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Object Detection and Motion Based Tracking of Moving Objects a Survey

Priyanka S. Bhawale[1]
Department Of Computer Engineering
GHRCOE, Chas, Ahmednagar,
Savitribai Phule Pune University
Ahmednagar, India

Ruhi R. Kabra[2]
Department Of Computer Engineering
GHRCOE, Chas, Ahmednagar,
Savitribai Phule Pune University
Ahmednagar, India

Abstract: ***The research on object tracking has attracted many researchers. An object in an image sequence is important for many applications, such as automatic video surveillance, autonomous robotic systems, human-computer interfaces, augmented reality, and healthcare. There are various tracking algorithms, which implements the techniques for object representation (based on object features, texture and shape models, or object contours), object position prediction and search in the next video frame. To perform video tracking an algorithm analyses sequential video frames. It then takes the output of the movement of targets between the frames. There are a variety of algorithms, each having pros and limitations. The algorithm must be selected based on the use of the object tracking in desired field. This paper provides various techniques or methods that are used for detecting, tracking and identification of objects.***

Keywords: component; Object tracking, object detection, object representation

I. INTRODUCTION

The goal of computer vision is to enable computer to intercept motion and understanding of human vision. Visual object tracking has been emerged as important and challenging topic in computer vision. The core of visual object tracking is to estimate the motion of the object in each frame of the input sequence of images. Object can be defined as thing of interest which can be used for further analysis. For example, boat fish, vehicle, planes, etc. Tracking is defined as to follow the motion of an object moving under the action of given forces. With the growing use of computer based applications object tracking technique has been very useful for surveillance, healthcare, traffic monitoring, autonomous robotic system, human-computer interfaces, etc. In surveillance system visual object tracking is used to detect and track suspicious object behavior. Object tracking is used for object detection and for estimation by counting any type of movement in the robotic systems. In traffic flow monitoring object tracking is used to track the vehicles and monitor the flow of the traffic so as to avoid any jams. One of the applications of object tracking is video compression. Example Video object tracking is applied in banks, parking lots, residential areas, malls for monitoring human activities. Object tracking is also used for hand gesture recognition in human-computer interaction applications. It is difficult to project 3D world into 2D image. This may cause loss of information. Various methods are used for tracking purpose. Object tracking is affected by the effect of noise and the changing illumination conditions of the object of interest. Tracking of object can be complex due to the articulated nature of the object. Occlusion can also be a major problem in the object tracking. Motion of the object can be complex and there can be many real time processing requirements for tracking. Hence proper method must be selected according to the where object tracking is being used. In this paper we discuss different the techniques used for object tracking.

II. Basic Concept

Object can be defined as a thing of interest which can be used for further analysis. Tracking is defined as following the motion of an object moving under the action of given forces. Firstly identification of the interest region is must. For this object detection algorithm is used. Objects have different color, shape and texture. Therefore fixed camera environment is assumed. Image is divided into set of pixels. First set consist pixels of foreground object and the second set contains the pixels of background object. Foreground objects are moving objects which we want to track example people, boat, cars, etc. The basic steps for tacking an object are Object representation, Object detection, Object tracking.

1. Object representation:

Without knowing what to track we cannot perform the tacking. Object representation gives the various methods by which the objects can be represented e.g., ellipse, contour, point, etc. Mainly objects can be represented by Shape and appearances. Methods of object representation are point, primitive geometric shapes, object silhouette and contour, articulated shape modes and skeletal models.

2. Object Detection:

Once the object representation method is decided then object detection method are applied on the interest object. Object Detection identifies objects of interest in the video sequence. It then clusters the pixels of these objects. Various techniques such as frame differencing, Optical flow and Background subtraction are used for object detection.

3. Object tracking:

After the successful detection of the object of interest, object tracking methods are applied on it. Tracking can be defined as the problem of approximating the path of an object in the image plane as it moves around a scene. The techniques of object tracking are point tracking, kernel tracking and silhouette. Tracking objects can be complex due to:

1. Loss of information caused by projection of the 3D world on a 2D image,
2. Noise in images,
3. Complex object motion,
4. Non rigid or articulated nature of objects,
5. Partial and full object occlusions,
6. Loss complex object shapes,
7. Scene illumination changes, and
8. Real-time processing requirements.

Hence proper method, depending upon the field where object tracking is used, should be applied.

III. Related Work

a) Object Representation Methods

First step of object tracking is the representation of the object of interest. Object can be represented by their shape and appearance. In this section, we will first describe the object shape representations used for tracking. Then address the joint shape and appearance representations [1].

1. Points: The object is represented by a point, that is, the centroid or it is represented by a set of points [2]. This representation is suitable for tracking objects that occupy small regions in an image.

2. Primitive geometric shapes: Object shape is represented by a rectangle, ellipse [2], etc. Object motion for such representations is usually modeled by translation, or projective homography transformation. These are more suitable for representing simple rigid objects. They are also used for tracking non rigid objects.

3. Object silhouette and contour: The boundary of a region is defined by the contour representation. The region inside the contour is called the silhouette of the object. These are suitable for tracking complex non rigid shapes [3].

4. Articulated shape models: Articulated objects are composed of body parts that are held together with joints. For example, the human body is an articulated object with torso, legs, hands, head, and feet connected by joints. The relationship between the parts is governed by kinematic motion models, for example, joint angle, etc. Articulated objects are represented by modeling the constituent parts using cylinders or ellipses.

5. Skeletal models. Object skeleton can be extracted by applying medial axis transform to the object silhouette [4]. This model is used as a shape representation for recognizing objects.

b) Object Detection Methods

Tracking mechanism requires an object detection mechanism when the object first appears in the video. Once the objects are represented using any of the mentioned models next step is to detect the object in the frame. This is done when the object first appears in the frame or video. The temporal information of the object in the first frame is extracted to detect it. Some models use more than one frame to extract the information; this is done by frame differencing. Some of the object detection methods are as follows:

1. *Frame differencing*

The moving object is determined by calculating difference between two consecutive images. It has strong adaptability for variety of dynamic environments. It is difficult to obtain complete outline of moving object [5].

2. *Optical Flow :*

In this method image optical flow field is calculated. And clustering processing is done according to the optical flow distribution characteristics of image. This method gets the complete movement information and detects the moving object. This method is sensitive to noise, poor anti-noise performance [6].

3. *Background subtraction:*

First step for background subtraction is background modeling. Background Modeling should be sensitive so as to recognize moving objects. Background Modeling outputs a reference model. This reference model is used in background subtraction. In background subtraction each video sequence is compared to the reference model to determine possible Variation. The variations between current video frames to that of the reference frame in terms of pixels signify existence of moving objects [7]. Currently, mean filter and median filter are widely used to realize background modeling. The background subtraction method is to use the difference method of the current image and background image to detect moving objects. This is a simple algorithm, but very sensitive to the changes in the external environment. This method has poor anti- interference ability. It provides the complete object information in the case background is known [8]. Various background subtraction models are MOG (Mixture of Gaussians), Bayesian decision rules, the Codebook-based model, Kernel density estimation [9]. The Codebook algorithm [10] constructs a background model based on a quantization/clustering method. Firstly for each pixel a background model is constructed. This model contains one or more codeword. A codeword is a data structure which contains information about color, brightness and frequency [10]. Stauffer & Grimson et al. [1] proposed a Gaussian mixture model based on background model to detect the object. Mixture of Gaussians was used to model the pixel color [1]. The pixel in the frame is compared with the background model. While checking the pixel is compared with every Gaussian in the model till a match is found. If found, the

mean and variance of the math is updated [1]. Non parametric Kernel density estimation can be used to model the per-pixel background. The pixel is matched with the pixel in the background model and with the nearby pixels [11].

TABLE I

Comparative study of object detection methods [8]

Methods		Accuracy	Computational Time	Comments
Background Subtraction	Gaussian Of Mixture	Moderate	Moderate	+ Low memory requirement
				- It does not cope with multimodal Background
	Approximate Median	Low to Moderate	Moderate	+ It does not require sub sampling of frames For creating an adequate background model.
				- It computation requires a buffer with the recent pixel values
Optical Flow		Moderate	High	+ It can produce the complete movement Information
				- Require Large amount of calculation
Frame Differencing		High	Low to Moderate	+ Easiest Method. Perform well for static Background.
				- It requires a background without moving Objects

c) Object Tracking Methods

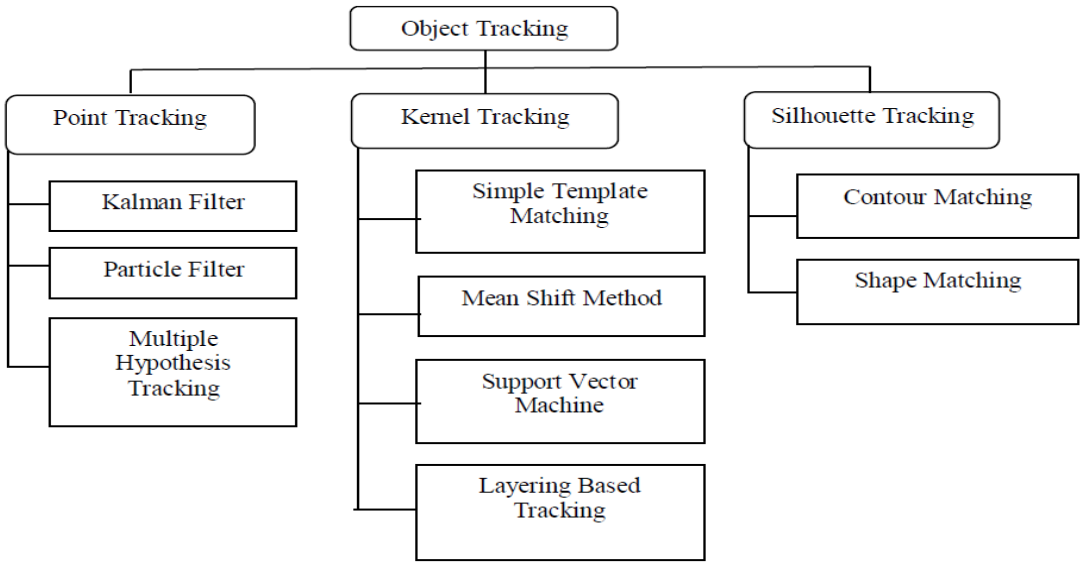

Fig 1. Object Tracking Methods [12]

1. Point Tracking:

In image, moving objects are represented by their feature points. In the incidence of occlusions there is the problem of false detection of object occurs. Point correspondence methods are divided into two categories, namely, deterministic and statistical methods. The deterministic method use qualitative motion heuristics to oblige the problem of correspondence. Probabilistic methods take the object measurement and uncertainties into account to establish correspondence [1]. Kalman filters can be used

for object tracking. Kalman filters are based on optimal recursive data processing algorithms. Kalman filter consists of two phase prediction and correction phases. The next state is predicted using the current set of observation. And then the current set is updated. The second step gives updates the predicted values and gives approximation of the next state [12]. Particle filter uses contours, color features or texture mapping for object tracking. Variable which is not sampled is selected. Particle filter samples the variable according to proposal distribution [12]. MHT (Multiple Hypothesis Tracking) algorithm is an iterative algorithm. Prediction about the position of the object in the frame is made. Then distance measure is used to compare the prediction.

2. Kernel Tracking:

Kernel tracking computes the motion of object form frame to frame. The motion of the object is in form of parametric motion or dense flow field computed in subsequent frames. There are two subcategories density-based appearance models, and multi view appearance models. Density-based models are simple and have relative low computational cost. Templates are formed using image intensity or color feature. There are three methods in kernel tracking approach Simple template matching, mean shift method, simple vector machine (SVM) and layering based tracking [12]. Simple Template matching can track only single object. The object of interest is verified with the frame form the video. It can deal with the partial occlusion of the object. In Mean shift method the object of interest is defined using rectangular frame. Then the tracked object is separated from the background. It uses translation and scaling to track the object motion. This method can deal with partially occluded objects. The simple vector machine uses training set of values. These training values are positive or negative, positive values contain tracked object and the negative sample contains the values which are not tracked. In Layering based tracking multiple objects can be tracked. Ellipse is used to represent the shape of the object and uses layer appearance based on the intensity. The background motion of the object is compensated and then the each pixels probability based on the foreground motion is estimated. This method can deal with full occlusion problem [13].

3. Silhouette Tracking:

This method generates an object model based on the previous frame. Using these object model the object from each frame is find out. This model can be in the form of a color histogram, object edges or the object contour. Histograms of color and edges can be used as the object models. This method models the object appearance by the edge information obtained inside the object silhouette to match silhouettes in consecutive frames [1].

A. Contour Tracking

Contour tracking methods, iteratively progress a primary contour in the previous frame to its new position in the current frame. This contour progress requires that certain amount of the object in the current frame overlay with the object region in the previous frame. Contour Tracking can be performed using two different approaches. The first approach uses state space models to model the contour shape and motion. The second approach directly evolves the contour by minimizing the contour energy using direct minimization techniques such as gradient descent. The most significant advantage of silhouettes tracking is their flexibility to handle a large variety of object shapes [12].

B. Shape Matching

These approaches examine for the object model in the existing frame. Shape matching performance is similar to the template based tracking in kernel approach. Another approach to Shape matching is to find matching silhouettes detected in two successive frames. Silhouette matching, can be considered similar to point matching. Detection based on Silhouette is carried out by background subtraction. Models object are in the form of density functions, silhouette boundary, object edges. Capable of dealing with single object and Occlusion handling will be performed in with Hough transform techniques [12].

IV. SUMMARY

In this paper various phases of object tracking system viz. object detection, object classification and object tracking has been studied. Available methods for these phases have been explained in details and a number of shortcoming and limitations were highlighted in each and every technique. Different methods for object detection are frame difference, optical flow and background subtraction. Object tracking can be performed using various methods like Kalman filter, particle filter and multiple hypothesis tracking. It can be summarized background subtraction is a simplest method providing complete information about object compared to optical flow and frame difference for detecting objects. Kalman filters can be used to track single or multiple objects. MHT can track multiple objects and can handle occlusion. Kernel based approach can track single objects and can handle partial occlusion. Silhouette tracking can handle variety of objects shapes and can handle occlusion. It can also deal with object split and merge. Advance study may be carried out to include find efficient algorithm to reduce computational cost and to decrease the time required for tracking the object for variety of videos containing diversified characteristics.

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AUTHOR(S) PROFILE

Ms. Bhawale Priyanka S. received the B.E. Degree in Information Technology and is pursuing M.E. degrees in Computer Engineering GHRCOE, Chas, Ahmednagar, She is working at Dr. N.J.P.I.T. College of Polytechnic.

Mrs. Ruhi R. Kabra Department of Computer Engineering, GHRCOE, Chas, Ahmednagar, Savitribai Phule Pune University.

