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A Review on Object Detection and Tracking Methods

Keerthana T[1], Kala L[2]

P.G. Student, Department of Electronics and Communication Engineering, NSS College of Engineering, Palakkad, India[1]

Associate Professor, Department of Electronics and Communication Engineering, NSS College of Engineering, Palakkad, India[2]

ABSTRACT: Videos and images reveal many interesting and useful information, which can serve the humankind in many ways. Researchers and professionals are motivated in studying and exploring the information in static and dynamic environment. There are many models built to detect and track the movement of the object, each one of the models built has its own advantages and limitations. A review has done to know the merits and demerits of the methods or techniques used in detection and tracking the objects in video frames. In many application of computer vision, object tracking is very essential task such as surveillance, vehicle navigation, autonomous robot navigation, etc. It involves the detection and tracking of interesting moving objects frame to frame. Its main task includes finding and following a moving object or multiple objects in image sequence or frames. Generally, there are three stages of video analysis; object detection, object tracking, and object classification. This paper present a brief survey of various video object detection and tracking techniques like frame differencing ,optical flow ,background subtraction, point tracking, kernel tracking and Silhouette tracking algorithms. In addition, it presents Comparative study of all the techniques

KEYWORDS: Object tracking, point tracking, kernel tracking, and silhouette

I. INTRODUCTION

One of the important and challenging task in the field of computer vision is object tracking. The rising need for automated video analysis and development of high-powered computers, and the availability of high quality and inexpensive video cameras has originate a great deal of interest in object tracking algorithms .Automation of Detection and Tracking system is very useful in many applications like in biomedical, security, identification of threats, unauthorized intruders in defence and navy. Many algorithms are available to track the moving object in static and dynamic conditions. Static method does not pose major problem as compared to the dynamic condition. In static environment conditions, background will be stationary throughout the video and the fore ground goes on changing its position in the video frame. The fore ground can be a single or multiple objects, detected and then tracked from initial frame. Videos consists of subsequent images (frames) which can move fast enough. So that, human eyes realize them continuously. All image-processing techniques usually applied on individual frames. Besides, the contents of two successive frames are usually closely related [1]. Videos with natural scenes are usually composed of several dynamic entities .Objects of interest often move along complicated backgrounds that are themselves moving in dynamic conditions. Hence, both the background and the fore ground will have motion. The differentiation of both the background and the fore ground is very difficult. Therefore, in many practical computer visions system assumes for a fixed camera environment, which can make the object detection process more straight forwarded [3].

Many issues have are considered before the object is decided as moving object in dynamic environment. A complete observation is obtained whether an object is moving or not from the video frame sequence. The other difficulty, in tracking is the problem of object occlusion. Now, for any processing videos we need frame-by-frame analysis. The three step includes Detection of object, tracking of that object, Analysis of that object.

Object tracking in video is the process of estimating the trajectory of an object in the image plane as it moves around a scene [15]. It involves the process of segmenting a region of interest of an object from a video scene and keeping

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track of its motion, orientation, occlusion etc. Moreover, depending on the tracking methods, a tracker can also give object-centric information, such as orientation, region, or silhouette of an object. Video object detecting and tracking has a wide variety of applications in video processing such as video compression, video surveillance, vision-based control, human computer interfaces, medical imaging, augmented reality, and robotics.

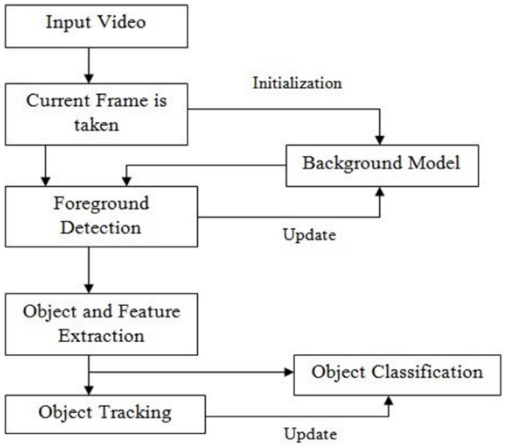
Selection of tracking algorithm can be done based on object representation, feature, object detection technique and object tracking algorithm. Most Common approaches of object representation includes points, primitive geometric shapes, Object silhouette and contour, articulated shape models, skeletal models. The common visual features considered for it are colour, textures, optical flow and edge. Major object detection methods are point detectors, frame differencing, background subtraction, segmentation, supervised learning.

II. RELATED WORK

In paper [4] an improved multiple human object tracking method is used based on motion estimation and detection, background subtraction, shadow removal and occlusion detection. The algorithm works efficiently in the event of occlusion in the video sequences. In paper [5] a tracking algorithm based on adaptive background subtraction about the video detecting and tracking moving objects representation. Firstly, median filter is to achieve the background image of the video and denoise the sequence of video.Then adaptive background subtraction algorithm, finds out detect and track the moving objects. In Paper [6] the moving objects are detected by subtracting the background images from static single camera video sequences in security systems. It tries to improve the background subtraction techniques for indoor video surveillance applications. Finally, compares with the existing methods. Paper [7] illustrates a new algorithm for detecting moving objects from a static background scene, which finds out moving object based on background subtraction. On statistical basis, a reliable background-updating model is used.

III. STEPS INVOLVED IN OBJECT TRACKING

The main task of object tracking is to foreground object detection, object classification and moving object tracking



. Figure 1: basic flowchart

A. *FOREGROUND OBJECT DETECTION:*

The first step in the process of object tracking is to find out the objects of interest in the video sequence and to cluster the pixels of these objects. Since moving objects are the primary source of information, most methods focus on the detection of such objects. Object detection includes the following methods: frame differencing, optical flow, and background subtraction.

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1. Frame differencing

The presence of moving objects are determined by calculating the difference between two consecutive images or frames. In this method, a background image without any moving objects act as reference image. Pixel value for each co-ordinate (x, y) for each colour channel of the background image usually subtracted from the corresponding pixel value of the input image. If the resulting value is greater than a particular threshold value, then that is foreground pixel otherwise, background .Its calculation is simple and easy to implement. For dynamic environments, this method has a strong adaptability. However, it generally fails to obtain complete outline of moving object. Since the detection of moving object is not as accurate because of the changes taking place in the background brightness that cause misjudgement [7].

2. Optical flow :

Optical flow [1] method calculates the image optical flow field, and perform clustering processing according to the optical flow distribution characteristics of image.
This method can get the complete picture of moving information and detect the moving object from the background much better and efficiently, however, a large quantity of calculation, sensitivity to noise, poor anti-noise performance, which makes it unsuitable for real-time demanding occasions.

3. Background subtraction:

Background modelling is the first step for background subtraction. It acts as the core of background subtraction algorithm. Background Modelling must be sensitive enough to recognize moving objects [10]. Background modelling yields reference model. This reference model is used in background subtraction where each video sequence is compared against the reference model to determine extend of possible Variation. The variations between current video frames and to that of the reference frame in terms of pixels signifies existence of Moving objects [10]. At present, mean filter and median filter [2] are widely used to realize background modelling. In background subtraction method, difference between the current image and background imageanalysed to detect moving objects. It is a simple algorithm, but very much sensitive to the changes in the external environment and has low anti- interference ability. However, it can provide the complete object information if background is known. Background subtraction have mainly two approaches [11]:

1) Recursive algorithm
2) Non-recursive algorithm

(i) Recursive algorithm:
Recursive techniques [11] [6] usually do not maintain a buffer for background estimation.

1) Approximate median method

The running estimate of the median is incremented by one if the input pixel is larger than the estimate, and decreased by one if it is smaller. The disadvantage of this method is that it does not provide smoother results in all conditions [16].

2) Adaptive background method

This method depends on gain value. Typical value of gain values $\alpha = 0.1$ to 0.9 only. The main advantage of this algorithm is that the increased efficiency of the segmented results by the gain values. In addition, auto threshold is included in this method [16].

3) Mixture of Gaussians

The background model is parametric. A number (or mixture) represents each pixel location of Gaussian functions that sum together to form a probability distribution function. Even though the mixture of Gaussian method is complex and tedious, it provides better results by our modified parameters Instead, they recursively update a single background model based on each input frame. As a result, input frames from distant past could have an effect on the current background model. Compared with non-recursive techniques, recursive techniques require less storage, but any error in

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the background model can linger for a much longer period. This technique includes various methods such as approximate median, adaptive background, Gaussian of mixture [16].

ii. Non-recursive algorithms

A non-recursive technique [6] [11] uses sliding-window approach for background estimation. It stores a buffer of the previous L video frames, and estimates the background image based on the temporal variation of each pixel within the buffer.

1. Median filtering:

Median filtering is the commonly used technique to find foreground images. The pixel parameters minimum, maximum, and largest inter-frame absolute difference are used. The main advantage of this method is that, the computation speed is high.

TABLE 1
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 work 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 of the object
				- Requires Large amount of calculation
		High	Low to Moderate	+ Easiest Method. Perform well For static background.
				It requires a background - without moving objects

The table describes a about the comparison of different object detection methods with their accuracy and computational time required and its advantages and disadvantages over the other methods.

IV. OBJECT CLASSIFICATION

After the process of object detection, the extracted moving region may be different objects such as humans, vehicles, birds, floating clouds, swaying tree and other moving objects. Hence, we use the shape features of motion regions to classify it. [7] The approaches to classify the objects are as follows: Shape-based classification, Motion-based classification, Colour-based classification, Texture –based classification.

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i.Shape-based classification**:**

Different descriptions of shapes such as representations of points, box and blob are available for classifying moving objects. Input to the network is mixture of image based and scene-based objectparameters such as apparent aspect ratio of blob bounding box, image blob area, and camera zoom. On each blob at every frame, does the classification and results are kept in histogram [14].

ii. Motion-based classification:

Non-rigid articulated object motion shows a periodic property, which is used as a strong cue for moving object classification. Optical flow is also or object classification.it considers the residual flow i to analyse periodicity and rigidity periodicity of moving entities. It is expected that rigid objects would present little residual flow where as a no rigid moving object such as human being had higher average residual flow and even displayed a periodic component[14].

iii. Colour-based classification:

Unlike many other image features (e.g. shape) colour is generally relatively constant as viewpoint changes and easily acquired. Although colour is not an appropriate feature in detecting and tracking objects, but the low computational cost of the algorithms proposed makes colour a desirable feature to exploit when necessary. To detect and track vehicles or pedestrians in real-time colour histogram based technique is used. According to [2] it creates a Gaussian Mixture Model to specify the colour distribution within the sequence of images and to segment the image into objects and background. It handles object occlusion using an occlusion buffer.

iv. Texture-based classification

Texture based technique [8] accounts for the occurrences of gradient orientation in localized portions of an image. It computes on a dense grid of uniformly spaced cells. For improved accuracy, it uses overlapping local contrast normalization for improved accuracy.

TABLE 2
COMPARATIVE STUDY OF OBJECT CLASSIFICATION METHODS [8]

Methods	Accuracy	Computational Time	Comments
Shape-Based	Moderate	Low	Simple pattern-matching approach, with appropriate templates. It does not work well in dynamic situations and is unable to describe internal movements well.
Motion based	Moderate	High	Does not require predefined pattern templates but fails to find out a non-moving human.
Texture based	High	High	Provides improved quality but expensive due to additional computation time.
Colour-based	High	High	It create a Gaussian Mixture Model to find the colour distribution within the sequence of images and to segment the image into objects and background

The table describes a about the comparison of different object classification methods with their accuracy and computational time required and its advantages and disadvantages over the other methods.

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IV. OBJECT TRACKING

Tracking is the process of estimating the path of an object in the image plane as it moves around a scene. The aim of an object tracking is to describe the route of an object in specified time by finding out its position in every single frame of the video [5]. According to paper [10], Object tracking includes point tracking, kernel based tracking and silhouette based tracking. For illustration, in point, trackers involves the detection in every frame; while geometric area or kernel based tracking or contours-based tracking, it only does detection when the object first appears in the scene. As described in [10], tracking methods falls into following categories

A .Point Tracking Approach

During tracking in a moving structure, the representation of moving objects by their feature points. Point tracking [10] is a complex problem particularly when occlusions occurs, leads to false detections of object. Recognition is relatively simple, at of identification of these points by thresholding.

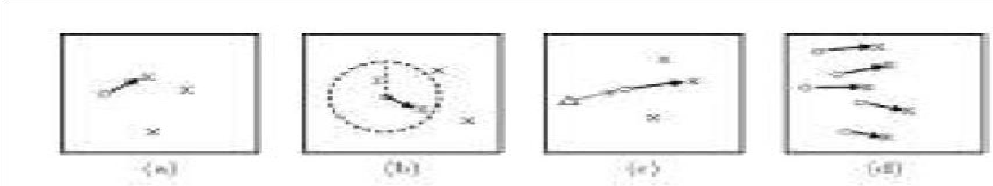

Figure 2: Point based tracking

1. Kalman Filter

It is a Optimal Recursive Data Processing Algorithm. The Kalman Filter undergoes the restrictive probability density propagation. Kalman filter [12] is a set of mathematical equations which gives an efficient computational (recursive) means to estimate the state of a process in several aspects such as: it supports estimations of past, present, and even future states, and it alse does the same even when the precise nature of the modelled system is unknown. The Kalman filter estimates a process generally by using a feedback control. The filter estimates the process state at some time and then gives back the feedback in the form of noisy measurements. Kalman filters equation falls into two groups: time update equations and measurement update equations. The time update equations are responsible for providing forward (in time) the current state and error covariance estimates acts as a priori estimate for the next time step. The measurement update equations are responsible for providing the feedback. Kalman filters always give optimal solutions. Kalman Tracking is capable of dealing with: Kalman filters always give optimal solutions. Another potential approach is to handling noises. Tracking is applicable for both single and multiple objects.

2. Particle Filter:

One of the drawback of Kalman filter is that the assumption of state variables are normally distributed (Gaussian). Thus, the Kalman filter is poor approximations of state variables that are not Gaussian distribution. The particle filtering can overwhelm this restriction. The particle filtering [10] creates all the models for one variable before moving to the next variable. Algorithm has an advantage over kalman filter is that when variables are generated dynamically and there can be unboundedly numerous variables. It also allows for new operation of resampling

This algorithm generally uses contours, colour features, or texture mapping. The particle filter is a Bayesian sequential importance Sample technique [10]. It recursively approaches the later distribution using a finite set of weighted trials. It also contains two fundamental phases: prediction and update as same as Kalman Filtering. It was developing advancement in the field of computer vision and another name is Condensation algorithm.

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3. Multiple Hypothesis Tracking (MHT):

In MHT algorithm [10], several frames has observed for better tracking outcomes.MHT is an iterative algorithm where each iteration begins with a set of already existing track hypotheses. Each hypothesis is viewed as a crew of disconnect tracks. For each hypothesis, does the prediction of object's position in the succeeding frame. The prediction there by 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

B. Kernel Based Tracking Approach:

In Kernel tracking [9], it computes the moving object, by an embryonic object region, from one frame to the next. The object motion is usually in the form of parametric motion such as translation, Affine, etc. These algorithms are diverge in terms of the presence representation used, the number of objects tracked, and the method used for estimation of object motion. In real-time, object illustration is commonly does using geometric shape. However, one of the major restrictions is that some parts of the objects remains outside of the defined shape while portions of the background may exist inside. This can be used to detect both rigid and non-rigid objects .They are large tracking techniques based on representation of object, object features ,appearance and shape of the object. Capable of dealing with: Tracking single image. Partial occlusion of object. Object motion by translation.

1. Simple Template Matching**:**

Template matching [9] [4] is a method of examining the Region of Interest in the video. In template matching, a reference image verifies with respect to the frame from the video. Tracking does for single object in the video and does overlapping of object is partially. Template Matching is a technique used or processing digital images to find small parts of an image that matches, or equivalent model with an image (template) in each frame. The matching procedure contains most of the image template for all possible positions in the source image and it then calculates a numerical index that specifies how well the model fits the picture for that position. It capable of dealing with: Tracking single image. Partial occlusion of object. Necessity of a physical initialization.

2. Mean Shift Method

Mean-shift tracking methods finds out the area of a video frame that is being locally most similar to a previously initialized model. The tracked image region is represented by a histogram .It uses a gradient ascent procedure to move the tracker to the location that maximizes a similarity score between the model and the current image region. In object, tracking algorithms target representation is mainly by its rectangular or elliptical region. It contains a target model and a target candidate. For more characterization that is specific, we use a target colour histogram. The representation of Target model is by its probability density function (pdf). Target model is that of regularized by its spatial masking with an asymmetric kernel.

3. Support Vector Machine (SVM):

SVM [13] is a broad classification method, which provides a set of positive and negative training values. In SVM, the positive samples contains the tracked image object, and the negative samples consist of all remaining untracked objects. It can handle single image, partial occlusion of object with the necessity of a physical initialization and necessity of training.

4. Layering based tracking

Another kernel based tracking method that includes the tracking of multiple objects. Based on intensity its each layer consists of shape representation (ellipse), motion such as translation and rotation, and layer appearance. Initial Layering is by compensating the background motion such that it calculates object's motion by means of its 2D parametric motion. It calculates every pixel's probability based on the object's foregoing motion and by its shape features [13].

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Capable of dealing with: Tracking multiple images. Fully occlusion of object. Object motion by translation, scaling and rotation.

C. *Silhouette Based Tracking Approach*

Some objects will have complex shapes such as hands, fingers, shoulders, which are not by simple geometric shapes. Silhouette based methods [9] can afford an accurate shape description for the objects. The purpose of a silhouette-based object tracking is to find the object region in every frame by means of an object model generated by the previous frames. It is capable of dealing with variety of object shapes, Occlusion and object split and merge.

1. Contour Tracking

Contour tracking methods [9], iteratively progress a primary contour in the previous frame to its new position in the current frame. This contour process requires a certain amount of the object in the current frame, which is overlayed with the object region in the previous frame. Generally, Contour Tracking involves two different approaches. The first approach uses a 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. One of the significant advantage of silhouettes tracking is that their flexibility to handle a large variety of object shapes very efficiently.

2. Shape Matching

These approaches examine for the presence of object model in the existing frame. Shape matching performance is mostly similar to the template based tracking in kernel approach. Another approach to Shape matching [10] is to determine the matching silhouettes detected in two consecutive frames. Silhouette matching, can also be considered similar to that of point matching. Detection based on Silhouette is under gone through background subtraction method. Models object will be in the form of density functions, silhouette boundary, and object edges. They are capable of dealing with single object and Hough transform techniques involves in occlusion handling.

V. CONCLUSION AND FUTURE WORK

. This paper does the analysis of various phases of object tracking system such as the object detection, object classification and object tracking. The paper involves the study of various available methods for these phases in detail and it highlights the number of shortcoming and limitations in each technique, we also discussed the various methods to track the objects briefly. We divide tracking method in three categories namely, point tracking, Kernel tracking and Silhouette tracking.With the advancement in studies, development of an efficient algorithm can reduce computational cost and to decrease the time required for tracking the object for variety of videos containing diversified characteristics effectively and efficiently

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