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A Motion Detection Algorithm for Tracking of Real Time Video Surveillance

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***Abstract* - Detection of real-time moving objects is very essential for video surveillance. Motion detection is a fundamental step in the lineage of information regarding objects in motion and to stable the functional areas, such as tracking, classification, recognition, etc. This paper proposes an efficient and accurate motion detection algorithm for the automatic video surveillance system and monitoring applications. The need of such an efficient real time video motion detection system is caused by their potential for deployment in the regions where security is the matter of interest.**

The process of motion detection receives a digital image from the camera. Incoming images are stored in a ring of three frame buffers; two frame buffers hold the current and the previous complete images while the extra frame buffer is about to happen. The absolute value of the difference between the grayscale values in each image is thresholded to provide a raw motion image. The raw motion image is then used to produce the motion receptive field map.

***Keywords-* video surveillance, tracking, motion detection, threshold, classification**

I. INTRODUCTION

In this chapter, we would just briefly look into the introduction of the project requirements needed for it and its purpose and aim. Also, a simple development plan for the prototype system which was drafted out is being presented here in this chapter. An overview of the system initially planned to be developed is also being presented here.

A motion detection algorithm begins with the segmentation part where foreground or moving objects are segmented from the background. The simplest way to implement this is to take an image as background and take the frames obtained at the time t, denoted by I(t) to compare with the background image denoted by B. Here using simple arithmetic calculations, we can segment out the objects simply by using image subtraction technique of computer vision meaning for each pixels in I(t), take the pixel value denoted by P[I(t)] and subtract it with the corresponding pixels at the same position on the background image denoted as P[B].

In mathematical equation it is written as;

$$P[F(t)]=P[I(t)] - P[B] \quad (1)$$

Where F refers to the foreground or resulted image after the computation at time t.

A. Purpose and Objective

As proposed earlier, this project is to be linked with another project to come up with the final system called Human Motion Detection System. This project would be focused on the Video Motion Detection module where we would perform research on the techniques and methodology to detect motion and to develop a module for a technique that we prefer to use in this project. This module would record down motion and pass it into the next module that would be on object classification where it classify human and non-human object. Thus, this project is to come up with a solution that detects motion effectively and record it down with one or more objects that are moving and causing motions.
The purpose of this project is to help new researchers learn and further research on their topic of interest, which in this case is the human motion detection system. The question to be addressed here in this module is, given a sequence of images, how do we detect motion or track a moving object? The project is to mainly answer this particular question addressed by providing a prototype to emulate or prove the algorithms or techniques that are available to perform motion detection by an input of images in a number of frames.

B. Description

Human Motion Detection System can be used in surveillance and security systems. The system that this project came up with will be useful for security in a fixed restriction area. Therefore, the background of the targeted area is assumed to be non-moving and considerations of sudden change in lightings are ignored as well. However, the considerations of other factors are taken into consideration. Basically, the initial plan was to use a technique called image segmentation to abstract the foreground image from the source image obtained and later processed to filter out noises or small images disturbance. To perform this, we would use Open Source Computer Vision Libraries from Intel to obtain contours from the foreground image subtracted. We will map these contours' pixels with the original images' to send raw data into the other module of the project performed by our partner on classifying the image frame obtained on whether it's a human motion or not. His module would return a percentage of recognition rates on whether the motion belongs to human or not. Based on a level on acceptable percentage that it is sure it's a human motion, the program would detects and displays the motion with a bounding box on the human which is in a different colour to other moving objects that caused motion as well since all moving objects are bounded by the rectangles. The program will record down the scene when the motion event occurs.

C. Resources and Requirements

Basically, the project is going to use a method described by David Moore's final thesis on "A real-world system for Human Motion Detection and Tracking" [3] from California Institute of Technology. Mainly, this module requires functions and algorithms written in the Intel's open CV library. In the hardware's perspectives, we had used a webcam for testing purposes with specifications up to 30 frames per second and support up to 600x800 screen sizes. However, the project had only implemented 300x200 of resolution. The reason behind is because of speed performance issues and also limitation by the Intel Open CV libraries rectangles drawing functions which did not draws well with larger resolution. This however maybe be only a problem in the version implemented here which is beta3.1.

II. SYSTEM DESIGN & ARCHITECTURE

In this chapter, we will look into the design of the methods and techniques implemented in the final prototype system. Diagrams of the architecture of motion detection algorithms are being presented here in this chapter as well.

A. System Overview

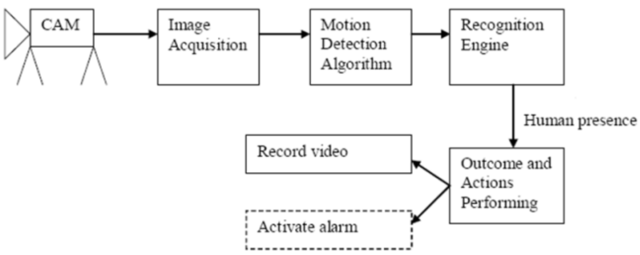


Fig. 1 Overview of a basic motion detection application system

As shown in figure 1, the basic human motion detection would have an alarm system integrated. Thus, to get a clearer picture of the system developed, figure 2 is shown below:

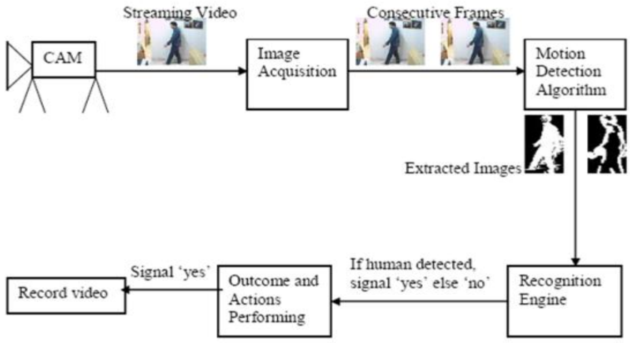


Fig. 2 Overview of the prototype human motion detection application system

III. METHODOLOGY

There are many approaches taken by researchers to perform motion detection. Here we would discuss two among them, the first being the conventional background modelling method which updates the background based on statistical data approach which will be discussed in section A. The second would be a method identified by IBM research group consists of Ying-Li Tian and Arun Hampapur which will be discussed in section B.

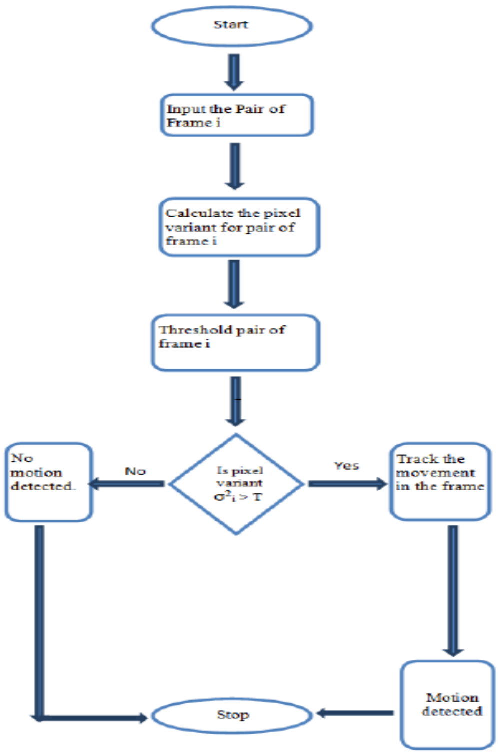


Fig. 3 Flowchart of motion detection method

A. Background Modelling

Background does not always stay the same. Thus to improve the most basic algorithm discussed in the previous topic, we make B into a 1D space. For example, let t2 denotes the time that a background is updated. An updating function denoted by Fn[B(t2)] refers to the function to update the background image B at time t2.

Therefore, after performing the initial calculation, the foreground is now extracted from this new background denoted by B (t2). Thus changing the equation (1) into;

P[F(t)]=P[I(t)] - P[B(t2)] (2)

Where B(t2)=Fn[B] meaning B(t2) is calculated by an updating function that is performed on the previous background. One way is by using data collected from the frames and performs some calculation on the background image. One example is to take or record down all the pixels of all the frames before time t2. After that, simply sums them up and calculate the average value and update the background B to get a new background B(t2) with this average value. However, there have been many ways to update the background.

Ramesh, Rangachar and Brian accumulative difference picture is another way to perform background updating algorithms. The advantage of their method is that there function such as Fn[B] discussed above can be done in every frames as they use an accumulative function to determine the result of the subtraction. Milan, Vaclav, Roger also presented a similar accumulation different picture technique denoted as "cumulative different image" in their text.

Ming and Tim used a Gaussian mixture model based on the RGB colour space for maintaining a background for motion detection. Their work is effective when applied to outdoor motion detection systems where it is fast in response to illumination changes for example illumination changes arising from moving clouds.

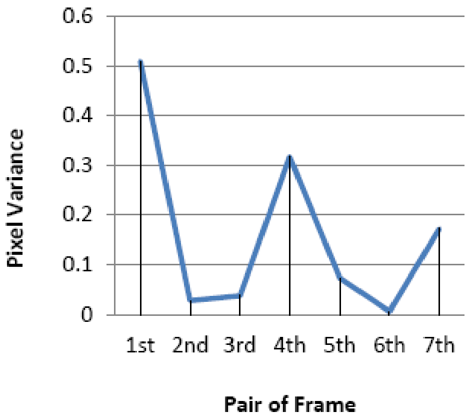
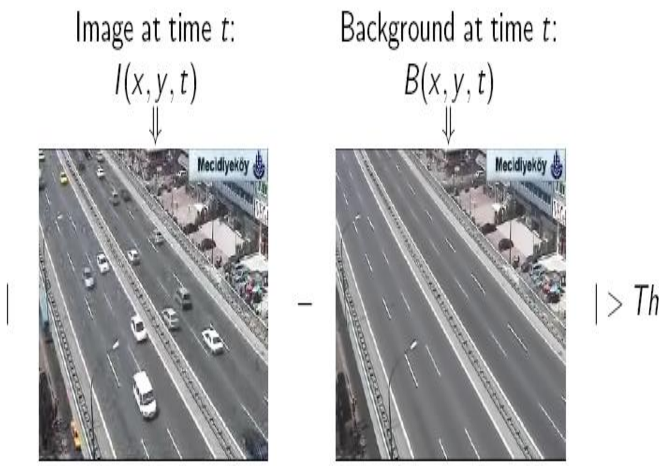


Fig. 4 Graph for motion detection

Moore also implemented a Gaussian model for maintaining a background for motion detection. According to his writings, the Gaussian models update can be based on either the K-Means or Expectation Maximization (EM) algorithms. In Ming and Tim paper, they chose to implement the EM algorithm.

B. Background Subtraction



1. Estimate the background for time t.
2. Subtract the estimated background from the input frame.
3.Apply a threshold, Th, to the absolute difference to get the foreground mask.

After the foreground objects have been segmented, they are separated or identified using some algorithm to detect these regions. One of the ways is by using the region identification algorithm of computer vision where each separated objects are labelled differently to be able to distinguish them. Of course, some image pre-processing would have to be applied before the labelling process is done. Either a threshold function can be used to obtain a binary image to be labelled or edge detection with the convolution operators can be chosen to find these objects in the foreground image and separate them. Some noise filtering functions may also be used to remove noise from the foreground images before proceeding to obtaining a binary image and labelling the objects.

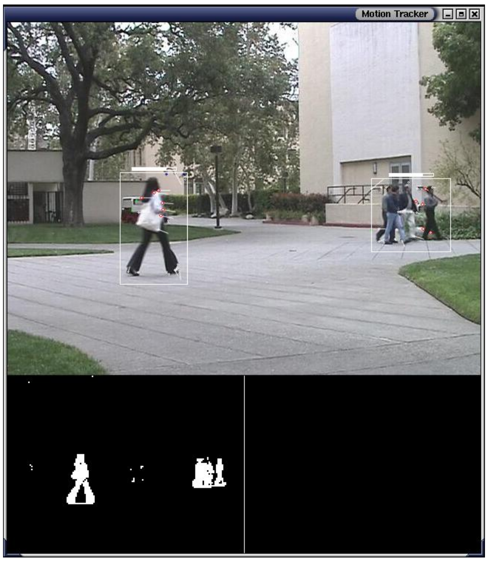


Fig. 5 A screen capture of the motion detector's graphical user interface

C. Salient Robust Motion Detection

The claim of Ying-Li Tian and Arun Hampapur is that most motion detection approaches requires hundreds of images without moving objects to learn a background model. Thus, the accumulative difference pictures as suggested by Ramesh, Rangachar and Brian would be an exception. The three major drawbacks of adaptive background subtraction that were identified were:

• It makes no allowances for stationary objects in the scene that start to move.
• It needs hundreds of images to learn the background model.
• It cannot handle quick image variations and large distracting motion.

Ying-Li Tian and Arun Hampapur had identified previously developed salient motion detection methods by other researchers that were similar to theirs. In their method, they combine temporal difference imaging and temporal filtered optical flow. Their assumption was that the object with salient motion moves approximately consistent in a direction within a given time period. The calculation presented for the temporal difference is somewhat similar to the accumulative difference pictures' calculation presented by Ramesh, Rangachar and Brian. They implemented the Lucas and Kanade method for calculating the optical flows.

A temporal filter is then applied to the results obtained from the algorithm of optical flows calculations. Combining the y-component and x- component together with the temporal difference image, they obtain the salient object. They have also identified some weaknesses for their algorithm in their paper which are:

• An object that moves in different direction such as moving in a zigzag cannot be detected because their assumption of the object moving in a consistent direction was contradicted.

• If the object stops a while, the algorithm would lose track of it, however if it begins to move again, it can be redetected.

D. Feature Extraction

After having all the moving objects labelled and segmented, the next step is to understand what the object is or in other words, to recognize them. In some cases, we may want to classify them accordingly. However, the classification engine is dependent on the application where the human motion detection system is applied at.

Here we would describe one of the ways to provide inputs into the classification engine. Many features can be used as inputs into the classification engine depending on how we would like to distinguish the objects that are moving in the area of interest. In this research in particular, we would like to distinguish human from other moving objects. To achieve this, Song, Goncalves, Feng and Perona, have used a probabilistic structure to model a human body. Using point tracking algorithm, they can pose estimation on the human motion to distinguish them from other moving objects. Their work refers to Johansson's stimuli where each joint of the body is shown as a moving dot which is the basis of the point tracking algorithm. Moore stated in his writings that there are many methods of tracking the moving dots or points. According to him, the Kanade-Lucas-Tomasi algorithm stands out for its simplicity but however suffers several flaws. Thus, Moore had implemented a derivation technique based on the work of Birchfield. An improvement work had also been carried out by Zivkovic and van der Heijden where they suggested a way to improve on the standard Kanade-Lucas-Tomasi algorithm. In their papers, they focus on the initial selection of the features points and suggest a method to improve the selection process to reduce detection errors.

Thus, to perform a point tracking algorithm, a motion detection algorithm would have to first initialize the feature points on the segmented foreground objects and track their movements using either the Kanade-Lucas-Tomasi algorithm or using a derivation of the Kanade-Lucas-Tomasi algorithm as researched by Birchfield. After tracking the movements of these points, their position and velocity of their movements resulting from the tracking algorithm would be used to map them with the model structure of human body.

Some research have also been carried out on tracking algorithms such as Andrew and Kentaro had presented a tracking method using probabilistic metric space in their papers. Their method has several valuable properties such that it provides alternatives to standard learning methods by allowing the use of metrics that are not embedded by vector space. It also uses a noise model that is learnt from training data. Lastly, it needs no assumption of probabilistic pixel wise independence.

IV. RESULTS & DISCUSSIONS

The final chapter would comments on the results obtained and discuss the several advantages and drawbacks for the algorithms implemented and compared. Here, we will also look into future works that can be carried out to further research in this area or this topic.

The system presented herein is successful as a robust detector of human motion. However, there is still much progress to be made, especially to handle shortcomings that are not exercised by the two video sequences used for performance measurement.

One such shortcoming is that the model of human motion contains a static representation of what a human figure should look like. Although this static representation was built using statistics over a certain period of time, the model is a time-average of these statistics and inherently cannot contain information about the periodic nature of the human gait. Thus, any moving object that has roughly the shape of a human and moves with the speed expected of a human will be detected as a human.

A second limitation is that of the background subtracter. We make the fundamental assumption that the background will dominate most scenes and will be stationary. This is unacceptable for more crowded environments where surveillance is desired. In addition, the requirement for a stationary background rules out situations where the camera is in motion, such as on vehicles or robotic cameras.

V. SCOPE OF FUTURE WORK

There are a variety of enhancements that could be made to this system to achieve greater detection accuracy and increased robustness:

• Objects could be tracked between frames rather than simply performing human motion detection on single frames.

• As described above, the current model of motion does not take into account the time dependent nature of a walking human. Much greater accuracy would be possible with a detector and model that takes advantage of this periodicity in time.

• The current background subtraction algorithm can be confused by fast lighting changes or moving shadows. A better algorithm would use a technique based on optical flow for the image segmentation. This approach would also allow the camera to be in motion relative to the background.

• Modeling different types of human motion should be explored, such as walking seen from different viewpoints. In addition, other forms of motion such as running should be modeled so that the detector can reliably detect and classify these cases.

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