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Overview Of Video Object Tracking System

Ms.Kavita Borse[1], Prof.Rupali Nikhare[2]
[1,2]Computer Engineering, Pillai Institute of Information Technology, Mumbai

Abstract— The goal of video object tracking system is segmenting a region of interest from a video scene and keeping track of its motion, positioning and occlusion. There are the three steps of video object tracking system those are object detection, object classification and object tracking. Object detection is performed to check existence of objects in video. Then the detected object can be classified in various categories on the basis on their shape, motion, color and texture. Object tracking is performed using monitoring object changes. This paper we are going to take overview of different object detection, object classification and object tracking techniques and also the comparison of different techniques used for various stages of tracking.

I. INTRODUCTION

Videos are the sequences of images or frame which are displayed in fast frequency so that human eyes can visualize the continuity content. All image processing techniques can be applied to individual frames. In addition to, the contents of two consecutive frames are usually closely related. There are basically, three steps of object tracking which are given in Figure.

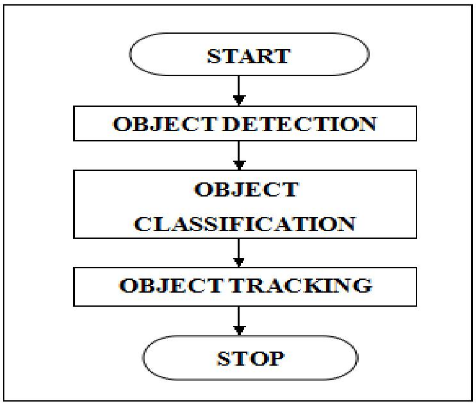

Figure 1. Basic Step for video object Tracking

A. Object Detection

Object Detection is to identify objects in the video sequence and cluster pixels of these objects. Object detection can have various techniques such as frame differences, Optical flow and Background Subtraction.

B. Object Classification

After the object detection we have to classify the object on the basis of their shape, motion, color and texture. There are some approaches of classification methods such as Shape-based classification method, Motion-based classification method, Color based classification method and Texture based classification method.

C. Object Tracking

Track or observe the moments of a particular object in every frame. The approaches to track the objects are point tracking, kernel tracking and silhouette based tracking.
The challenges that should be taken care in video object tracking are described below:

- Noise in an image
- Difficult object motion
- Imperfect and entire object
- Occlusions Complex objects structures

Now we are going to discuss all these three steps in detail.

II. OBJECT DETECTION TECHNIQUE

First step in the process of object tracking is to identify objects of interest in the video sequence and to cluster pixels of these objects. Find the region of interest of user. Detailed explanation for various methods is given below.

A. Frame Differencing

In this technique the moving objects is determined by calculating the difference between two consecutive images or frames. As shown in Figure the result of object detection using frames difference method.

Figure 2. (a) Original Frame

Figure 2. (b) Frame Difference Method

Frame Differencing deals with:

- Its calculation is simple
- Easy to implement
- For dynamic environments, it has a strong adaptability, but it is generally difficult to obtain complete outline of moving object, as a result the detection of moving object is not accurate

B. Optical Flow

Optic flow is a useful for tracking objects which are in motion. Optical flow method is to calculate the image optical flow field and then do clustering processing according to the optical flow distribution characteristics of image. This basic method in this context is called optical flow, which reflects the image changes during a time interval

Optical Flow deals with:

- Using this method we can get the complete movement information.
- It detect the moving object from the background better
- Require the large quantity of calculation
- Sensitivity to noise
- Poor anti noise performance

- It is not suitable for real-time demanding occasions

C. Background Subtraction

First step for background subtraction is background modeling. Background Modeling is to yield reference model. The reference model is used in background subtraction in which each video sequence is compared against the reference model to determine possible Variation or changes in the frames. The variations between current video frames to that of the reference frame in terms of pixels signify existence of moving objects. Figure shows the Result of background subtraction.

Figure 3. Result of Background Subtraction

Background Subtraction deals with:

- Simple algorithm
- It is very sensitive to the changes in the external environment
- Poor anti- interference ability

III. OBJECT CLASSIFICATION

The detect moving region may be different objects such as vehicles, birds, humans, floating clouds, swaying tree and other moving objects.

A. Shape-Based Classification

It is simply a pattern matching. The different descriptions of shape information such as representations of points, box and blob are available or stored for classifying moving objects. Input is a mixture of image-based and scene-based object parameters such as image blob area, box .Classification is performed on each blob or region at every frame and results are kept in histogram.

B. Motion-Based Classification

To detect the moving object motion based classification used. Optical flow is also useful for object classification. Residual flow can be used to analyze rigidity and periodicity of moving entities.

C. Color-Based Classification

Color is relatively constant under viewpoint changes and it is easy to be acquired but color is not appropriate for detecting and tracking objects, but for the low computational cost of the algorithms proposed makes color a desirable feature to exploit when appropriate. To detect and track vehicles in real-time color histogram based technique is used.

D. Texture-Based Classification

Texture based technique counts the occurrences of gradient orientation in localized portions of an image is computed on a dense grid of uniformly spaced cells and uses overlapping local contrast normalization for improved accuracy. Texture is a degree of intensity dissimilarity of a surface which enumerates properties such as smoothness and regularity.

IV. VIDEO OBJECT TRACKING METHODS

The purpose of an object tracking is to generate the route for an object above time by finding its position in every single frame of the video. The jobs of detecting the object and creating correspondence between the object occurrences through frames can either be accomplished separately or jointly. In the first stage, Region of interest (ROI) in each frame is determined by means of an object detection algorithm and then tracking corresponds to objects in every frame. In final stage, the object region is projected by iteratively updating object location obtained from previous Frames. Object Tracking is generally categorized as:

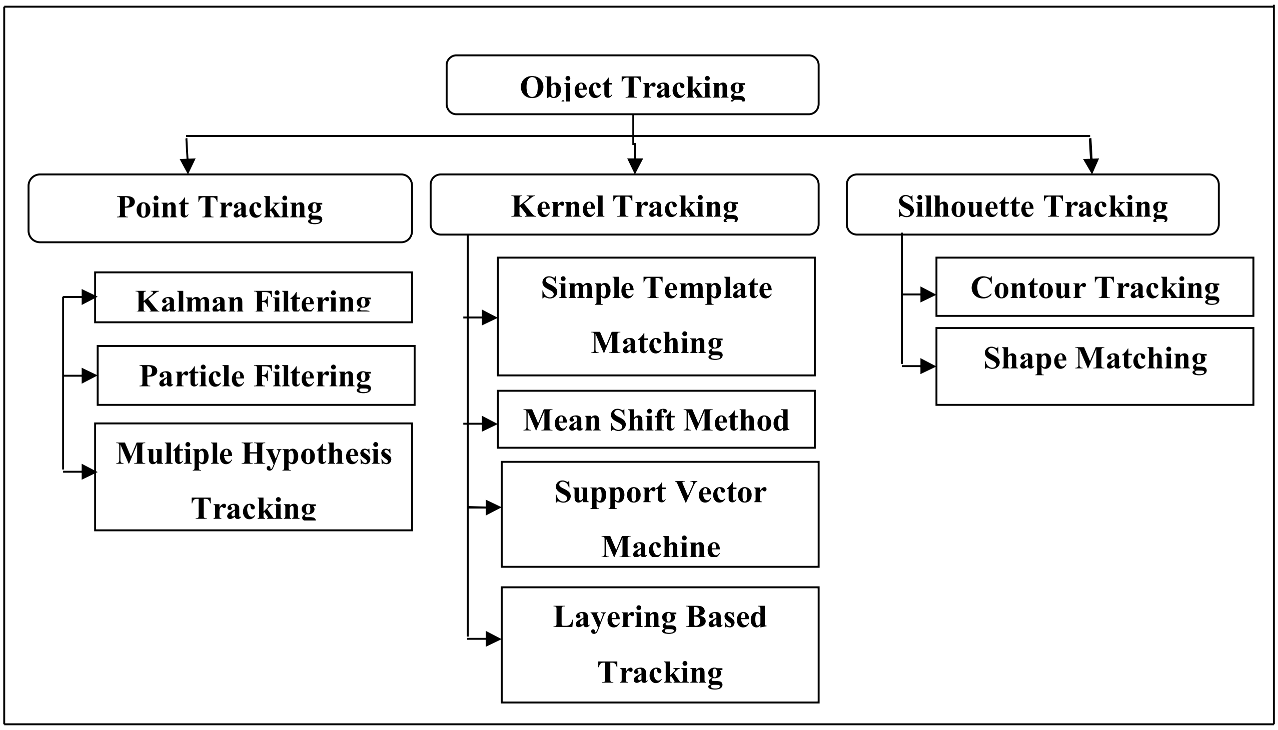

Figure 4. Categorization of Object Tracking

Now we are going to discuss in detail about each tracking approaches and their functionality of object tracking, merits and demerits.

A. Point Tracking Approach

In this, the moving objects are represented by their feature points during tracking. Point tracking is a complex problem particularly in the incidence of occlusions and false detection of object.

Point Tracking deals with:
It is simple
Useful for tracking very small objects.
Some approaches based on point tracking are as follows:

- **Kalman Filter**

Kalman filter is based on Optimal Recursive Data Processing Algorithm. In other words, they are tracked based on the criteria chosen to evaluate performance. Optimal point will be taken based on criteria that make sense.

The Kalman Filter performs the restrictive probability density propagation. They composed of two phases, prediction and correction. Prediction of the next state using the current set of observations and update the current set of predicted measurements. The second step is gradually update the predicted values and gives a much better approximation of the next state. Showed clearly in figure.

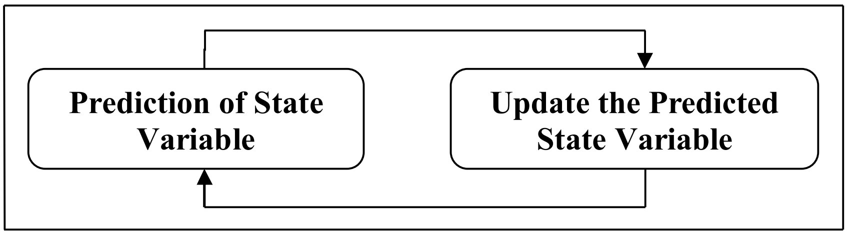

Figure 5.Basic Steps of Kalman Filter

The result of kalman filter is as shown in figure 6. (a) Shows the initial position of frame and figure 6. (b) Shows the result of kalman filter.

Figure 6. (a) Original Frame

Figure 6. (b) Result of Kalman Filter Method

Kalman Filter deals with:

- It gives optimal solutions.
- Handling noise
- Tracking is applicable only for single

- **Particle Filter**

This generates all the models for one variable before moving to the next variable. Algorithm has an advantage when variables are generated dynamically and there can be confoundedly numerous variables. It also allows for new operation of re sampling. One restriction of the Kalman filter is the assumption of state variables are normally distributed (Gaussian). Thus, the Kalman filter is poor approximations of state variables which do not Gaussian distribution. This restriction can be overcome by the particle filtering. It also consists of two phases: prediction and update as same as Kalman Filtering.

- **Multiple Hypothesis Tracking (MHT)**

If motion correspondence is recognized using only two frames, there is always a limited chance of an incorrect correspondence. Better tracking outcomes can be acquired if the correspondence choice is overdue until several frames have been observed. The MHT algorithm upholds several correspondences suggestions for each object at each time frame the final track of the object is the most likely set of correspondences over the time period of its observation.

MHT is an iterative algorithm. Iteration begins with a set of existing track hypotheses. Each hypothesis is a group of disconnect tracks. each hypothesis, a prediction of object's position in the succeeding frame is find and the predictions are then compared by calculating a distance measure.

Multiple Hypothesis Tracking deals with:

- Tracking multiple object
- It also handles occlusions.

- Calculating of optimal solutions.

B. Kernel Based Tracking Approach

Kernel tracking is usually performed by computing the moving object, which is represented by geometric shapes like rectangle and ellipse. But one of the restrictions 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 rigid and non-rigid objects .They are large tracking techniques based on representation of object, object features ,appearance and shape of the object.

There are a variety of tracking methodologies present based on this Kernel tracking approach:

- **Simple Template Matching Method**

Template matching is a brute force method of examining the ROI in the ongoing video, a simple way of tracking wit reference image. Here in template matching, a reference image is verified with the frame that is separated from the video. It can track only single object in the video. Translation of motion only can be done in template matching. As shown in figure here the reference image is taken from the video and they are compared with the successive Frames in the video.

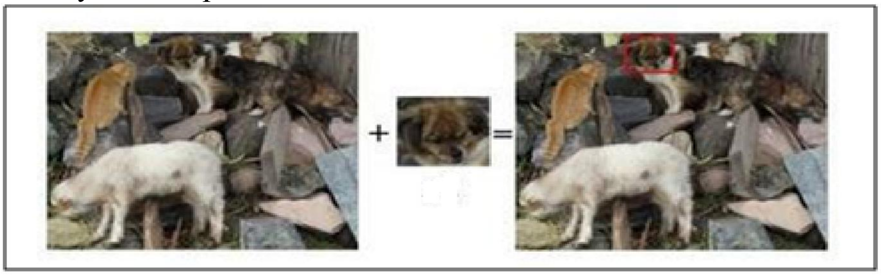

Figure 7.Simple Template Matching

Simple Template Matching deals with:
- Tracking single object.
- Partial occlusion of object

- **Mean Shift Method**

The task is to first define an Region of Interest (ROI) from moving Object by segmentation and then tracking the object from one frame to next. Region of interest is defined by the rectangular window in an initial frame. Tracked object is separated from background by this algorithm. The accuracy of target representation and localization will be improved by Chamfer distance transform. Minimizing the distance among two color distributions using the Bhattacharya coefficient is also done by Chamfer distance transform. In tracking an object, we can characterize it by a discrete distribution of samples and kernel is localized.

Steps for Mean shift tracking
Probabilistic distribution of target in first frame is obtained using color feature.
Compare the distribution of first frame with consecutive frame.
Bhattacharya coefficient is used to find the degree of similarity between the frames.
Loop will continue till the last frame.
Mean Shift Method deals with:
- Tracking only single object.
- Object motion by translation and scaling.
- Necessity of a physical initialization.
- Object is partial occlusion.

In the Figure 8. (a), the initialization or selection of the object of interest was performed. After that Figure 8. (b), (c) show how the Mean-shift algorithm tracks the vehicle. It shows that the tracking window is not centered on the object of interest. Then we can observe that this tracking window lost its object. This is also evident by referring to Figure 8. (c).

Figure 8. (a) Initialize ROI

Figure 8. (b) Start to Track the Object

Figure 8. (c) Mean Shift Method Lost ROI

- **Support Vector Machine (SVM)**

SVM is a broad classification method which gives a set of positive and negative training values. For SVM, the positive samples contain tracked image object and the negative samples consist of all remaining things that are not tracked. During the analysis of SVM, score of test data to the positive class.

As shown in figure SVT takes as input the initial guess of the position of the vehicle (dashed rectangle) and finds the position with the highest SVM score (solid rectangle).

Figure 9.Support Vector Machine (SVM)

Support Vector Machine is capable of dealing with:

- Tracking single image
- Partial occlusion of object
- Necessity of training
- Object motion by translation

- **Layering Based Tracking**

This is another method of kernel based tracking where multiple objects are tracked. Each layer consists of shape representation such as ellipse, rectangle, and motion such as translation and rotation and layer appearance based on intensity.

Layering Based Tracking deals with:

- Tracking multiple images
- Fully occlusion of object

- Object motion by translation, scaling and rotation

C. Silhouette Based Tracking Approach

Objects having composite shapes such as hands, head, and shoulders, are cannot defined by geometric shapes. Silhouette based approaches will afford a perfect description of shape for those objects. The aim of a Silhouette based object tracking is to find the object region by means of an object model .This model is verifying the object region in each frames. Model can be represented by a histogram, object edges or contour.
Silhouette tracking classify into two categories, contour tracking and shape matching.

▪ Contour Tracking

Contour tracking methods, in divergence to shape matching methods, iteratively develop an original contour in the foregoing frame to its new position in the present frame, overlapping of object between the current and next frame. Contour tracking is in form of State Space Models. State Space Models: State of the object is named by the parameters of shape and the motion of the contour. The state is updated for each time according to the maximum of probability.

In Contour Tracking, explicitly or implicitly are used for the representation on silhouette tracking. Representation based on explicitly will defines the boundaries of silhouette whereas in case of implicitly, function defined by grid. Contour evolution: iteratively evolve an initial contour in the previous frame to its new position in the current frame. This technique or method requires that some part of the object in the current frame overlaps with the object region in the previous frame.

Contour Tracking is capable of dealing with:

- Handling of large variety of object shapes easily
- Handling Occlusion
- Dealing with object split and merge

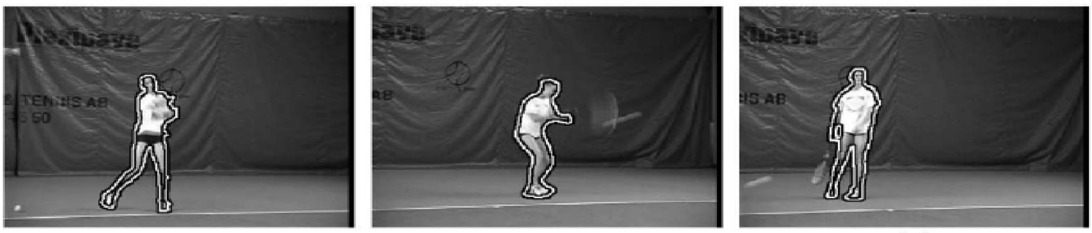

Figure 10. Contour Tracking

D. Shape Matching

These approaches examine for the object in the existing frame. Shape matching is similar to the template based tracking in kernel tracking approach. Shape matching is to find matching silhouettes detected in two successive frames. Silhouette matching is similar to point matching. in the Silhouette tracking detection is based on background subtraction. Object are in the form silhouette boundary or object edges.

Shape Matching is capable of dealing with:

- Edge based template, Silhouette tracking feature of shape matching are able to track only single object.
- Occlusion handling performed in with Hough transforms techniques.

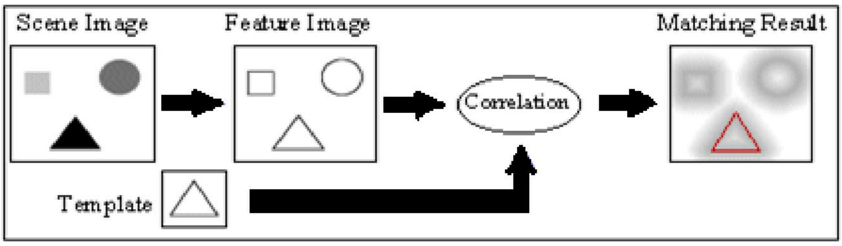

Figure 11. Shape Matching

IV. COMPARISION OF ALL TRACKING TECHNIQUES

The advantages and disadvantages of different video object tracking methods is as shown in the Table 1. The parameters for the comparison are category, number of object tracking, optimal result and need of training rules.

Table 1. Comparison of the Various Video Object Tracking Methods

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

V. APPLICATIONS

Some of the tracking applications are:

A. Computerized video surveillance

The movements or action in particular an area are monitored by automated vision system.

B. Robotic vision

To recognize different obstacles in the path to avoid overlapping. Point tracking method is used in the object vision.

C. Traffic monitoring

In specific countries highway traffic is constantly observed using cameras. The surveillance system is supported by an object tracking system, to identify the breaking rules made of vehicles or any other unlawful act. Here the optic flow object tracking method is used.

D. Animation

Object tracking algorithm can also be prolonged for animation.

E. Gesture Identification

Identification of human parts like eye, hand, and face etc.The contour matching method is used.

IV. CONCLUSION

Object is tracked mainly on the bases of object detection, object classification, tracking and decisions about activities. We mainly classifies object tracking approach as point tracking, kernel based tracking, and silhouette based tracking. In the object detection, Frame differencing, optical flow and the background subtraction methods, Frame differencing provide High accuracy, Low computational time also it is the Easiest Method and Perform well for static background.

In the object classification, Texture based and color based are widely used because they provide higher accuracy and Provides improved quality with the expense of additional computation time. In the tracking technique the point trackers involve detection in every frame, while geometric area or kernel based tracking or contours-based tracking require detection only when the object first appears in the scene. Contour based Tracking will track multiple object with fully overlapping and flexibly also it handle the occlusion and provide the optimal result.

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