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Object Tracking Techniques for Video Tracking: A Survey

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---ABSTRACT---

Object detection and tracking are the tasks that are important and challenging in various computer vision applications such as surveillance, vehicle navigation, and autonomous robot navigation. Video surveillance works in a dynamic environment, especially for humans and vehicles. It is a technology helpful in fighting against terrorism, crime, public safety and for efficient management of traffic. Detection of moving objects from a video is important for object detection, target tracking, and understanding behaviour in video surveillance. Tracking of stationary foreground regions is one of the most important requirements for surveillance systems based on the tracking of abandoned or stolen objects or parked vehicles. To detect stationary foreground objects, the use of Object tracking techniques is the most popular choice. The objective of this paper is to highlight the various techniques of object tracking. This paper shows how one can simplify tracking by imposing constraints on the motion or appearance of objects. Prior knowledge about the number and the size of objects, or the object appearance and shape helps to simplify the problem. Numerous approaches for object tracking have been discussed.

KEYWORDS: *tracking, frames, pixel, detection, tracking, spatial*

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I. INRODUCTION

Object tracking holds an important place in the field of computer vision. Object detection involves putting objects in frames of a video sequence. The location of moving objects or multiple objects over a period of time using a camera is called tracking. Technically, tracking is the problem of estimating the trajectory or path of an object in the image plane as it moves around a scene[1]. The high-powered computers, the availability of high quality and inexpensive video cameras, and the increasing need for automated video analysis has generated a great deal of interest in object tracking algorithms. There are three key steps in video analysis:

[1] Detection of interesting moving objects.
[2] Tracking of objects from frame to frame.
[3] Analysis of object tracks to recognize their behaviour.
[4] Mainly the use of object Tracking is pertinent in the task of:
[5] Motion-based recognition.
[6] Automated surveillance.
[7] Video indexing.
[8] Human-computer interaction.
[9] Traffic monitoring.
[10] Vehicle navigation.

II. THE COMPLEXITIES OF TRACKING

Tracker assigns consistent labels to the tracked objects in different frames of a video. Additionally, depending on the tracking domain, a tracker can also provide object-centric information, such as orientation, area or shape of an object. Tracking objects can be complex due to:

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

By imposing constraints on the motion and appearance, objects can be tracked. Almost all tracking algorithms assume that the object motion is smooth with no abrupt changes. One can constrain the object motion to be of constant velocity or a constant acceleration based on prior information. Huge knowledge about the number and the size of objects, or the object appearance and shape, can also be used to simplify the problem. A number of approaches for object tracking have been proposed.

III. PARAMETERS FOR OBJECT TRACKING

In a tracking scenario, an object can be defined as anything that is of interest for further analysis. For instance, boats on the sea, fish inside an aquarium, vehicles on a road, planes in the air etc. are a set of objects that may be important to track in a specific domain. Objects can be represented by their shapes.
In this section, we will describe the object shape representations commonly employed for tracking.

[1] Points: The object is represented by a point, that is, centroid (fig 1(a)) or by a set of points (fig 1(b)). The point 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 (fig 1(c), (d)) etc. primitive geometric shapes are more suitable for representing simple rigid objects, and are also used for tracking non rigid objects.

[3] Object silhouette and contour: Contour representation defines the boundary of an object (fig 1(g), (h)). The region inside the contour is called the silhouette of the object (fig 1(i)). Silhouette and contour representations are suitable for tracking complex non rigid shapes.

[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 legs, hands, head, feet connected by joints. In order to represent an articulated object, one can model the constituent parts using cylinders or ellipses as shown in fig 1(e).

[5] Skeletal models: Object skeleton can be extracted by applying medial axis transform to the object silhouette. This method is commonly used as a shape representation for recognizing objects. Skeleton representation can be used to model both articulated and rigid objects (fig 1(f)).

Object representations are usually chosen according to the application domain. For tracking object, which appear very small in an image, point representation is usually appropriate. For objects whose shapes can be approximated by rectangle or ellipse, primitive geometric shape representations are more appropriate. For tracking objects with complex shapes, for example, humans, a contour or silhouette based representation is appropriate.

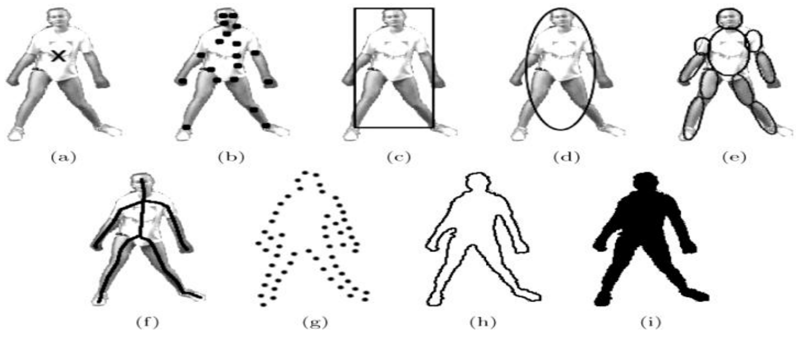

Fig 1, object representations (a) centroid, (b) multiple points, (c) rectangular patch, (d) elliptical patch, (e) part-based multiple patches, (f) object skeleton, (g) complete object contour, (h) control points on object contour, (i) object silhouette. [2]

IV. FEATURE SELECTION FOR TRACKING

Selecting the right features plays a critical role in tracking. The most desirable property of visual feature is its uniqueness so that the objects can be easily distinguished in the feature space. In general many tracking algorithms use these features. The details of visual features are:

[1] Colour: The apparent colour of an object is influenced primarily by two physical factors, 1) the spectral power distribution of the illumination and 2) the surface reflectance properties of the objects. In image processing, the RGB (red, green, blue) color space is usually used to represent color.

[2] Edges: Object boundaries usually generate strong changes in image intensities. Edge detection is used to identify these changes. Algorithms that track the boundary of the objects usually use edge as the representative feature.

[3] Optical Flow: Is a dense field of displacement vectors which defines the translation of each pixel in a region. It is computed using the brightness constraints, which assumes brightness constancy of corresponding pixels in the consecutive frames.

[4] Texture: Texture is the measure of the intensity variation of the surface which quantifies properties such as smoothness and regularity.

V. MOVING OBJECT DETECTION ALGORITHMS

5.1 Frame Difference:

In this method, a background image without any moving objects of interest is taken as reference image. Pixel value for each co-ordinate (x, y) for each colour channel of the background image is 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. This method is simple and easy to implement, but the results are not accurate enough, because the changes taking place in the background brightness cause misjudgement.

5.2 An Improved Moving Object Detection Algorithm Based On Frame Difference and Edge Detection

A combined approach is an efficient algorithm in which moving areas are detected by forming several small blocks of edge difference image. The edge difference image is obtained by computing difference between two images. Canny edge detecting algorithm is used to detect the edges of continuous frames. The smallest rectangle containing the moving object can be obtained. It is possible to get the exact position of the moving objects by calculating connected components in binary images, delete those components whose area are so small. The improved moving object detection algorithm based on frame difference and edge detection has much greater recognition rate and higher detection speed than several classical algorithms.

5.3 A Moving object Detection Algorithm for Smart Cameras

YongseokYoo [10] suggested a new frame differencing method for moving object detection using signed difference and Earth Mover's Distance (EMD). First, a signed difference image is acquired by subtracting two consecutive frames. For each fixed block in the signed difference image, a motion pattern is calculated by EMD. The EMD is defined as the minimum total amount of cost to move piles of earth to holes until all the earth is moved or all the holes are filled. The neighbouring blocks are then linked to detect moving object regions. The main idea behind this algorithm is to calculate matching costs for given directions separately rather than to calculate exact EMD by linear programming. Here block-based motion is used to locate moving object regions. An input image is divided into blocks of fixed size and pairing vectors are calculated for each block. Blocks with large pairing vectors indicate that there are motions in them. By combining these blocks, moving objects can be detected.

VI. MOVING OBJECT DETECTION FOR VIDEO SURVEILLANCE APPLICATIONS

Xiaoshi Zheng[11] proposed an automatic moving object detection algorithm based on frame difference and region combination for video surveillance applications. Initially an automatic threshold calculation method is used to 0obtain moving pixels of video frames. Frame difference is obtained by absolute difference value of two frames. Moving pixels and static background pixels can be distinguished by a threshold value. In order to make all moving pixels continuous and filter isolated pixels, moving regions are obtained by morphological CLOSE operation. In this algorithm we have three phases i.e.

[1] moving object detection phase
[2] moving object extraction phase
[3] moving object recognition phase

6.1 Background Subtraction:

In this method, the moving regions are detected by subtracting the current image pixel-by-pixel from a reference background image. The pixels where the difference is above a threshold are classified as foreground otherwise background. Some morphological post processing operations are performed to reduce noise and enhance the detected region.

6.2Real-Time Moving Object Detection for Video Monitoring System:

The method of moving object detection is based on background subtraction for real time moving objects. It proposes a new self-adaptive background approximating and updating algorithm for moving object detection. To obtain the correct shapes of the moving objects in every frame of the sequence, there are several steps. The subtraction of two consecutive frames provides the image and the background model provides the image. By using a temporal low-pass filter the background model is updated. The updating process is applied to all the pixels of the model. In order to cope the sudden changes with sudden light changes and leaves swings situation, finally AND/OR operators are applied to the images to remove tiny noise in the images. The moving object regions can extract accurately and completely by the self-adaptive threshold segmentation method.

VII. FRAME DIFFERENCE AND BACKGROUND SUBTRACTION:

The combination of background subtraction and frame differencing can improve the detection speed and overcome the lack of sensitivity of light changes.

Moving Object Detection Algorithm Based On Improved Background Subtraction

Lianqiang Niu[11] describes an algorithm for moving object detection based on combining of improved background subtraction. This method can improve the detection speed and overcome the lack of sensitivity to light changes. Considering the pixels relativity, Gaussian Mixture Model in background subtraction is used. To extract a motion region, the differences between the current frame and its previous frame is calculated. After getting the motion scene background by improved Gaussian Mixture Model, the foreground image is extracted. Foreground image is obtained by subtracting the current image frame from background image. Symmetrical differencing is used to detect the undetected regions. At each position of the pixel, the foreground images which are achieved by using background subtraction and symmetrical differencing are processed by a logical OR operation to obtain an accurate foreground image.

VIII. BACKGROUND UPDATING:

In background updating, the background of the selected pixels are replaced by the average of the current and background pixels.

8.1A Moving Object Detection Algorithm Based On Colour Information

X H Fang [11] suggested an algorithm to detect moving object based on color information. This algorithm uses a pixel and its neighbours as an image vector to represent that pixel and modeled different chrominance component pixel as a mixture of Gaussians, and set up different mixture model of Gauss for different YUV chrominance components. In order to make full use of the spatial information, color segmentation and background model were combined. Simulation results show that the algorithm can detect intact moving objects even when the foreground has low contrast with background.In the spatial object surveillance systems, the detection of moving objects must be quick and accurate. The background changes slowly in surveillance, so only detected objects are usually considered to be moving. Hence the background model algorithm is always used to detect moving object. The principle of background model algorithm is to set up statistical model of background, and then make the difference image of current image and background image to extract moving foreground. Stauffer *at al* took use of Mixture of Gaussian (MOG) as the statistic model of background [11], and every parameters of Gaussian distribution change continuously to be adapt for the gradual change of background. The algorithm has better adaptive capability for incomplete dynamic background. The fault of MOG is that, when foreground texture and colour are homogeneous and have low contrast with background, the detected foreground is also not intact.

IX. CROSS CORRELATION:

Manoj S Nagmode described a method to detect and track the moving objects to detect and track the moving objects by using Normalized Cross Correlation algorithm (NCC) [12]. In this an approach is proposed for the detection and tracking of moving object in an image sequence. Two consecutive frames from image sequence are partitioned into four quadrants and then the Normalized Cross Correlation (NCC) is applied to each sub frame [13]. The sub frame which has minimum value of NCC indicates the presence of moving object. Next step is to identify the location of the moving object. Location of the moving object is obtained by performing component connected analysis and morphological processing. After that the centroid calculation is used to track the moving object. Number of experiments performed using indoor and outdoor image sequences. The results are compared with Simple Difference (SD) method. The proposed algorithm gives better performance in terms of Detection Rate (DR) and processing time per frame.

9.1Detect and Track Moving Object Using Partitioning and Normalized Cross Correlation

Normalized cross correlation (NCC) algorithm is based on finding the cross correlation between two consecutive frames in an image sequence. Correlation is basically used to find the similarity between two frames. If the two consecutive frames are exactly same, then the value of Normalized cross correlation is maximum. In that case no moving object is detected. Now suppose there is a moving object in the image sequence, means the two consecutive frames are not exactly same, with respect to positions of the pixel values. In that case the value of Normalized [12] cross correlation is less than maximum value obtained. This concept of Normalized cross correlation is used for the detection of moving object in an image sequence.

X. CONCLUSION

Object tracking means tracing the progress of objects as they move about in visual scene. Object tracking, thus, involves processing spatial as well as temporal changes. Certain features of those objects have to be selected for tracking. These features need to be matched over different frames. Significant progress has been made in object tracking. Taxonomy of moving object detection is been proposed. Algorithm based on FD & edge detection have Higher recognition rate and higher detection speed but False detection under complicated background. Algorithm for smart cameras have an advantage of Rejecting false motions due to illumination changes but Falsely detecting specular reflections from moving objects. Algorithm for video surveillance applications is Automatic and efficient in detecting moving objects but Calculations are more complex. Performances of various object detection algorithms have also been discussed.

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