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Presenting a novel algorithm for moving object detection

By

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Abstract:

In this paper the common methods for motion detection were surveyed. Then, a new approach named "Moving Average Filter" presented as a heuristic technique for modeling the background of the frames sequence in presence of the moving object. This technique shows a better result in contrast to the common techniques since it is faster and has good noisy environment detections because of low pass filtering characteristic of the Moving Average Filter. In addition, using the technique presented for implementing Moving Average Filter the volume of computation time are greatly reduced. Therefore, this technique is reasonably suitable to be implemented in portable and real time applications.

Keywords:

Motion detection, Moving Average Filter, Background modeling

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1. Introduction:

The motion detection is one of the most important requests in a wide variety of fields. In today's world with the daily advances of technology and the complexity of human relations, problems such as security and visual surveillance at various environments [2,4], intelligent traffic control in large cities and highways, automatic speed measurement of vehicles, tracking human, and objects in various places are greatly desired. These demands ask for using new and accurate techniques for motion detection. Motion detection mainly separates the static parts of image from moving ones. In other words, parts of the image which are moving are extracted using various techniques and the result will be used in the next stages. The motion detection algorithms are one of the important research topics in the machine vision field. There are various techniques and algorithms for motion detection and tracking. These techniques will be surveyed, and then they are compared in the following sections. Then, our approach, i.e. Moving Average Filter is presented.

2. Moving Object Detection:

There are two main approaches used in motion detection. They are Spatial Domain methods, and Frequency Domain methods. The Spatial domain techniques are applied at the pixels level and the moving frame segments separated using the intensity changes in different frames by some predefined threshold levels. There are different techniques for estimating the optimum intensities and threshold levels. In the second approach, i.e., frequency domains, the image transformations specially the Fourier transform are used to detect the present motion. For instance, the shift property of Fourier transform can be used for object detections with constant speed. The main problem in motion detection is the noises presented in the scene which change the intensity of static pixels. These pixels detected as moving parts of frame and the accuracy of detection decreases. Thus the techniques, increasing the accuracy of detection are of the more importance. In the next sections, we will explain the three common methods, and then introduce our methods.

2.1 Background Subtraction:

In this method a sequence of frame which only contains background, and doesn't have any moving part considers as a reference frame. Then, the new frames are compared based on the selected reference frame. Please note that due to the noises, addition of static objects, and light intensity changes, the background image is not static. These changes, therefore, can cause errors in moving object detection procedure.

2.2 Thresholding of Time Differences:

In this approach, the moving pixels are detected using the threshold of the differences between continuous frames. If $f(x,y,t_i)$ and $f(x,y,t_j)$ were two frames of a sequence which captured at t_i and t_j moments, a method of comparing pixels of these frames is to create the difference image. The main problem of this technique is the noise effect. Noise can directly change the intensity values and there is a possibility that the differences between the intensity of pixels be the effect of noise. One solution for this problem is using some threshold levels as shown in the equation 1.

$$d_{ij}(x,y) = \begin{cases} 1 & |f(x,y,t_i) - f(x,y,t_j)| > T \\ 0 & otherwise \end{cases} \quad (1)$$

2.3 Optical Flow Techniques:

Optical flow is an estimation of local movement of image. It is based on local differentials in a sequence of images. Optical flow in 2D spaces determines each pixels amount of displacement contrary to corresponding pixel in the adjacent frames [3]. While in 3D spaces, the optical flow determines each voxels amount of displacement contrary to corresponding voxel in the adjacent frames. The basis of optical flow is the motion constraint equation (eq.2).

$$\frac{\partial I}{\partial x} v_x + \frac{\partial I}{\partial y} v_y + \frac{\partial I}{\partial t} = 0 \quad (2)$$

In which $v_x = \frac{\partial x}{\partial t}$, $v_y = \frac{\partial y}{\partial t}$ are the x and y components of image speed or the optical flow, and $\frac{\partial I}{\partial x}$, $\frac{\partial I}{\partial y}$, $\frac{\partial I}{\partial t}$ are the intensity differentials at the point (x, y, t). We can rewrite this equation as follow (eq.3):

$$\nabla I . v = - I_t \quad (3)$$

In which $\nabla I = (I_x, I_y)$ is the spatial gradient of intensity, and $v = (v_x, v_y)$ is the image velocity, or the optical flow of (x, y) pixel at moment t. This equation is a two variable equation which mainly results the velocities normal to the local intensity structures. There are two different algorithms introduced by Horn-Schunck, and Lucas-Kanade algorithms for solving the mentioned equation. These algorithms both need high processing capacity, therefore make it difficult to be implemented in real time systems. In the next section, we introduce our approach for image detection.

2.4 Moving Average Filter:

In this approach, the motion objects are detected by comparing the current frame with a model of background. This model of background is obtained based on moving average filter as follow. We consider a predefined number of frames as an N element sequence. By averaging these sequences, an image will be obtained which the pixels of moving object were attenuated by 1/N, and in the obtained image there will be a shadow of moving object which its intensity has an inverse relation with the amount of N. In contrast, the pixels correspond to the static segments of scene will be multiplied by 1/N, but because the location of background pixels do not change, after averaging the intensity remains fixed in these areas (figures 1, 2). One important advantage of this method is that there is no need to provide a reference image.

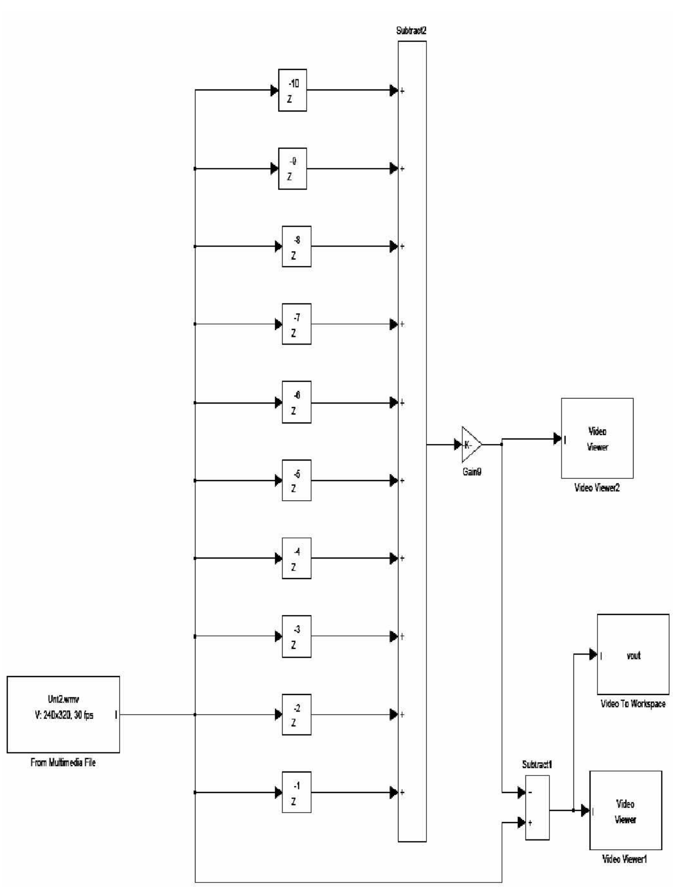

Figure (1): *The diagram of modeling background using moving average filter.*

Figure (2): *Attenuation of pixels corresponding to moving object because of using Moving Average Filter*

3. Practical Results:

In this section, we present the obtained results of the explained four approaches. As a reference frame, consider the video shown in figure 4. We applied the mentioned four approaches for motion detections. They are: (a) frame differencing method, (b) optical flow method using Horn-Schunck, (c) Lukas-Kanade algorithms, and (d) the modeling of background using Moving Average Filter method. The results of these approaches were shown in figures 3-7, respectively.

Figure (3): *The reference frame video.*

Figure (4): *The result obtained by applying frame differencing algorithm.*

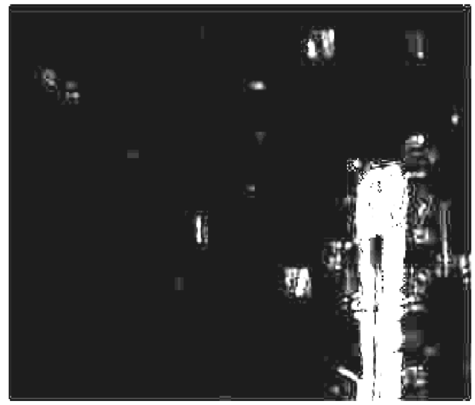

Figure (5): *The result obtained by applying optical flow using Horn-Schunck algorithm*

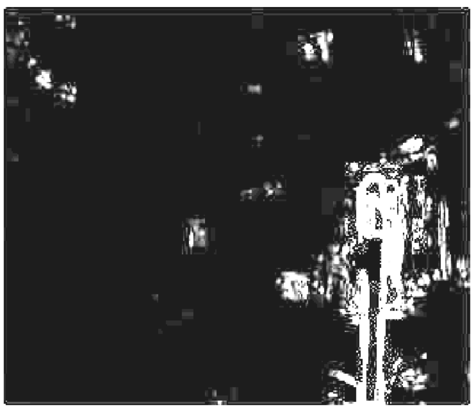

Figure (6): *The result obtained by applying optical flow using Lukas-Kanade algorithm.*

Figure (7): *The result obtained by using Moving Average algorithm.*

In the next section, a brief discussion is made for the results of these four algorithms.

4. Discussions:

In this section, we compare the four aforementioned algorithms. In the first one, i.e., the consecutive frame differences method, since a reference image is not used, and this reference frame may change due to the environment lighting changes, or addition of motionless objects, which are the case for the static background subtraction method, is not very applicable. In addition, as some disadvantages of this method, is the velocity and frame rate affects the results, and also this method admits the noise considerably. As seen in figure 4, the detected object is eroded, and this erosion depends on the velocity of object and frame rate. The next two other approaches, as shown in figures 5, 6, also do not provide very good results. The figure 7, the result of Moving Average Filter method shows better performance than all of the mentioned approaches. In addition, this approach has a very good detection in the presence of noise. Another great advantage of this method is the computation time which is lower than others. By using the Moving Average Filter approach most of the problems, i.e., noise, computation time, and updating the image are almost solved. Thus, the problems such as effects of environment lighting changes or addition or elimination of static objects will be reduced considerably. Also, because of low pass filtering feature of this method, the noise effects will be reduced and generally a better result is achieved. Increasing the N (number of sequence frames) will upgrade the detection accuracy. However, as one important disadvantages of this method, it may depend on N. We increased the processing speed as follow. In this method any increase of N only affects the first cycles of process, and after initialization the motion detection process will be limited to processing few frames which are independent of N. The general equation for Moving Average Filter with a sequence of N frames is shown in equation 4:

$$X = x(T) + x(T-1) + ... + x(T-(N-1)) \tag{4}$$

The Moving Average Filter yields the output Y by adding current input frame to the sum of N-1 previous data and dividing the result by N. As can be seen, this operation requires N memory locations for frames and N-1 summing operations. In contrast, an effective method will be introduced which requires only one addition and one subtraction operations which can highly improve the speed of processing for image type data's. To improve this method, we rewrote the equation 4 as equation 5:

$$X = y(T) + x(T) - x(T-N) \tag{5}$$

So, except for the initialization, the processing time does not depend on the length of images sequence, and only has just one addition and subtraction.

5. Conclusions:

In this paper, common methods of motion detection were surveyed. Then a new technique named "Moving Average Filter" was introduced. The results show that this method has a better performance than the common methods. Especially, this method works well in the presences of noise. In addition, by using the technique introduced for implementing the Moving Average Filter this technique has supremacy in processing capacities. Also we consider improving the quality of detection by applying different weights to frames of sequence for averaging. Because of performance, and light processing tasks, this technique is suitable to be implemented in portable and real time systems. The only requirement for this technique is the need for high capacity memory which does not seem to be so important by the recent advances in memory manufacturing and severe reduction of prices.

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