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Systematic Survey on Object Tracking Methods in Video

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Abstract

Object tracking in video structures is one of the important ongoing exploration areas in the field of computer vision. The aim of object tracking is to find an object of a pre-defined class in a video frame.Video structures consists of multiple frames and huge facts, hence video tracking is a time overriding procedures. Tracking is nothing but identification of interest, especially on tracking of moving vehicles or walkers. In event of any strange actions, an attentive should be provided. Normally a video tracking system combines three stages of data treating: object extraction, object recognition and tracking, and decisions about activities. In this paper, we analysis various object tracking techniques.

Key Terms – Object extraction, Object recognition, Object tracking, Occlusions, Object Model.

I. Introduction

Object tracking can be defined as the method of segmenting a region on interest from a video scene and keeping track of its motion, positioning, occlusion etc. in order to extract worthwhile evidence[1]. To generated interest idea in object tracking algorithms by high-powered computers, the availability of high quality video cameras. There are three basic phases in video examination: detection of interesting objects in video scene, tracking of such objects from frame to frame, and analysis of object tracks to recognize their activities.

Fig 1 : Basic Tracking and recording

Tracking can be defined as the problem of approximating the path of an object in the image plane as it moves around a scene.

Tracking can be challenging because of:

- Loss of evidence caused by estimate of the 3D realm on a 2D image,
- Noise in an image,
- Difficult object motion,
- Imperfect and entire object occlusions,
- Complex objects structures.

Several methods for object tracking have been surveyed and they are classified according to the tracking behavior.

Classification is based on:

- Which Features of image should be used?
- How should the motion, appearance, and shape of the object be showed?.

The goal of this survey is to cluster tracking techniques into broad classifications and provide inclusive descriptions of illustrative methods in each classification [2].

Some of the tracking applications are:

- Motion-based identification: recognition of an object based on motion in a categorisation of images.
- *Automatic surveillance* in public places for unusual events.
- *Traffic observing* for monitoring traffic stream.
- *Gesturing identification* of human parts like eye.

II. Features for Object Tracking

Selecting the accurate features plays a critical part in tracking. Feature selection is strictly associated to the object representation. For instance, color is used as a feature for histogram-based representations, whereas for contour-based representation, object edges are usually used as features

1. *Colour*: All video frame formats are based on different colour spaces model. The data of different frame can be stored in dissimilar colour spaces ranging from gray scale, RGB, YCbCr and HSV colour

spaces. The data that is stored in each frame is the brightness in each spectral band. Colour images are denoted as red (R), green (G) and blue (B) layers or RGB. Other distinctive colour spaces used in the area of Object tracking are YCbCr and HSV [3].

2. *Edges:* Object boundaries are frequently generates strong changes in image intensities. These changes are identified by Edge detection. A key property of edges is that they are less sensitive to illumination changes compared to color features. Most of the algorithm will be using edge as main agent in object tracking.

3. *Texture:* Texture is a degree of intensity dissimilarity of a surface which enumerates properties such as smoothness and regularity. Compared to color space model, texture requires a processing step. On basis of color, the texture features are less sensitive to illumination changes as same as to edge features.

III.Classification of Object Tracking

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 attained by means of an object detection algorithm, and then tracking corresponds to objects across frames. In final stage, the object region is projected by iteratively updating object location obtained from previous frames [2]. Object Tracking is generally categorized as:

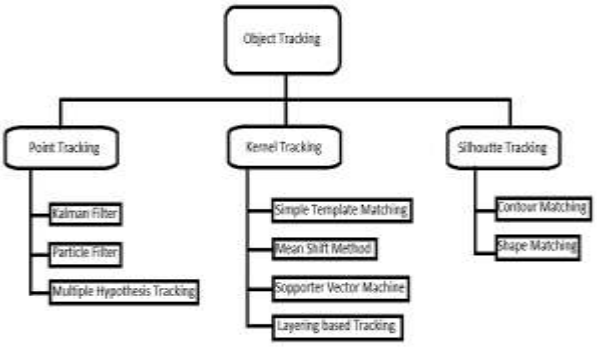

Fig 2: Object Tracking Methodologies.

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

1. Point Tracking Approach

Explanation:

It is a regular task of computer vision with abundant applications. In an image structure, moving objects are represented by their feature points during tracking [6]. Point tracking is a complex problem particularly in the incidence of occlusions, false detections of object [3].Recognition can be done relatively simple, by thresholding, at of identification of these points. [5]

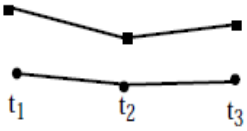

Fig 3: The lines represent the point correspondences in time

The cost of correspondences is mainly by *Kinematic limits*.

- *Proximity* assumes the position of the object will not change especially from one frame to other(see Figure 4(a)).
- *Extreme velocity* limits the possible correspondences to the neighborhood around the object in circular manner (see Figure 4(b)).
- *Minor velocity change* (even motion) assumes the direction and speed of the object does not change hugely (see Figure 4(c)).
- *Mutual motion*: velocity of objects in a small neighborhood to be similar wit regular interval of duration.(see Figure 4(d)). This constraint is appropriate for objects represented by multiple points [2].

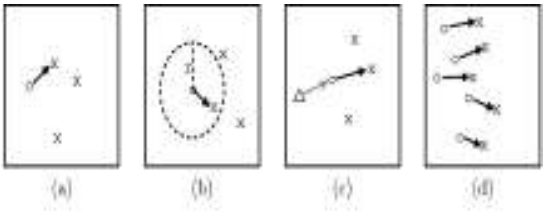

Fig 4: Kinematic Limit.

Point Tracking is capable of dealing with:

- Appropriate for tracking very small objects.

We are going to deliberate about some approaches based on point tracking.

(a). Kalman Filter :

Explanation:

They are 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 [7].

` 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 5.

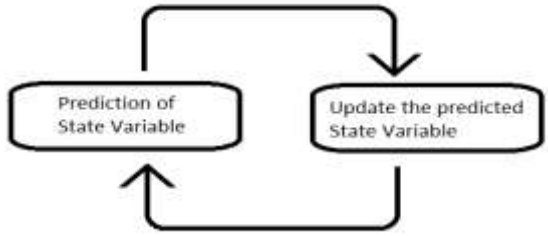

Fig 5 .Basic steps of Kalman Filter

The Kalman filter attempts to discover a balance between predicted values and noisy measurements. The value of the weights is determined by modeling the state equations. The determination of the Kalman filter is to track the system being measured at discrete intervals of time[8].

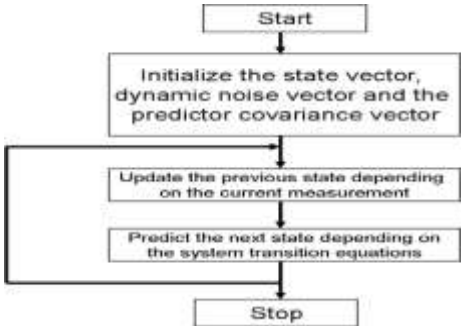

Fig 6:Algorithm for Kalman Filter

Kalman Tracking is capable of dealing with:

- Kalman filters always give optimal solutions.
- Another potential approach is to handling noise
- Tracking is applicable only for single and multiple object [2][8].

(b) Particle Filter:

Explanation:

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 unboundedly numerous variables. It also allows for new operation of resampling [10].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 overwhelmed by using particle filtering [8].

This algorithm usually uses contours, color features, or texture mapping. The particle filter is a Bayesian sequential importance Sample technique, which recursively approaches the later distribution using a finite set of weighted trials.

It also consists of fundamentally two phases: prediction and update as same as Kalman Filtering. It was developing area in the field of computer vision communal and applied to tracking problematic and is also known as the Condensation algorithm [9]

In the method of staring with population of particle, each will assign value to no variables and weight of 1.

At each step, the procedure will be:

- Select a variable that has not sampled. For each particle, it samples the variable according to some proposal distribution. The weight of the particle is reorganized as in importance sampling.
- Select a piece of evidence to absorb which is not absorbed previously. Weight of the particle is increased
- Population should be resampled. Resampling creates a new population of particles, each with the similar weight. Some particles may be elapsed or repeated [10].

(c) Multiple Hypothesis Tracking (MHT):

Explanation:

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 crew of disconnect tracks. For each hypothesis, a prediction of object's position in the succeeding frame is made. The predictions are then compared by calculating a distance measure.

MHT is capable of dealing with:

- Tracking multiple object
- Ability to tracks for objects entering and exit of Field Of View (FOV).
- It also handles occlusions.
- Calculating of Optimal solutions [2].

2. Kernel Based Tracking Approach:

Explanation:

Kernel tracking is usually performed by computing the moving object, which is represented by a embryonic object region, from one frame to the next. The object motion is usually in the form of parametric motion such as translation, conformal, affine, etc.

These algorithms diverge in terms of the presence representation used, the number of objects tracked, and the method used for approximation the object motion [2].In real-time, illustration of object using geometric shape is common. 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 be detected in rigid and non-rigid objects .They are large tracking techniques based on representation of object, object features ,appearance and shape of the object.[11].

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

(a)Simple Template Matching:

Explanation:

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.

Capable of dealing with:

- Tracking single image.
- Partial occlusion of object.
- Necessity of a physical initialization.

(b)Mean Shift Method:

Explanation:

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 amongst 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 [12].

Steps for kernel 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 [11].

Capable of dealing with:

- Tracking only single object.
- Object motion by translation and scaling.
- Necessity of a physical initialization.
- Object is partial occlusion [2].

(c) Support Vector Machine (SVM)

Explanation:

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

Capable of dealing with:

- Tracking single image.
- Partial occlusion of object.
- Necessity of a physical initialization.

- Necessity of training.
- Object motion by translation.

(d) Layering based tracking:

Explanation:

This is another method of kernel based tracking where multiple objects are tracked. Each layer consists of shape representation (ellipse), motion such as translation and rotation, and layer appearance, based on intensity. Layering is achieved by first compensating the background motion such that the object's motion can be estimated from the rewarded image by means of 2D parametric motion. Every pixel's probability of calculated based on the object's foregoing motion and shape features.

Capable of dealing with:

- Tracking multiple images.
- Fully occlusion of object.
- Object motion by translation, scaling and rotation

3. Silhouette Based Tracking Approach:

Explanation:

Objects having composite shapes, for example, hands, head, and shoulders, are cannot be well 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 in the form of a color histogram, object edges or contour.

We classify silhouette tracking into two categories, namely, shape matching and contour tracking.

Capable of dealing with:

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

(a)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.

(b)Shape Matching:

Explanation:

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 which is described in (Section 1).

Detection based on Silhouette is carried out by background subtraction. Models object are in the form of density functions, silhouette boundary, object edges.

Type of racking	Region	Appearance features
Silhouette Tracking	Complete	Object model
Point Tracking	Points	position-based

Table 1: Comparing table for Silhouette and Point Tracking

Capable of dealing with:

- *Edge based template, Silhouette* tracking feature of shape matching are able to track only single object.
- Occlusion handling will be performed in with Hough transform techniques [2].

s.no	Methodology	Category	Reference	#	Entry	Exit	Occlusion	Optimal	Training rule
1	Kalman filter	Point tracking	[2]	S	√	√	x	√	-
2.	MHT	Point Tracking	[2]	M	√	√	√	√	-
3.	Particle Filter	Point Tracking	[13]	M	x	x	√	√	-
4.	Template matching	Kernel Tracking	[2]	S	-	-	P	-	x
5.	Mean shift	Kernel Tracking	[2,11]	S	x	x	P	-	x
6.	SVM	Kernel Tracking	[2]	S	-	-	P	-	√
7.	Layering based tracking	Kernel Tracking	[2]	M	-	-	F	-	x
8.	Shape matching	Silhouette tracking	[2]	S	-	-	x	-	x
9.	Contour matching	Silhouette tacking	[2]	M	-	-	F	√	√

Table:1 Qualitative Comparison for Tracking methodologies.(**#**:no of objects tracking, **S**:single,**M**:multiple,**P**:partial,**F**:full, Symbols √ and × denote whether the tracker can or cannot handle occlusions, and requires or does not require training).

IV. Conclusion:

In this paper, we present a widespread survey of object tracking methods. Object is tracked mainly on the bases of *object extraction, object recognition and tracking, and decisions about activities.* We mainly classifies object tracking approach as *point tracking, kernel based tracking, and silhouette based tracking.* For illustration, 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. We trust that, this article can give valued vision into this significant research topic and encourage new research.

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