چهارمین کنفرانس ملی ایده های نو در مهندسی برق

۲۰و۲۱ آبان ماه ۱۳۹۴ - دانشگاه آزاد اسلامی واحد اصفهان (خوراسگان)

Real-Time video streams motion detection Using sum of absolute differences technique

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Abstract: *This paper describes an algorithm to detect moving objects using changes in their location. The target applications are motion detection system, motion analysis system and video processing for surveillance and security purposes. The provided algorithm is based on flowchart for tracking objects using an USB / Web Camera which reduce the total cost of the system. Every difference between positions of objects can be important point for detection, so analysis of this data is the main goal. By using color differences and Mean filter it is possible to detect object and then based on the application decide on detection status. In the flowchart, program process used a flag for check status and take appropriate decision. The program will continue working for detection if the flag value is equal to 1, else the program will be terminated. In custom-built GUI, system user(s) can monitor detection status and filters value for data analysis.*

Keywords: Sum of absolute differences, Motion Detection, Image processing, Surveillance and Security, Moving Objects

1. Introduction

Motion detection means it is a process of detecting a change in position of an object relative to its surroundings or the change in the surroundings relative to an object. Motion detection is broadly used in many computer vision tasks like pose estimation, human tracking and face recognition. For object tracking a camera is often utilized to obtain information of moving objects.

By using motion detection technologies, it is possible to monitor and capture every motion. As motion detection system is real-time and it is implemented widely, system is used to detect any motion in a real-time video and once motion has been detected, the warning system will activate by mean of an alarm and capture the real-time video. Once motion has been detected, other features can be considered to decide whether a video signal has to be presented to the surveillance operator.

Nowadays the real-time information is very important in the surveillance area such as in military reconnaissance, mobile robot navigation, path planning and etc. In real-time processing there are two problem, first is processing speed and second is reliability of the moving objects detection and also the measure of quality related algorithm of two major indexes. Motion detection from a moving observer has been a very important technique for computer vision applications. Especially in recent years, for autonomous driving systems and driver supporting systems, vision-based navigation method has received more and more attention worldwide. There are different methods and algorithms to overcome the problems. One of its most important tasks is to detect the moving obstacles like cars, bicycles or even pedestrians while the vehicle itself is running in a high speed. Methods of image differencing with the clear background or between adjacent frames are well used for the motion detection.

2. Motion Detection

The motion detection methods are classified according to the method of finding moving objects [1].

Different methods are described as follows:

2.1 Temporal differencing

Temporal difference (TD) learning is a prediction method. It has been mostly used for solving the reinforcement learning problem. "TD learning is a combination of Monte Carlo ideas and dynamic programming (DP) ideas" [2]. In this case, temporal differencing method use the difference between two or three adjacent frame based on time series image to subtract and get difference images. This method is highly adaptive to dynamic scene changes. Correlations between the images are often used to monitor the dynamic changes of the object [3]. However, it generally fails in detecting whole relevant pixels of some types of moving objects.

2.2 Background subtraction

It is particularly a commonly used technique for motion segmentation in static images. It will detect moving regions by subtracting the current image pixel-by-pixel from a reference background image that is created by averaging images over time in an initialization period. The idea of background subtraction method is to initialize a background firstly, and then by subtracting current frame in which the moving object present that

current frame is subtracted with background frame to detect moving object. This method is simple and easy to implement, and accurately extracts the characteristics of target data, but it is sensitive to the change of external environment, so it is applicable to the condition that the background is known [4].

2.3 Optical flow

Optical flow reflects the image changes due to motion during a time interval dt [5]. It gives better performance under the moving camera, but this algorithm is very complex and complicated computation and also it needs special hardware support, so it is difficult to meet the requirements of real-time video processing.

3. Sum of absolute differences Technique (SAD)

A metric or distance function is a function d(x, y) that defines the distance between elements of a set as a non-negative real number. If the distance is zero, both elements are equivalent under that specific metric. In digital image processing, the sum of absolute differences (SAD) is an algorithm for measuring the similarity between image blocks. It works by taking the absolute difference between each pixel in the original block and the corresponding pixel in the block being used for comparison [6]. The sum of absolute difference is equivalent to the L1-norm of the difference, also known as Manhattan- or Taxicab-norm. The abs function makes this metric a bit complicated to deal with analytically, but it is more robust than Sum of Squared Difference [7].

$$d_{SAD}: (x, y) \rightarrow \| x - y \|_1 = \sum_{i=1}^{n} |x_i - y_i| \quad (1)$$

Where *x*, *y* are the coordinates and *i*, *n* are the arguments of sum operator for difference points.

There are many applications for SAD such as motion estimation, object recognition and video compression. Figure 1 can give an example of SAD method that the subtraction will produce a new matrix. In matrix Fig. 2 there are some negative values. Therefore this technique will take the absolute value of all matrix elements and then sum up these elements. Figure 3 represent result matrix for summation. The result of this summation gives SAD between the image and template windows [8].

1	3	8
5	6	2
0	4	7

5	1	3
0	8	9
2	4	6

Fig. 1. Template and Search Matrix.

-4	2	5
5	-2	-7
-2	0	1

Fig. 2. Differences Matrix.

4	2	5
5	2	7
2	0	1

Fig. 3. Absolute Matrix.

SAD can be computed by using the equation:

$$d(A, B) = \sum_i \sum_j |A(i, j) - B(i, j)| \quad (2)$$

$$SAD = 4+2+5+5+2+7+2+0+1=28 \quad (3)$$

4. Image Differencing using SAD

The sum of absolute differences (SAD) method is simple and fast way to find differences between captured frames. Based on this method is possible to find any differences and changes in video stream. It is mathematically represented using the following equations:

$$D(t) = \frac{1}{N} \sum |I(t_i) - I(t_j)| \quad (4)$$

Where N is the number of pixels in image used as scaling factor, $I(t_i)$ is the image I at the time i, $I(t_j)$ is the image I at the time j and D(t) is the normalized sum of absolute difference for that time. In an ideal case that there is no motion,

$$I(t_i) = I(t_j) \quad (5)$$

And D(t)=0. However noise is always presented in images and a better model of the images in the absence of motion will be,

$$I(t_i) = I(t_j) + n(p) \quad (6)$$

Where $n(p)$ is a noise signal. The value D(t) that represent the normalized sum of absolute difference can be used as a reference to be compared with threshold image value.

5. Algorithm and flowchart

The program application uses sum of absolute differences (SAD) technique. Base on provided algorithm and flowchart in the Fig.4 it is clear that after program initialization, the flag value will check by software program and if the flag=0 the program clear all pre-defined variables and break the program but if the flag=1 the program will start to capture video frame by frame and compare their value with previous frames. The result is important because by using a mean filter, average the RGB colors and by sum of this value we can detect motion in video stream. For each color channel the program get the RGB value by dividing the subtracted value per 307200 pixels. This Value obtained by 640×480 pixel input video frame size. After image acquisition and then motion detection processing, program must evaluate the detection by using threshold image. In this case if final image is a valid threshold image program should decide on surveillance action and start the program loop for next detection but if final image is not a valid threshold image the program should start the image acquisition and motion detection processing again for a valid threshold image.

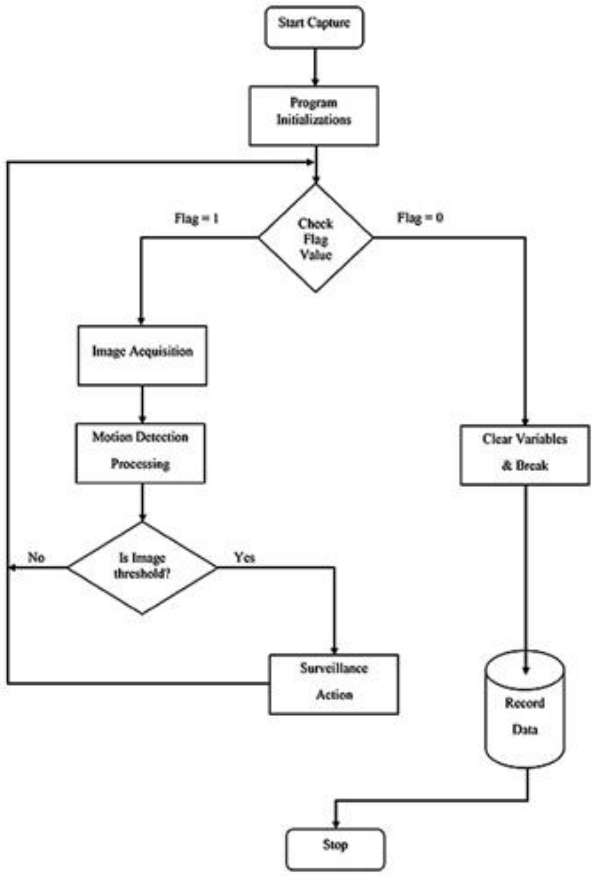

Fig. 4. Algorithm and Flowchart.

6. Graphical user interface

Users crave the ability to use graphical user interfaces (GUIs) to perform tasks. While command line input can be beneficial and easier to implement, error handling and decision making can be more intuitive through a GUI. Designing the visual composition and temporal behavior of a GUI is an important part of software application programming in the area of human-computer interaction. Its goal is to enhance the efficiency and ease of use for the underlying logical design of a stored program, a design discipline known as usability [9]. Figure 5 represent custom-built GUI that monitor data value and video stream simultaneously.

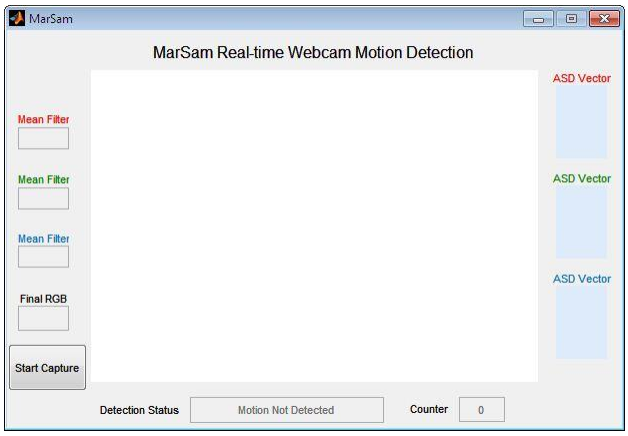

Fig. 5. Custom-built GUI.

In this case, the value of mean filter, ASD vector and detection status is available for analysis. While system preview video stream, the program decide on detection status by sum of absolute differences and average values. For high detection sensitivity level it is possible to decrease the Final RGB level. For example if we set Final RGB greater than 45 as default value the best performance will achieve empirically. By decrease or increase this value the program need more or less color level in each color channel. Based on following equation the program will find the Final RGB value: (this equation is same for each color channel)

$$I_{diff} = |I_{t-1} - I_t| \quad (7)$$

WhereI_{diff} , is absolute difference of two images I_{t-1} is the image frame at time t-1 and I_t is the image frame at time *t*.

$$I_{ch} = \sum I_{diff} \quad (8)$$

Where I_{ch} is row vector of the sum of each column.

$$I_{Mean} = \sum I_{ch}/307200 \quad (9)$$

WhereI_{Mean} is grabbing average RGB value of 640×480 pixels.

$$\text{Final RGB} = \sum(I_{Mean}/3) \quad (10)$$

Where Final RGB is average of three color channel for motion detection.

7. Conclusion

In This paper, using SAD methods serve as a beneficial method to help surveillance and security user(s) protect their environment. It provides an effective way of detecting moving object. This method focuses on accumulating and recognizing entire object patterns rather than focusing on detailed features. The advantages of this approach are the low use of memory and amazingly fast yet descriptive representation of capturing motion. Using a custom-built GUI makes an easy way to preview data and video stream for analysis. As a future work, extended efforts are being made to enhance the security provisions.

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