detect moving regions in the video sequence against the background. This method is very complicated and includes difficult computation but has a high level of detection accuracy as it copes even when the camera is shaking. Optical flow can also be used for detecting both static as well as moving objects in the same frame. The challenges of detecting moving objects are influenced by environment where the video is captured and the camera used. A video captured at indoors or outdoors may have shadows and sudden changes in illumination. So it is better to deal with complex backgrounds, abrupt motion, occlusion, and moving shadows. Besides, there may have motion-blurred objects or partial lens distortion. It includes illumination changes, changes in appearance of moving objects, presence of unpredicted motion and occlusion.

F. Object Tracking

Object detection is performed to understand the presence of objects in particular video frame and to detect that object. Object tracking is for identify the moving object position and separate a region of interests from video sequences and keep the track of its motion and position. It estimates the movement of an object to be tracked by observing its position in each frame of the video. Object tracking approach is classified into three types such as kernel, point and silhouette based tracking.

In point tracking, detected objects are represented by points. This type of tracking is difficult in case of false detection of object. Point tracking are of mainly three types namely Kalman, multiple hypothesis filter and particle filter.

Kalman filter track moving objects by estimating the velocity and even acceleration of an object with the measurement of its locations. It is applied only for tracking objects with linear motion models rather than non-linear motion models. This filter is an optimal estimator convenient form for online real time processing [2]. Kalman filter is to remove noise from the noisy data. Its applications are tracking of objects in many computer vision applications, stabilizing depth measurements, cluster tracking, fusing data from radar, laser scanner and so on. Multiple hypothesis methods are more efficient due to its better tracking outcomes. MHT or Multiple hypotheses follows an iterative algorithm which starts with a set of existed tracked hypothesis. The hypotheses are propagated anticipation that subsequent data will resolve the uncertainty. The key principle of the MHT method is that difficult data association decisions are deferred until more data are received. MHT is capable of tracking more than one object and handles the occlusions, calculates the optimal solutions. Particle Filter is most widely used filter to track single and multiple moving objects. It is a technique for implementing recursive Bayesian filter by Monte Carlo sampling. The idea behind is to represent the posterior density by asset of random particles with associated weights and compute he estimate based on these samples and weights. Particle filters have been widely used in medical image analysis, contour tracking, and image segmentation.

Objects having complex shapes such as head, hands, shoulders cannot be explained by simple geometric shapes. Silhouette based methods provide an accurate shape description for these objects. These methods can be in the form of a color histogram, object edges or object contour. This model is divided in to mainly two categories as shape matching and contour tracking. Shape matching is somewhat similar to template matching where an object silhouette and its associated model are searched in the current frame. The search is performed by computing the similarity of the object with the model generated from the hypothesized object silhouette based on previous frame. In 1993, Huttenlocher et.al performed shape matching using an edge- based representation. Another approach to match shapes is to find corresponding silhouettes detected in two consecutive frames. Contour tracking methods iteratively evolve an initial contour in the previous frame to its new position in the current frame. This contour evolution requires that some part of the object in the current frame overlap with the object region in the previous frame.

Kernel tracking [5] is commonly used for track single object. It is usually performed by locating the moving object, which is represented by an embryonic object region, from one frame to next. Based on kernel tacking approach there is variety of kernel tracking approaches. Template matching is used for finding a sub image of a target image. It uses brute force to search an image for a region that matches the template in the previous image. Though this type of searching is computationally expensive, optimizations overcome this by limiting the search to a certain region. Segmentation defines region of interest from moving object from one frame to next represented by a rectangular window in an initial frame. Tracked object is separated from background using mean shift algorithm. Support vector is a type of classification method which gives a set of positive and negative training values. In case of SVM, positive values have image of tracked object and the other one contain the rest of things, which are not being tracked. In Layering based tracking, multiple objects are tracked. Each layer consists of shape representation such as ellipse, rectangle and motion such as translational and rotation and layer appearance based on intensity. These types of tracking deals with fully occlusion of object and tracking multiple images.

III. CONCLUSIONS

Object detection and tracking is becoming an active research area in the field of computer vision for the past few decades. Object detection is the first step for tracking objects. Object detection and tracking has various practical applications, such as motion analysis, people and vehicle tracking, crowd analysis, etc. This paper provides an overview on all techniques on object detection, classification and tracking. The paper mainly focuses on the working principle of all these methods. As the object detection and tracking deals with many challenges. Every method has its own advantage but one particular method is unable to deal all the problems alone.

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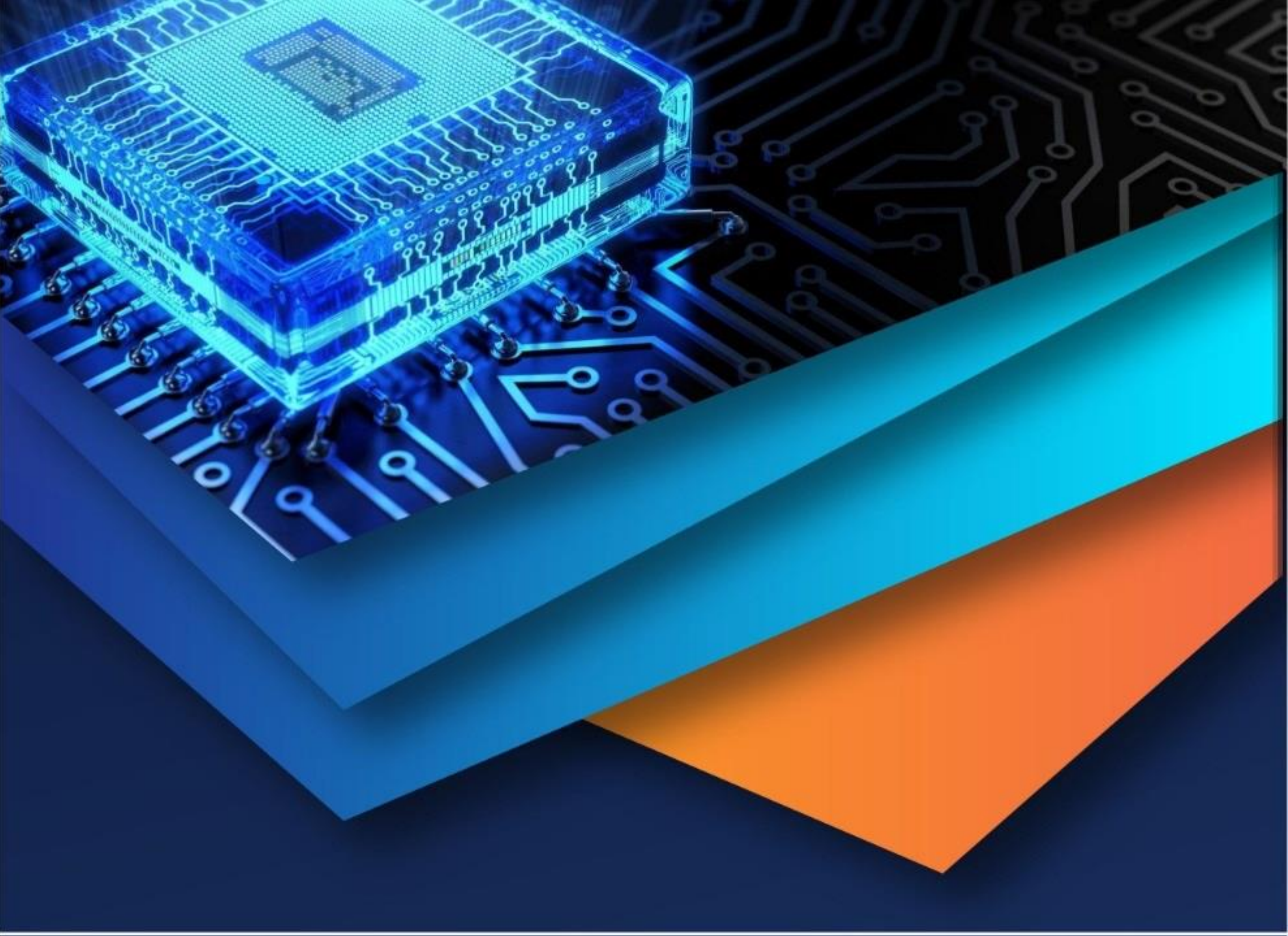

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