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Detecting Moving Objects in Traffic Surveillance Video

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ABSTRACT

Object detection is an evolving research field due to its wide applications in many areas such as traffic surveillance, motion analysis, 3D reconstruction, activity recognition, medical imaging etc. However real time object detection is a challenging task due to dynamic tracking environment and different limiting parameters like anthropometric variations, view point, dimensions of an object, camera motions, cluttered background, occlusion etc. In this paper, a moving object method has been proposed which makes use of optical flow in conjunction with motion vector estimation for object detection in a sequenceof frames. The optical flow gives valuable information about the object movement. The motion vector estimation technique can provide an estimation of object position from consecutive frames which increases the accuracy of this algorithm and helps to provide robust result irrespective of image blur and cluttered background. The use of median filter with this algorithm makes it more robust in the presence of noise. The obtained results indicate that proposed method performs well over conventional methods.

Keywords: Feature-based object detection, Motion detection, Optical Flow.

1. INTRODUCTION

With rapid growth of technology, the applications are increasing with the implications of computer vision based system. Computer vision makes computer "see" like a human being. One key application of computer vision is object detection and/or recognition. The method that is widely used to get the basic information or the early processing steps to get information from the given data is usage of optical flow [1, 2]. Optical flow disseminates the velocities of moving points in an image. And it is the consequence of relative motion of moving object with respect to static background. Therefore, optical flow delivers important information of object momentum w.r.t. time. Difference in the optical flow for different objects helps segmenting the images and certainly detecting the particular region of interest.

The real time object tracking is an important issue in computer vision. It has its role in a number of research areas such as object motion estimation, human and non-human activity recognition, vehicle navigation, 3D representation and 3D reconstruction, etc. The object tracking is more popular in automated surveillance applications because in surveillance systems single human operator cannot monitor the area under surveillance if number of cameras increases. In medical diagnosis, sometimes the physician cannot analyze video captured by the instrument; in such critical cases object detection and tracking system works more efficiently than human being.

In applications for an intelligent video surveillance system [2], the detection of a human being is important for human gait characterization, abnormal event detection, people counting, pedestrian detection, person identification and tracking, gender classification, fall detection of elderly people, etc.

Optical flow for motion vector estimation and object detection has been used in proposed method.

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2. RELATED WORK

There have been many researches done for object detection. Every of the technique proposed in literature have some pros and cons. All available techniques based on their approach of operations can be placed in some categories and these are as follows.

2.1. Feature-based object detection

Image features standardization and registration of reference points are important objectives in feature-based object detection [3]. Features are the information coded from primary image information as color, shape, texture etc. The images are transformed to different color spaces to handle change in resolution, orientation and illumination. Features are extracted from image and the objects of interest are modeled based on these features. Object detection is then achieved as by doing pattern matching of features of objects in image.

2.2. Shape-based approaches

Complexity in segmenting objects of interest in images makes shape-based object detection [4] a harder problem. In order to detect the boundary of the object, the image needs to be preprocessed for all kind noise removal and image enhancement. The filters and other image enhancement algorithms depend on the application space and/or scene. The segmentation algorithms are required for segmenting different types of objects such as persons, fly's, animals etc. For complex scenes, scale invariant transformations and noise removal is also required. After the detection of object, the object is located by its boundary which is marked by edge detection and/or boundary-following algorithms. The problem of object detection and its position localization gets more complex for complex scenes involving occlusions and shading on objects of interest.

2.3. Motion based object detection

Moving objects detection [3, 5], obviously is of important significance in video processing for object detection and tracking. A lot of research has been done on the object detection and tracking in last few years. When compared to object detection without using motion information, the motion detection adds complexity in the form of temporal change requirements of moving object. While on other side, motion based detection provides some other information source for object tracking.

3. PROPOSED METHOD

In this paper, a robust method for object detection is proposed which covers detection of moving objects with static background. A technique utilizing optical flow [2] is proposed here for moving object detection and tracking. This technique is simple and legible to work in real time processing for object detection. Some pre-processing and post-processing techniques are also applied to improve the quality of frames which were extracted from the video and also to improve the quality of result which were finally obtained.

3.1. Optical Flow

Motion detection is one integral operation in many of the image processing tasks. One approach to detect motion of objects in any scene is optical flow [2]. Optical flow cannot be computed locally, since at one point only one independent measurement is available in any image sequence. But velocity of the flow has two components, one is in horizontal direction and other in vertical direction.

$$E = \iint \left(I_x u + I_y v + I_t \right)^2 dxdy + \alpha \iint \left\{ \left(\frac{\partial u}{\partial x} \right)^2 + \left(\frac{\partial u}{\partial y} \right)^2 + \left(\frac{\partial v}{\partial x} \right)^2 + \left(\frac{\partial v}{\partial y} \right)^2 \right\} dxdy \tag{1}$$

Consequently, optical flow gives important information about rate of change of the spatial arrangement of the objects in the video. This is the velocity information of the moving object and is calculated based on movement in consecutive frames. The optical flow between two images is computed by applying some flow constraints. The first is spatial coherence and the equation 2 follows this constraint.

$$I_x u + I_y v + I_t = 0 \tag{2}$$

I_x, I_y and I_t [8] are the spatio-temporal image brightness derivatives. u is the horizontal optical flow and v is the vertical optical flow. It uses either the Horn-Schunck or the Lucas-Kanade method to find these variables u and v.

Horn-Schunck Method: The assumption taken here is that the optical flow is continuosly smooth over the entire image. Based on this assumption, the Horn-Schunck method computes the estimate of velocity vector [u v], that minimizes the above equation 1.

$$\Sigma_{x\in\cap} W^2 [I_x u + I_y v + I_t]^2 \tag{3}$$

Lucas-Kanade method: To solve the optical flow constraint equation for u and v, the Lucas-Kanade method divides the original image into smaller sections and assumes a constant velocity in each section. Then, it performs a weighted least-square fit of the optical flow constraint equation to a constant model for [u v] in each section [7]. The method achieves this fit by minimizing the above equation 3.

3.2. Phases

Step 1: Either enter the video or capture a live video which you have selected for the moving object detection. For reading a recorded video, MATLAB function VideoReader() has been used.

v = VideoReader(file name) creates object v to read video data from the file named filename.

The specification of video which we chose for running our algorithm are:

Frame Width & Height - 640x480

Data Rate - 200 kbps

Frame Rate -30 fps.

For reading live video stream from the webcam, we used imaq.VideoDevice function.

obj =imaq.VideoDevice(adaptername) creates a VideoDevice System object, obj, using the first device of the specified adaptername. adaptername is a text string that specifies the name of the adaptor which communicates with the device.imaqhwinfo function and is used to determine the adapters available on the system.

Step 2: Read a black image for plotting the motion vectors[8] which we will get using the optical flow.

Step 3: Preprocessing steps are applied in the extracted frames to improve the performance of optical flow calculation. Several filter [9, 10] operations are done as a part of pre-processing which intensify or reduce certain image details that enables easier and faster evaluation.

Examples: Normalization Edge filters Soft focus, selective focus; User-specific filter; Static/dynamic banarization; Image plane separation Binning.

Each of three frames applies Gaussian filter and average filter for noise removal and applies histogram equalizations for contrast enhancement. Numerous image filters are used for imageoptimization, noise suppression,edgeenhancement, character modification etc.

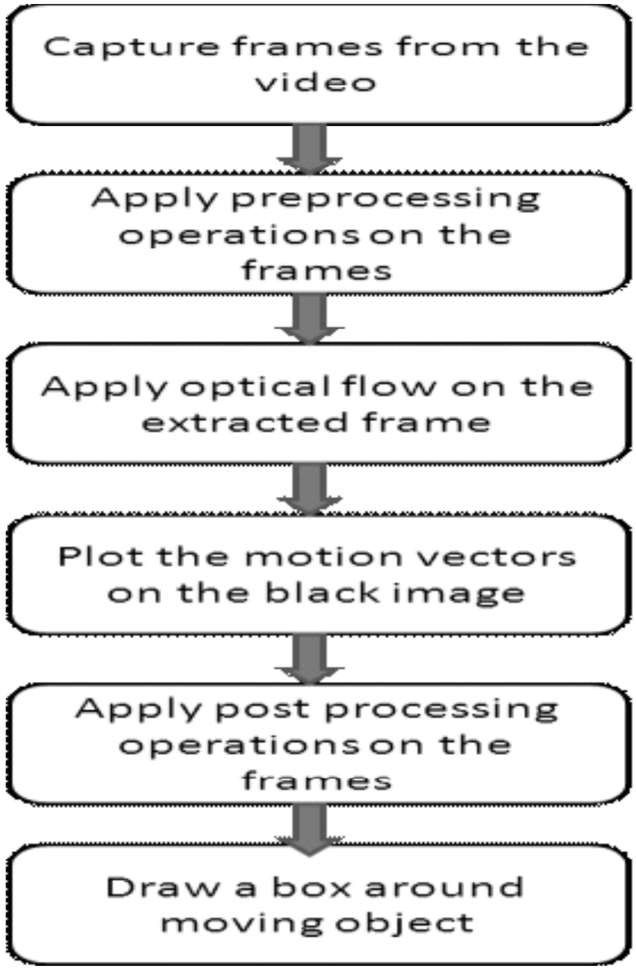

Figure 1: Framework of the proposed method

Step 4: Now we apply optical flow on each extracted frame to get the motion vectors and then plot the motion vectors [2] on the above black image to get the information about the moving object.

Step 5: Then we apply morphological operation dilation to gradually enlarge the boundaries of regions of foreground pixels. Dilation is a basic morphological operation modeled as a simple mathematical function. Dilation was originally developed for binary images while later on it was expanded to grayscale images and then to complete colored lattices. The dilation operation usually uses a structuring element for probing and expanding the shapes contained in the input image.

Step 6: Next we find top and bottom right white pixel having value 1. Then we use symmetry to draw a rectangle on one of the three frames extracted in step 2. Using these points to draw the rectangle, start from the first row of image and keep scanning until we find one. Similarly for the bottom right point, start scanning from the last row and last column of image and continue.

4. RESULTS

Various parameters which were used to show the results of our proposed algorithm are:

False Positive - An error which indicates presence of a condition when actually it is not present.

True Negative - An error in which a test results in absence of a condition when it is present in actual.

Intermediate results obtained after the application of various techniques are:-

Figure 2: Applying Median Filter

Figure 3: Applying Gaussian Filter

Figure 4: Applying Histogram Equalization

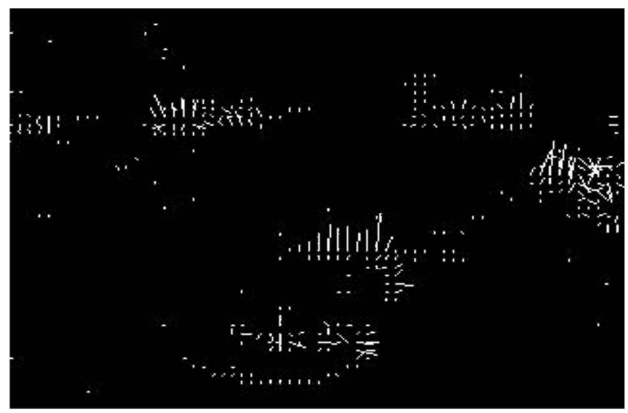

Figure 5: Applying Erosion

Figure 6: Applying Dilation

After the various intermediate results,what is obtained as final result is the detected moving objects are shown by the vectors in the images below-

Figure 7: Image depicting moving objects

Figure 8: Image depicting moving objects

A graph showing the accuracy, false positive rate and true negative rate of Three Frame Differencing algorithmis plotted in fig 9.

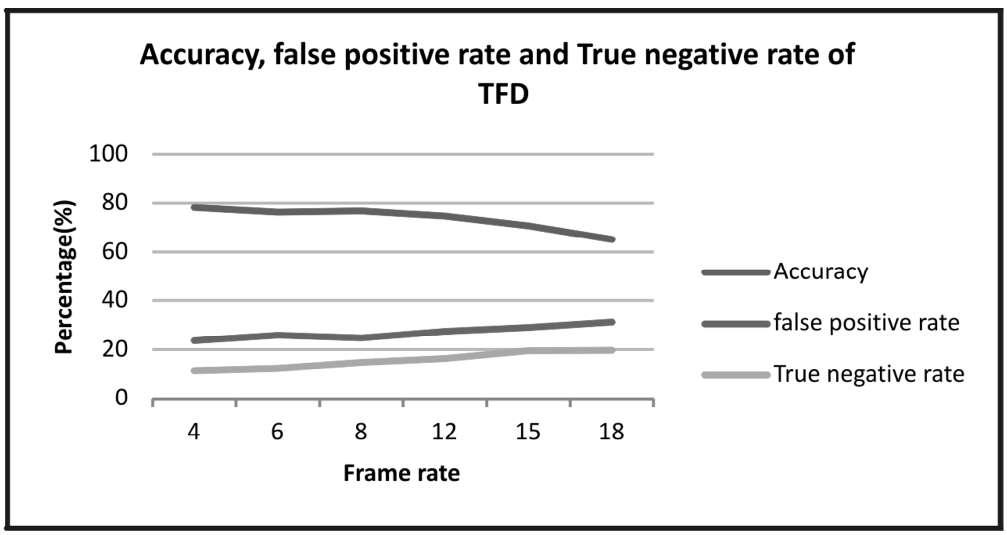

Figure 9: Accuracy, FPR, TNR of Three-frame differencing technique

Table 1
Table showing the results of three frame differencing against which graph has been plotted.

Frame Rate	*Accuracy*	*False Positive Rate*	*True Negative Rate*
4	78.3	23.7	11.4
6	76.4	25.9	12.4
8	76.8	24.9	14.8
12	74.8	27.6	16.3
18	70.7	29.1	19.6
18	65.2	31.4	19.8

Graph showing the results of object detection using Optical Flow, i.e. accuracy,false positive rate and true negative rateis plotted in fig 10.

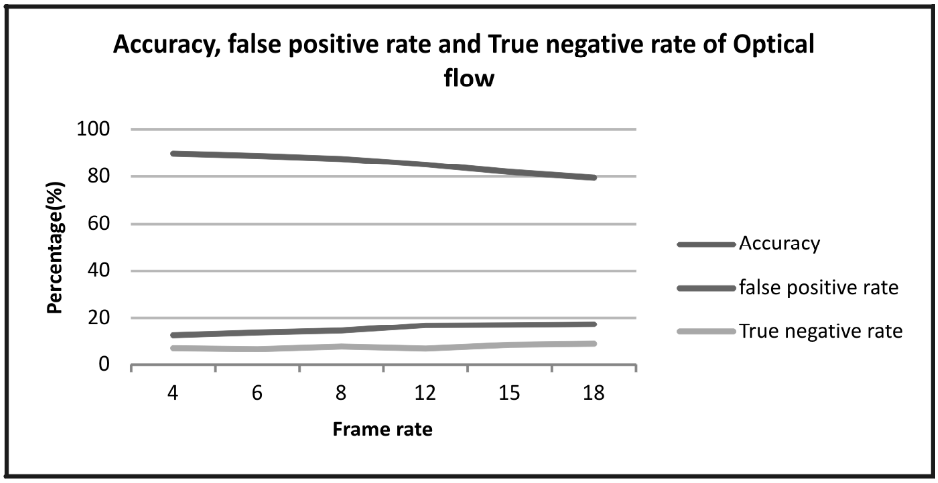

Figure 10: Accuracy, FPR, TNR of optical flow

Table 2
Table showing false positive rate, true negative rate and accuracy of Optical Flow

Frame Rate	*Accuracy*	*False Positive Rate*	*True Negative Rate*
4	89.8	12.5	7.1
6	88.7	13.7	6.7
8	87.4	14.5	7.8
12	85.1	16.7	6.9
15	81.9	16.9	8.5
18	79.5	17.2	8.9

Graph showing the result of comparison between Three Frame Differencing and Optical flow which has been shown by fig 10 and Table 3 below:

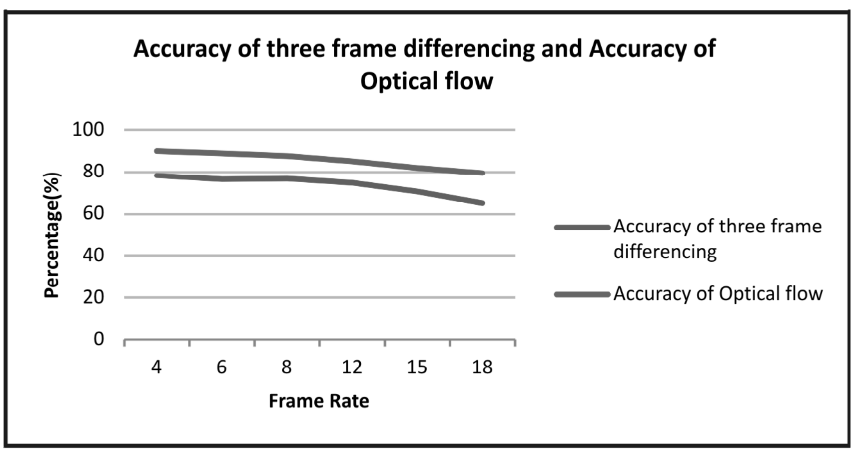

Figure 11: Accuracy of Three Frame Differencing vs. Optical flow

Table 3
Accuracy table of 3 frame differencing vs. Optical flow

Frame Rate	*Accuracy of three frame differencing*	*Accuracy of Optical flow*
4	78.3	89.8
6	76.4	88.7
8	76.8	87.4
12	74.8	85.1
15	70.7	81.9
18	65.2	79.5

In our algorithm, the Frame Rate is varied and different percentage ofaccuracy, false positive and true negative frames are obtained, which is plotted in the graphs shown above.

5. CONCLUSION

This project is proposed for moving object detection based on the optical flow. As a conclusion, traditional three frame differencing can be enhanced to get better and more accurate results. This is shown by adding optical flow. The algorithm developed is performing vehicle detection and then tracking. This system then can be used for counting vehicles and checking speed of vehicles at roadways and freeways. The further adaptations can be done for developing an advance warning intelligent transportation system that alerts commuters in advance of speed reductions and congestions.

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