Frame Differencing with Post-Processing Techniques for Moving Object Detection in Outdoor Environment

Intan Kartika and Shahrizat Shaik Mohamed

School of Science, Information & Engineering
KDU College
Penang
MALAYSIA
intan_lim@hotmail.com

***Abstract*— Background subtraction is a process of separating moving foreground objects from the non-moving background. This technique must adapt to the illumination, motion and the geometry background changes such as shadow, reflections, and etc. In this paper, one of the traditional background subtraction techniques which is frame differencing (FD) is conducted to detect the moving object in outdoor environment. The result of moving object detection using FD is not perfect that enable this research to experimental two existing post-processing techniques which are adaptive threshold and shadow detection in HSV color space for outdoor environment. Experimental result showed that FD with post-processing techniques are able to detect good moving object in outdoor environment with no shadow based on accuracy improvement data.**

***Keywords*— Background Subtraction, Frame Differencing, Adaptive Threshold, Shadow Detection.**

I. INTRODUCTION

With the rapid growth of technology recently, the computer vision based system has been established and implemented in many applications. Computer vision is an artificial intelligence that makes computer can see like a human. One of the computer vision's fundamental tasks is moving object detection.

The main idea of moving object detection system is to extract the moving foreground objects from the static background. However, dynamic scene changes such as shadows, illumination changes, camera noise and etc make the objects detection have less accuracy.

There are many researches have been done for object detection. Each technique proposed from low to high complexity and has its own strengths and weaknesses. In addition of that, different techniques will resolve different issues and challenges on background subtraction.

The objectives in this project are to create simple, accurate and less complexity traditional background subtraction technique with post-processing for moving object detection in outdoor environment with no shadow.

II. BACKGROUND STUDY

Background subtraction is a popular technique used to detect the moving object from a stationary camera. It is done by comparing the current frame and the background.

There are two main categories of background modeling technique which are non-recursive technique and recursive technique. Non-recursive technique uses sliding window approach to estimate the background and store the previous frame in a buffer [1]. It is a very adaptive technique but requires large memory. In comparison to non-recursive technique, recursive technique requires less memory. It only stores one frame as the background and updates it time to time. The disadvantage of this technique is if there is any error at the background model, it needs longer time to disappear [2]. Example of non-recursive technique are frame differencing, median filter, linear predictive filter, and non-parametric model [1,2]. In recursive technique, there are several techniques apply namely as approximated median filter, Kalman filter and Mixture of Gaussian (MoG) [1,2].

Based on the past literatures, traditional background subtraction technique alone not sufficient enough to produce good moving object detection. Therefore, many post-processing techniques have been invented and tested in order to satisfy the demand such as shadow detection, morphological technique, blob processing, optical flow among others [3, 7].

III. METHODOLOGY

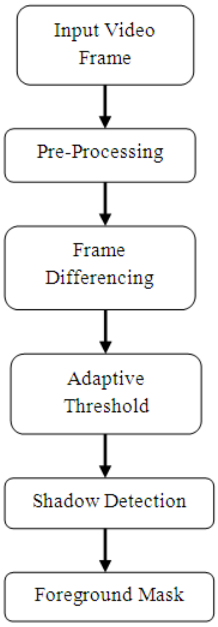


Fig. 1 Block Diagram of FD Background Subtraction Method with Post-Processing

Fig. 1 shows the flow of the FD background subtraction method with post-processing. The flow starts from processing the raw video input frame. The input frame will be converted it into a simpler format for the next step at pre-processing stage. Next, background will be modeled and updated in background modeling using FD technique. Unidentified pixel will be validated in order to attain the target moving foreground object. In post-processing, adaptive threshold method will be applied in a way to provide a better foreground detection results. Finally at shadow detection stage, process of shadow removal will be performed to produce more accurate foreground mask.

A. Background Modeling

Background Modeling is a process of estimates the background of the input video, model the background and finally updates it continuously.

FD is the simplest form among of background subtraction method. It is done by comparing the pixel from the current frame and the previous image as the background [4].

$$\left| \text{frame}_t - \text{frame}_{t-1} \right| > T \tag{1}$$

The current frame will be subtracted from the previous frame and the pixel difference will be compared with a threshold as given in (1). Threshold is a value to determine whether the given pixel is foreground or background. If the absolute difference between the two frames is greater than the threshold, the pixel will be assumed as part of the foreground. Otherwise, it is considered as background pixel. The main consideration for this technique is on how to determine the suitable threshold value.

The advantage of this method is its highly adaptive background model and less computational load. In fact that the background is based on the previous frame, it can adapt to changes in the background at 1/fps (one frame period) [5]. In the other hand, if the objects motionless for more than one frame period, it will be considered as part of the background. Another fatal consequence using frame differencing is that uniform moving object will be detected as background.

B. Adaptive Threshold

Adaptive threshold (AT) takes grayscale or color image as input and outputs a binary image. This technique examines the intensity of a certain size of the neighborhood pixel [6]. It takes the average of the neighborhood pixel intensity as the threshold. The theory behind this technique is that smaller area of an image will have approximately uniform illumination [7]. The size of the neighborhood pixel should be sufficient enough to cover the foreground and background pixels. Otherwise, poor threshold value will be selected.

This technique works well for stationary image segmentation. In this paper, this technique is adopted from [7] and proposed to be used for video stream which consists of a collection of images. It will be applied with assumption that the foreground object exist in the current frame. The result from this technique will then be merged with the FD result.

C. Shadow Detection

Generally shadow detection (SD) best to be applied with color space based on the idea that the shadow will be in the darker regions.

HSV (Hue, Saturation, Value) color space is corresponding closely with the human perception of color. It separated the luminance and the chrominance. The saturation and value components will be used to segment the moving object and suppress the moving shadow [8, 9].

Firstly, the values of the HSV components are obtained from both the current frame, I(x,y), and the background frame, B(x,y), and then applied into (2), (3) and (4) referred to [8,9]. It will be classified as shadow pixel if it meets the condition given in (5) [8,9].

$$v = \frac{I_v\,(x,y)}{B_v\,(x,y)} \tag{2}$$

$$s = I_s\,(x,y) - B_s\,(x,y) \tag{3}$$

$$h = |I_h(x,y) - B_h(x,y)| \tag{4}$$

$$S(x,y) = \begin{cases} 0, & \text{if } (\alpha < v < \beta)\ \&\ (s < T_s)\ \&\ (h < T_h) \\ 1, & \text{otherwise} \end{cases} \tag{5}$$

where,

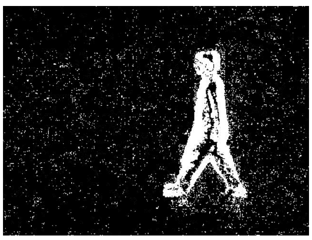
- v = value components
- s = saturation components
- h = hue components
- α , β = value threshold ($0 < \alpha < \beta < 1$)
- T_s = saturation threshold
- T_h = hue threshold

By setting the shadow pixel to 0 (black), it will be easier to remove it when it is merged with the result attained from the merging of FD and adaptive threshold.

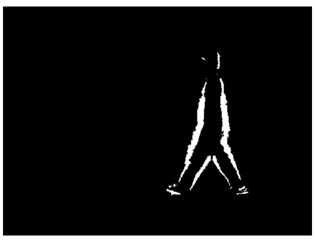
IV. RESULT & DISCUSSION

Experiment is conducted using an outdoor video with resolution of 640 x 480. As mentioned in part III. A, it is necessary to determine a suitable threshold (T) value where the foreground and background pixel will be separated completely. In this paper, experimental begins by applying predetermined threshold. The output will be evaluated based on the accuracy, true positive rate (TPR) and false positive rate (FPR). Fig. 2 (a) shows the result of object detection using low threshold value (from 1 to 7) where most of the background pixels classified as foreground pixels. In the other hand, Fig. 2 (b) shows the result for high threshold value (above 15) where part of the object being cut off and become worse.

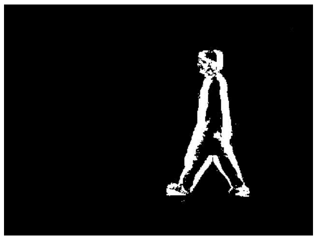
From the experimental result shown in Fig. 3, a range of threshold value from 8 to 14 is acceptable. This range of threshold value gives lower FPR, medium TPR but high accuracy within 95%. This selected range will be used for the next stage.



(a)



(b)



(c)

Fig. 2 Result of Object Detection by Varying the Threshold Value (a) T = 3 (b) T = 55 and (c) T = 10

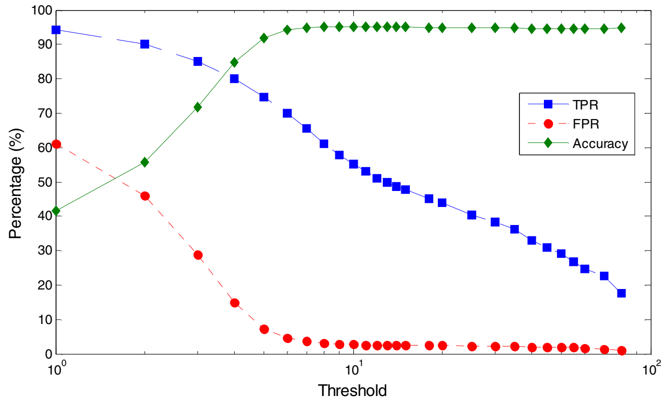


Fig. 3 TPR, FPR and Accuracy percentage with different threshold value

Based on the experimental conducted by testing FD alone, it produce inaccurate object detection as shown in Fig. 2(c) where some of background pixel has been classified as foreground pixel. In order to increase the accuracy of the result, adaptive threshold is applied.

For adaptive threshold, the threshold value depends on the neighborhood pixel intensity and size of the neighborhood pixel needs to be considered. Next experiment will concentrate using T = 10 as reference. In Fig. 4, it is shown that by using equal neighbor pixel size (N) from (55x55) to (69x69) will grant highest accuracy. For the next step, neighbor pixel size of (65x65) with accuracy 96.89% has been selected from the range as shown in Fig. 5.

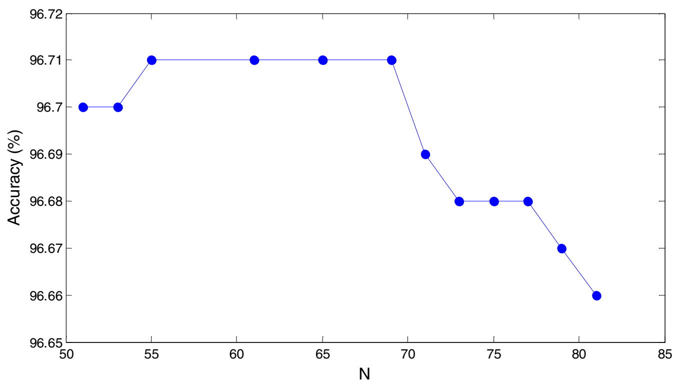


Fig. 4 Neighbor Pixel Size vs. Accuracy

Fig. 5 Neighbor Pixel Size of 65x65

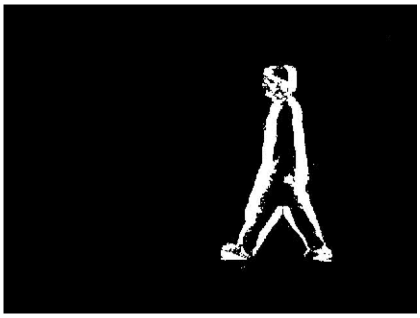
Shadow detection has been applied to increase the moving object detection accuracy. The four parameters, α, β, T_s and T_h, have been varied one at a time with the reference value described in [8]. Based on the experiment results for this project, the best accuracy value achieved when $\alpha = 0.5$, $\beta = 0.9$, $T_s = 0.05$ and $T_h = 0.2$ as shown in Fig. 6. The parameters selected should consider that shadow will be always darker than the object while maintain the original color. This additional post-processing technique is proven successfully improved the accuracy of moving object detection from 96.89 % to 96.95% for outdoor environment.

Fig. 6 Shadow Detection

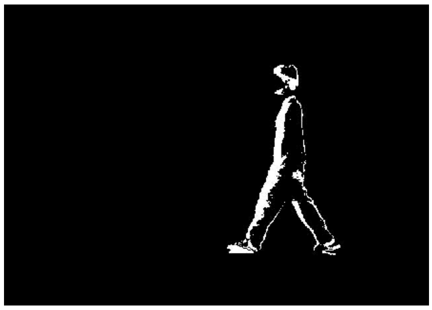
Fig. 7(a) shows the original input frame 105th. Fig. 7(b) shows the result of traditional background subtraction FD by subtracting frame 105th with the previous frame 104th as the background. Fig. 7(c) is the output of FD with adaptive threshold. At this stage, the result shows that shadow has been captured as foreground. Therefore, the output from this technique will be merged with the output from the shadow detection. This technique proved that shadow can be eliminated perfectly as shown in Fig. 7(d).

Through all the experiments, the accuracy is increasing stage by stage when different value of threshold been selected as shown in Fig. 8. FD is the accuracy line for traditional background subtraction frame differencing alone. FD+AT is the accuracy line after adaptive threshold technique is performed while FD+AT+SD is the accuracy line for the final foreground mask after shadow detection stage.

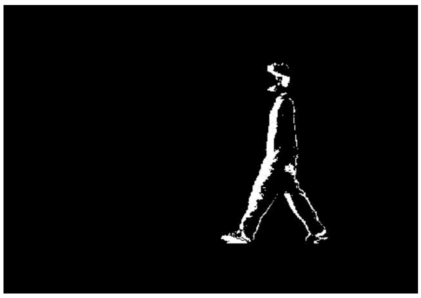
(a)



(b)



(c)



(d)

Fig. 7 Moving Object Detection with (a) Original Video frame, (b) Output of FD (c) Output of FD with adaptive threshold and (d) Output with adaptive threshold and shadow detection

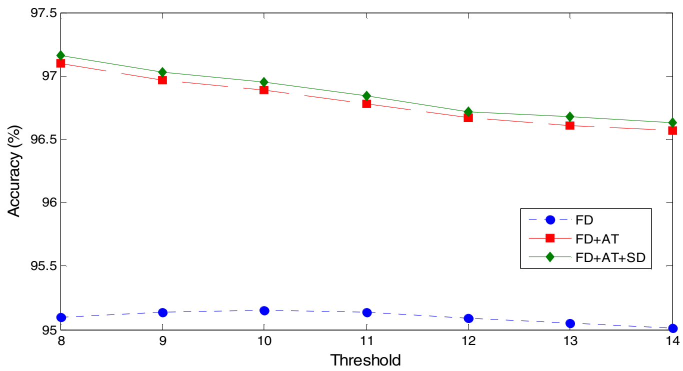


Fig. 8 Threshold vs. Accuracy for Moving Object Detection for FD and post-processing techniques

V. CONCLUSION

As a conclusion, simple traditional FD can be enhanced to detect good moving object detection by introduced post-processing techniques. In this paper, the results show that by adding two existing techniques which are adaptive threshold (AT) and shadow detection (SD) in HSV color space, it is capable to produce good moving object detection with no shadow for outdoor environment. In future, it is good for other researcher to test these similar techniques for indoor environment and other traditional background subtraction method such as Median Filtering (MF) and Mixture of Gaussian (MoG).

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