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A Review on Object Detection and Tracking in Video

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ABSTRACT

In video or an image, object detection and tracking is most popular now a days and use for motion detection of various object. Identify objects in the video sequence and cluster pixels of these object is the first step in object detection. Object classification is the next important step to track the object. The object tracking can be applied in most of the fields that include computerized video surveillance, robotic vision, traffic monitoring, gesture identification, human-computer interaction, military surveillance system, vehicle navigation, medical imaging, biomedical image analysis and many more. The objective of this paper is to present the various steps included in tracking objects in a video sequence, namely object detection, object classification and object tracking. This paper presents various object detection and tracking methods and also the comparison of various techniques used for different stages of tracking.

Keywords : Object Detection, Object Classification, Object Tracking, Video Processing

I. INTRODUCTION

In the field of computer vision, object tracking plays a vital role [1]. Object detection and tracking are both most active research areas with number of application including computerized video surveillance, robotic vision, traffic detection, vehicle navigation, object identification and much more. Video is sequence of images, each is called as frame. There are both moving and static object in sequence of images. Moving object which can be a person, bird, vehicleetc. also called as foreground object and background object can be the static things. Detecting the semantically meaningful moving object is the task of moving object detection [2]. Object detection is the first step towards tracking process.Object Tracking is carried out to check the presence of object in videos. Basically there are three steps in object tracking. Object Detection, Object classification, Object Tracking

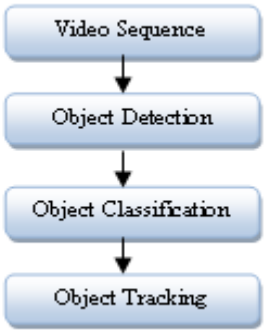

Fig.1.1. Steps for Video Object Tracking

Object Detection

Object Detection is done to identify objects in the video sequence [3] and cluster pixels of these objects [4]. Object detection can have various methodologies such frame differencing, optical flow and background subtraction[5].

Object Classification

Object can be classified after the object detection on the basis of their shape, motion, color and texture. There are many approaches of classification methods such as shape-based, Motion-based, color based and texture based classification method.

Object Tracking

Object tracking is the process of finding an object of interest in the video to get the useful information by keeping the track of its motion, occlusion, orientationetc.[6].There are various approaches to track the objects such as point tracking, Kernel tracking and silhouette based tracking. There are various object tracking algorithm that can be classified, for example, on the appearance based model tracking algorithms can be classified into generative and discriminative tracking[7][8].

1.1. Overview of Object Detection

In video sequence identify the objects of interest and cluster pixels of these object is the first step in the process of object tracking. Detection of the region of interest of user can be achieved by various techniques such as frame difference, optical flow, background subtraction as shown in figure 1.2.

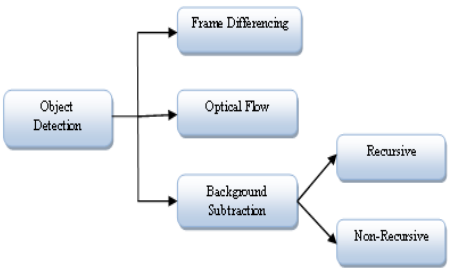

Fig.1.2. Categorization of Object tracking

1.2.1. Frame Differencing

Frame differencing is object detection technique in which the moving object is determined by calculating the difference between two consecutive images or frames. It is easy to implement and its calculation is simple. It also has a strong adaptability, for dynamic environments, but to obtain complete outline of moving object it is generally difficult [9], as a result it is not accurate for the detection of moving object.

1.2.2. Optical Flow

For tracking the objects which are in motion optical flow method is useful. This method is used to calculate the image optical flow field and perform the clustering processing according to the optical flow distribution characteristics of image [10]. In this context this basic method is called optical flow. By using optical flow method we can get the complete moment information but it requires large quantity of calculations.

1.2.3. Background Subtraction

Background modeling is first step for background subtraction. It is achieved by building a background model. To obtain the reference model background modeling is used. In background subtraction the reference model is used in which each video sequence is compared against the reference model to determine possible changes in the frame. Existence of moving objects is determined by variations between current video frames to that of the reference frame in terms of pixels [11]. Background subtraction algorithm is simple. It is more sensitive to the changes in the external environment.There are two types of algorithms [12] for background subtraction. They are recursive algorithm and non-recursive algorithm.

A. Non-recursive algorithm: For background estimation a non-recursive technique uses a sliding-window approach. Number of previous video frames that are select are stored in a buffer and the background image is estimated based on the temporal variation of each of the pixels within the buffer. Since select numbers of frames are only stored in the buffer, errors caused by frames outside the buffer limit are not taken into consideration. Because of large buffer requirements Storage requirements for non-recursive techniques may be very large. This problem is overcome by storing the video at lower frame rates. Various commonly used non-recursive techniques

include frame differencing, median filtering, linear predictive filtering and non-parametric modeling [13].

B. Recursive algorithm: In the case of a recursive technique no buffer is used. Based on each input frame a single background model is updated. This means that in the current model even frames from the distant past could cause an error. This also reduces the storage space, as no memory would be necessary to buffer the data. Some recursive techniques include approximated median filtering, Kalman filtering and Mixture of Gaussians (MoG).

1.3. Object Classification

Object can be classified based on their shape, Motion, Texture, color.

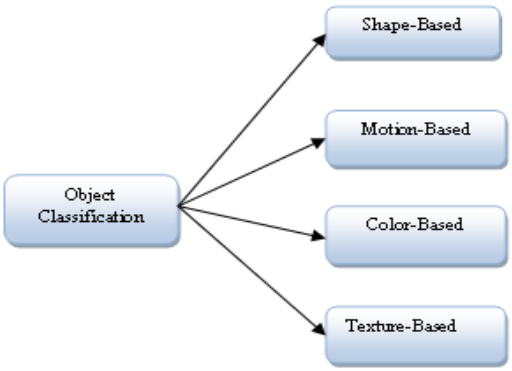

Fig.1.3 Classification of object

1.3.1.Shape-Based Classification

Shape based classification means matching a pattern. For classifying moving objects the different descriptions of shape information such as representation of points, box and blob are stored or available.Elaboratethe study of various shape features with accuracy and performance measurements [14].

1.3.2 Motion-Based Classification

Motion-based classification is used to detect the moving object. For object classification optical flow is also useful. To analyze rigidity and periodicity of moving entities residual flow can be used.

1.3.3. Color-Based Classification

Color is easy to be acquired and under viewpoint changes color is relatively constant. For detecting and tracking the object color is not appropriate. In real-time to detect and track the vehicles color histogram based technique is used.As a real-time tracking frameworks color has been generally utilized[15].Based on color image segmentation and color histogram with background subtraction for tracking objects a vision based moving object tracking system with wireless surveillance system has been proposed [16].

1.3.4. Texture-Based Classification

Virtually all surfaces, the grain of wood, the weave of fabric, the pattern of crop in fields, etc texture is an innate property. To carry useful information the textural properties of images appear, for discriminating purpose features have always been calculated for textures. By means of texture descriptors texture is represented. They observe region homogeneity and histograms of region borders. Various different texture descriptors include homogeneous texture descriptor (HTD), texture browsing descriptor (TBD) and edge histogram descriptor (EHD).

1.4 Object Tracking Methods

After objects detected and classified them, the next step would be the actual tracking process. Tracking can be defined as in the image plane problem of estimating the trajectory of an object as it moves around a scene. Object tracking is the process of finding an object of interest in the video to get the useful information by keeping tracking track of its motion, occlusion and orientation etc. Object tracking methods which are discussed in detail below. They include point tracking, kernel tracking and silhouette tracking [17].

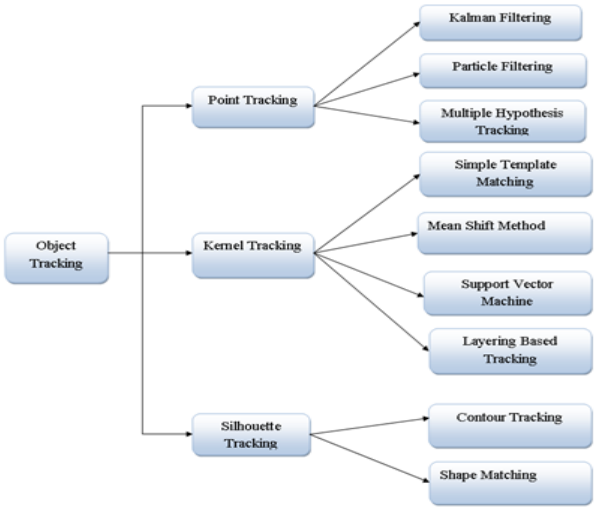

Fig.1.4. Categorization of Object Tracking

1.4.1 Point Tracking

During Tracking in the point tracking approach moving objects are represented as points and are generally tracked across frames by evolving their state (object position and motion). Particularly in the incidence of occlusions and false detection of object point tracking is complex problem [18]. Point Tracking is simple and useful for tracking very small objects. Point tracking may be Kalman filtering, particle filtering or Multiple Hypothesis Tracking (MHT).

A. Kalman Filtering

Kalman filter uses Optimal Recursive Data Processing Algorithm. In Kalman filtering based on criteria that make sense optimal point will be taken [19].A series of measurements observed over time is used by kalman filtering algorithm, that containing noise and other inaccuracies, and produces estimates of unknown variables. To produce a statistically optimal estimate of the underlying system state the Kalman filter operates recursively on streams of noisy input data [20].

There are two steps in the algorithm, prediction and correction. The prediction step produces estimates of the current state variables along with their uncertainties. Then, the outcome of the next measurement is observed and the estimates are updated using weighted average, with more weight being given to estimates with higher certainty. Since it is a recursive algorithm, in real time only the present value, previous value and uncertainty matrix are enough to calculate. Kalman Filter deal with handling noise, it gives optimal solutions and tracking is applicable only for single.

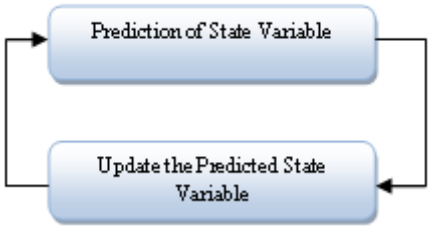

Fig 1.4.1 Kalman Filter Basic Steps

B. Particle Filter

Before moving to the next variable particle filter generates all the models for one variable. When variables are generated dynamically algorithm has an advantage and there can be confoundedly numerous variables. It allows also for new operation of re-sampling. One restriction to the Kalman filter is the assumption of state variables are normally distributed (Gaussian). Thus, the Kalman filter is poor approximations of state variable. This restriction of the Kalman Filter can be overcome by the particle filtering. Particle filter uses contours, colour features or texture mapping. It also consists of two Steps: First step is prediction and second step is update as same as Kalman Filtering.

C. Multiple Hypothesis Tracking (MHT)

Always there is a limited chance of an incorrect correspondence if motion correspondence is recognized using only two frames. Better tracking outcomes can be acquired, if several frames have been observed. MHT is an iterative algorithm. The MHT algorithm begins with the parent hypothesis set. The set of hypothesis of the previous iteration is known as parent hypothesis set and the set of measurements from the beginning until that iteration. Each

hypothesis represents a group of disconnect tracks. Each hypothesis find a prediction of object's position in the succeeding frame and the predictions are then compared by calculating a distance measure.Multiple Hypothesis Tracking deals with the tracking the multiple objects, calculating of optimal solutions and it also handles occlusions [21].

1.4.2. Kernel Based Tracking Approach

By computing the moving object Kernel tracking is usually performed. Using the geometric shapes like rectangle and ellipse Kernel tracking is represented. But one of the restrictions to the Kernel Based Tracking Approach is that parts of the objects may be left outside of the defined shape while portions of the background may exist inside. This can detect non-rigid and rigid objects. There are a various tracking methodologies present based on this Kernel tracking approach:

A. Simple Template Matching Method

In digital image processing for finding small parts of an image or video that match a template image Template matching technique is used. Template matching technique is termed to be a brute force method of examining regions of interest in a video. It is a simple way of tracking with reference image. Here in template matching, the frame that is separated from the video is verified with a reference image.Only single object in the video can track in this technique. In template matching only translation of motion only can be done. Simple Template Matching deals with tracking single object and Partial occlusion of object.

B. Mean Shift Method

From moving object define an Region of Interest (ROI) by segmentation and then tracking the object, from one frame to next is the task of Mean Shift Method. In an initial frame Region of interest is defined by the rectangular window. By this algorithm tracked object is separated from background. The accuracy of target representation will be improved by Chamfer distance transform. Using the Bhattacharya coefficient minimizing the distance among two color distributions is also done by Chamfer distance transform.The drawbacks of this method are only one object can be tracked, the ROI has to be initialized manually. If the object is moving with high speed within the frame it cannot track an object.

C. Support Vector Machine (SVM)

A broad classification method which gives a set of positive and negative training values is SVM. For SVM, tracked image object contain the positive samples and the negative samples consist of all remaining things that are not tracked. But the necessity of physical initialization and necessity of training it can handle single image. The algorithm which is used bySupport Vector Machine are supervised learningmodels and their associated learning algorithms which analyze data and recognize patterns based on previously learnt data. Mostly for classification and regression Support vector machines are used. In SVM algorithm the basic idea is that it classifies the points into two sets of hyperplanes. The tracked objects that are classified as one set and the objects that don't have to be tracked as another set. It can track only a single object. It cannot handle partial occlusions.

D. Layering Based Tracking

For tracking the multiple objects layering based tracking is used. This is another method of kernel based tracking. In this method each layer consists of particular shape such as ellipse, rectangle based on that, the particular object is tracked in that layer. Layering is achieved by features such as motion or colourand motion such as translation and rotation and layer appearance based on intensity.Layering Based tracking deals withtracking multiple images, fully occlusion of object and object motion by translation, scaling and rotation.

1.4.3. Silhouette Based Tracking Approach

Some objects having composite shapes such as hands, head, and shoulders, are cannot defined by geometric shapes. Silhouette based approach is done to track complex shapes that cannot be represented by simple geometric shapes. Silhouette tracking classify into contour tracking and shape matching.

A. Contour Tracking

In Contour tracking method, from the previous frame the contour of the object is taken and it iteratively proceeds to calculate the contour of the next frame. Contour tracking is performed by two ways. First, the contour shape and motion are modeled using state space models. The second method is more direct and direct minimization techniques such as gradient descent for minimizing the contour energy, thereby evolving the contour. To track objects of irregular shapes this method can used. Contour Tracking deals withHandling of large variety of object shapes easily, Handling Occlusion, Dealing with object split and merge.

B. Shape Matching

Shape matching is same to the shape-based classification technique. But, we use shapes to track the particular shape instead of classifying the object. It is also same to template matching, because the shape on the frame is compared with the shape in the database and thus tracking is done. To obtain the required results silhouettes from two successive frames can also be matched. Shape Matching is deal withEdge based template, Occlusion handling performed in with Hough transforms techniques, Silhouette tracking feature of shape matching are able to track only single object.

1.5 All Tracking Techniques Comparison

Table 1.1 Comparison of different video object tracking method

Sr. No	Methodology	Occlusion	Optimal Result	Training Rules	Number of Object Tracking
1	Kalman Filter	No	Yes	No	Single
2	Particle Filter	Yes	Yes	No	Multiple
3	MHT	Yes	Yes	No	Multiple
4	Template Matching	Partial	No	No	Single
5	Mean Shift	Partial	No	No	Single
6	SVM	Partial	No	Yes	Single
7	Layering Based Tracking	Full	No	No	Multiple
8	Contour Matching	Full	Yes	Yes	Multiple
9	Shape Matching	No	No	No	Single

II. CONCLUSION

In object tracking approaches obtaining correct track of the object of interest is crucial. This paper summarizes the different approaches to object detection and tracking.The different phases of object tracking have been studied. Object tracking approach classifies such as point tracking, kernel based tracking, and silhouette based tracking. Various object detection methods are frame difference, optical flow, and background subtraction methods. For static background Frame differencing perform well, it is easiest method, also provide low computational time and high accuracy. Object can be classified on the basis of shape, motion, color and texture. The Texture based and Color based are most widely used because they provide higher accuracy and low computational time. In the tracking technique kernel based tracking or contours based tracking require detection only when object appears first in the scene, while point tracking involves detection in every frame. Contour based tracking is used to track the multiple object. It provide the optimal result and it also handle the occlusion.

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