A Survey on Object Detection and Tracking Methods

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Abstract— Object tracking and detection is first step in applications such as video surveillance. The main aim of object tracking has been developed to estimate location, velocity and distance parameters with the help of static camera. Several object tracking methods are proposed to improve the moving target location by using different algorithm. Each method has its own applicability, advantage and disadvantage. Mainly this paper is to review and study of the different methods of object detection. We focused mainly on detection of objects from video sequence rather than object classification. A comparative study of object detection methods and importance of optical flow detection algorithm has been enlisted.

Key words: Object Detection, Moving Objects, Optical Flow, Video Object

I. INTRODUCTION

In present age security and safety are one of the major concern of any organization. Thus there is a need for the surveillance system which are both cost and application efficient. The objective of object tracking is to associate target objects in consecutive video frames. The association can be especially difficult when target is moving fast relative to the frame rate. Another situation that increases the complexity when tracked object changes orientation over time. To perform object tracking an algorithm analyzes the sequential video frames and outputs the movement of target between frames. There are a variety of algorithms, each having strengths and weaknesses. There are two major components of a visual tracking system: target representation and localization, as well as filtering and data association. Tracking algorithm can be divided into two categories: the deterministic methods and probabilistic methods. In recent years, number of successful single object tracking system appeared, but multiple object tracking is still challenging , and it will be harder especially in the case of that the objects have a similar appearance. In this paper various object detection method and algorithm has been studied including traditional method and optical flow detection. The advantage of optical flow detection provides over the other methods is briefly described.

II. CLASSIFICATION OF OBJECT DETECTION METHODS

The main aim of any tracking method must be to provide visually good quality of detection of moving objects , by removing the noise and preserving the structure of the target. Following are the basic steps for tacking an object, as describe in many literature.

A. *Object Detection:*

Object Detection is to identify objects of interest in the video sequence and to cluster pixels of these objects. Object detection can be done by various techniques such as frame differencing, Optical flow and Background

B. *Object Classification:*

Object can be classified as vehicles, birds, floating clouds, swaying tree and other moving objects. The approaches to classify the objects are Shape-based classification, Motion-based classification, Color based classification and texture based classification.

C. *Object Tracking:*

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 approaches to track the objects are point tracking, kernel tracking and silhouette.
Few methods of object detection are described as follows.

1) *Frame Differencing:*

The presence of moving objects in a frame is found out by calculating the difference between two successive images. Frame differencing method has a strong adaptability for a range of dynamic environments, but it also shows errors in obtaining complete outline of moving object, which is responsible for the empty phenomenon, as a result accuracy level of detection of moving object is very low.

2) *Temporal Differencing:*

Temporal differencing method uses pixel- wise difference between two or three successive frames in a video imagery to extract moving regions from the background. It is a high adaptability with dynamic scene changes al- though it cannot always extract all relevant pixels of a foreground object mostly when the object moves slowly or has uniform texture. When a foreground object stops moving, temporal differencing method cannot detect a change between successive frames and results in loss of the object.

3) *Point Detectors:*

Point detectors are used in finding some useful points in images which have an expressive texture in their respective localities. A useful interest point is one which is in- variant to changes in illumination and camera viewpoint. Some commonly used interest point detectors include Moravecs detector, Harris detector, KLT detector, SIFT detector.

4) *Background Subtraction:*

One consistent method of object detection involves building a representation of the scene known as the background model and finding deviations from the model for each incoming frame in the video images. Any significant change in an image region from the background model is noted down as a moving object. The pixels in the regions of the undergoing change are marked as moving objects and reserved for further processing. This process is referred to as the background subtraction. Background subtraction has mainly two approaches:

a) *Recursive Algorithm:*

Recursive techniques do not maintain a buffer for background estimation. This technique includes various methods such as approximate median, adaptive background, Gaussian of mixture.

b) Non-Recursive algorithm:

A non-recursive technique uses a sliding-window approach for estimating changes in the background. Non-recursive techniques have high adaptability as they do not depend on the history beyond those frames stored in the buffer as in recursive algorithms.

D. Optical Flow:

Optical flow method involves calculating the image optical flow field and doing clustering processing according to the optical flow distribution characteristics of image. This method can get the complete movement information of an object and it is useful for detecting the moving object from the background with the 85% accuracy, but this method has a few disadvantages including large quantity of calculations, sensitivity to noise, poor anti-noise performance, which make it not appropriate for real-time object detection and tracking. Optical flow estimation tries to assign to each pixel of the current frame a two-component velocity vector indicating the position of the same pixel in the reference frame. There are several optical flow estimation algorithms known in the literature. According to the taxonomy proposed in, we can cluster algorithms in the following categories: region-based matching, differential (Lucas-Kanade, Horn-Schunk) and energy-based algorithm. Optical flow method generates optical flow field for every pixel in sequential images, in which the velocity and direction of every pixel are obtained.

III. OPTICAL FLOW ESTIMATION FOR OBJECT TRACKING

Optical flow method generates optical flow field for every pixel in sequential images, in which the velocity and direction of every pixel are obtained. Given an image I and $I(x, y, t)$ represents the gray value of pixel I(x, y) at time t. Let (u, v) represent the optical flow components of $I(x, y)$. Suppose that pixel $I(x, y)$ at time t moves to $I(x+\Delta x, y+\Delta y)$ at time $t+\Delta t$, where $\Delta x = u*\Delta t$ and $\Delta y = v*\Delta t$, and the gray value of $I(x, y)$ and $I(x+\Delta x, y+\Delta y)$ are the same. So we get the equation below:

$$f(x+\Delta x, y+\Delta t, t+\Delta t) = f(x,y,t) \quad (1)$$

Using Taylor series expansion, the equation becomes

$$f(x,y,t)+\Delta x\frac{\partial f}{\partial x}+\Delta y\frac{\partial f}{\partial y}+\Delta t\frac{\partial f}{\partial t} = f(x,y,t) \quad (2)$$

Divided by Δ t , and let Δ t tend to zero, then get the equation below:

$$\frac{dx}{dt}\frac{\partial f}{\partial x}+\frac{dy}{dt}\frac{\partial f}{\partial y}+\frac{\partial f}{\partial t}=0 \quad (3)$$

For simplicity of expression, give some variable definition.let

$$u=\frac{dx}{dt}, v=\frac{dy}{dt}, f_x=\frac{\partial f}{\partial x}, f_y=\frac{\partial f}{\partial y}, f_t=\frac{\partial f}{\partial t}$$

Then the optical flow constraint equation becomes

$$uf_x+vf_y+f_t=0 \quad (4)$$

In this equation f_x, f_y and f_t can be easily got from the image. And with other constraints, we can get the value of u and v . The moving speed of every pixel in axis x and y is got from optical flow method. If given two continuous frames, optical flow method can be used to calculate the moving speed and direction of every pixel that move from the first frame to the second frame. Dividing the whole region into eight sub-regions as shown in Fig. 1, we get eight moving directions. As shown in Fig. 2, region between two adjacent dotted lines belongs to the same direction. Given the target region, then the moving direction is determined by voting method.

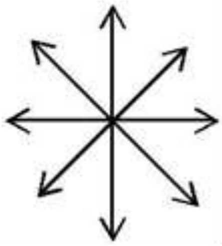

Fig. 1: Eight Sub-Regions of the Whole Region

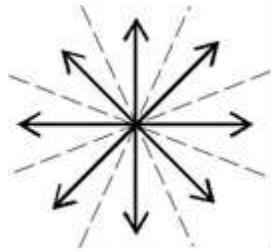

Fig. 2: Direction Determining Method

Before applying optical flow estimation on frames, the image format is converted from RGB to gray (Fig. 3 (a)); because Intensity measurements act well on gray-scale frames. Depends on methodology steps, the proper optical flow estimation (Locus-Kanade or Horn-Schunk) has been applied. Then, the median filter is performed to reduce noise corruptions. The optical flow estimation regardless of mobility, results in high contrast spots which are focused on.

The algorithm continues with blob analysis to detect specific objects, and remove unwanted blobs based on size and features like motion (Fig. 3 (c)). The blob constraints, depend on their utilizations, are fairly varied. The most important one which we have set is the density, i.e., the amount of pixels that exist in one blob.

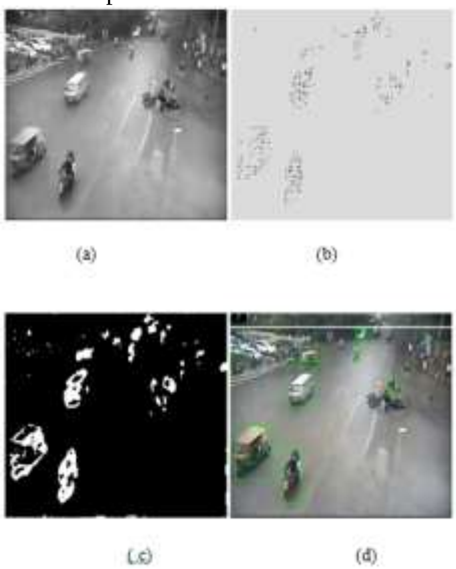

Fig. 3: An urban video frame (a) Gray-scale image, (b) optical flow motion vectors, (c) binary image with blobs and (d) tracking motion vehicles with boundary boxes.

The final point in the algorithm is the tracking of moving objects and counting the number of detected vehicles that is shown above the images (Fig. 3 (d)).

Table I depicts the average processing times (in ms) of proposed framework when applied on a 120- frame-video and RGB(120× 160) Image format using matlab.

Stages	Lucas-Kanade	Horn-Schunk
Optical flow estimation	5.2	6
Filtering Segmentation	1.6	1.6
Motion Vectors Computing	.44	.58
Tracking + Count Number	11.3	11.3
Initializing and Finalizing	5534.4	6201.1
Total	5,552.9	6,220.5

Table 1: Average Processing Time (In Ms) Of Various Stages within Framework

IV. Conclusion

In this work ,a relative study of object detection and tracking by using optical flow motion vectors has been done. The classification of Object detection methods and an overview of traditional methods have been presented. The main goal is to focus on the advantage that optical flow provide over the traditional filters for tracking of multiple objects. Various optical flow algorithms are with specific detection technique like region-based matching, differential (Lucas-Kanade, Horn-Schunk) and energy-based algorithm which provide complete information regarding object movement. Horn-Schunk algorithm, as the most suitable method of optical flow estimation , to detect moving objects by intensity changes of frames.

References

[1] Sepehr Aslani & Homayoun Mahdavi-Nasab,” Optical Flow Based Moving Object Detection and Tracking for Traffic Surveillance”, International Journal of Electrical, Computer, Electronics and Communication Engineering Vol:7, No:9, 2013.

[2] Zhiwen Chen , Jianzhong Cao , Yao Tang , Linao Tang ,” Tracking of Moving Object Based on Optical Flow Detection”, International Conference on Computer Science and Network Technology 978-1-4577-1587-7/11/2011 IEEE.

[3] Silviu Bota and Sergiu Nedevschi ,” Tracking MultipleObjects in Urban Traffic Environments Using Dense Stereo and Optical Flow” 14th International IEEE Conference on Intelligent Transportation Systems Washington, DC, USA. October 5-7, 2011.

[4] Houssam Salmane, Yassine Ruichek and Louahdi Khoudour,” Object tracking using Harris corner points based optical flow propagation and Kalman filter” 14th International IEEE Conference on Intelligent Transportation Systems Washington, DC, USA. October 5-7, 2011.

[5] Liang Xiao, Tong-qiang Li,” Research on Moving Object Detection and Tracking” Seventh International Conference on Fuzzy Systems and Knowledge Discovery (FSKD 2010)

[6] Kinjal A Joshi, Darshak G. Thakore,"A Survey on Moving Object Detection and Tracking in Video Surveillance System",International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-2, Issue-3, July 2012.

[7] Yuqiang Fang, Bin Dai,” An Improved Moving Target Detecting and Tracking Based On Optical Flow Technique and Kalman Filter”, 4th International Conference on Computer Science & Education 2009

[8] Manjunath Basavaiah,” Development of Optical Flow Based Moving Object Detection and Tracking System on an Embedded DSP Processor”, Journal of Advances in Computational Research: An International Journal Vol. 1 No. 1-2 January-December, 2012.

[9] Himani S. Parekh, Darshak G. Thakore , Udesang K. Jaliya ,” A Survey on Object Detection and Tracking Methods”, International Journal of Innovative Research in Computer and Communication Engineering Vol. 2, Issue 2, February 2014.

[10] Meha J. Patel, Bhumika Bhatt,"A Comparative Study of Object Tracking Techniques",International Journal of Innovative Research in Science,Engineering and Technology Vol. 4, Issue 3, March 2015.

[11] S.A.Tiwaskar,"Survey on Object Detection from Video Sequence",International Journal for Research in Emerging Science and technology, Vol.1, Issue 6, November-2014.

[12] Gottipati. Srinivas Babu,"Moving Object Detection Using Matlab" ,International Journal of Engineering Research & Technology (IJERT) Vol. 1 Issue 6, August – 2012 ISSN: 2278-0181.

