Automated Vehicle Monitoring System

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Abstract— **An automated vehicle monitoring system is proposed in this paper. The surveillance system is based on image processing techniques such as background subtraction, colour balancing, chain code based shape detection, and blob. The proposed system will detect any human's head as appeared at the side mirrors. The detected head will be tracked and recorded for further action.**

Keywords— Sueurveillance, Suspicious Activities, Video Image, Vehicle, Short Message

I. INTRODUCTION

Safety is one of the essential aspects of human lives. Safety assurance that someone has could affects his/her quality of life. Safety assurance also deal with things that belong to us. This paper will particularly focus on monitoring parked vehicle based on image processing mechanism.

Numerous methods have been proposed for an anti-theft system for a vehicle. Song *et al*. [1] proposed a system based on sensor network, where car sensor form a network which will monitor unauthorized vehicle movements. However, this system may not work well in a sparse parking area in a sense that sensors cannot generate a good enough network for protection purposes. An anti-theft system based on 24 GHz frequency intrusion sensor was proposed by Hori *et al* [3] to sense object movement. However, this system is still does not has any practical use yet.

A system that detect an unlocked door and enabled the owner to monitor the vehicle position through GPS once the engine is started was developed [4]. While in [5], a combination of face detection and finger print recognition were used to complement the car intrusion avoidance system. The system will stored the owner's face image which will act as a reference image to compare with the face image of the driver. In addition, fingerprint of the driver will be scanned although the paper did not mentioned clearly on how these being implemented. The drawback of this system is that the system will fail to recognize suspicious activity such as breaking windows.

Approach introduced in this paper took different mechanism where motion detection algorithm is used. Through the motion detection algorithm several parameters will be extracted which will be used to determine the status of the current frame whether it contains suspicious activity. Movements near the vehicle will be monitored and recorded, where an intrusion is considered when activity such as breaking the glass windows of the vehicle is taken place. The system will notify the owner once suspicious activity is detected.

The rest of this paper is organized as follows. Section 2 describes the approach of the system, while the detailed implementation will be presented in section 3. Section 4 concludes this paper and suggest the future research directions.

II. REAL-TIME SURVEILLANCE SYSTEM

The proposed system consist of two main modules: (1) image processing module and (2) database module. Moving human will be detected through motion detection technique in the first module. A notification will be sent to the owner through short message service when a suspicious activity is detected. A centralized database will stored the current frame and status of the vehicle. However, this paper focuses only on the image processing module as shown in the following figure.

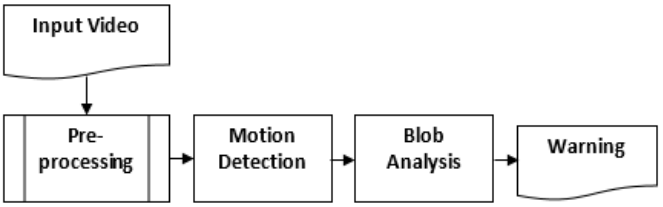


Fig. 1 Image processing module

A. *Image Processing Module*

Stream of real-time video captured using two webcam monitoring right and left side window is feed into the system. The video is capture in resolution of 480x640 with fifteen frames per second rate in RGB color space. For simulation purposes, the processed video is a recorded video. Each frame will go through the first stage in the system which is a pre-processing stage

The input video will be processed on frame by frame basis. At first each frame will be converted to grayscale image for efficiency purposes [7]. Region of interest (ROI) will be defined in this stage, where it will define the processing area. In this case, our processing area is the respective vehicle's window area. The boundary of ROI also could be used to determine the distance of an object from the vehicle.

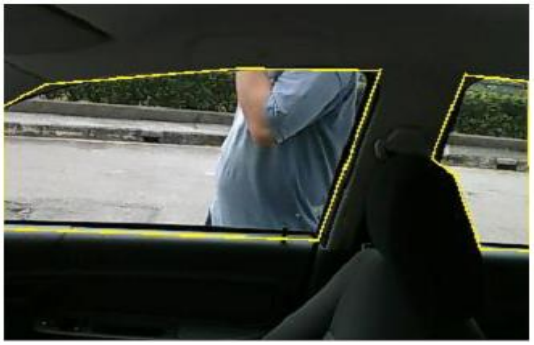


Fig. 2 Sample ROI

B. Motion Detection

Produced output from pre-processing stage is further processed in motion detection stage in order to locate a moving object in the scene. Background subtraction method is used for motion detection purposes [8]. Color balancing mechanism is required before background subtraction technique. Color balancing process is necessary to reduce or minimize the effect of different level of light intensity on the image [15]. Color balancing is important in motion detection stage as area with different light intensities can be detected as moving object on the scene. Color balancing technique used in this paper is based on gray world algorithm which stated that average of three color channels is neutral gray [13].

Residual image produced by background subtraction could give an indication whether there is moving object candidate in the scene. Any residual which located outside region of interest will be ignored. A pre-defined threshold value will be used to sufficiently remove noise from the residual image and at the same time preserve any meaningful information. This filtered residual image will go through a blob processing stage.

C. Morphological Operations and Filtering

Operation such as morphological operation, blob filtering and monitoring will be carried out in blob analysis stage. At the first step, the residual image will dilated and eroded respectively [9]. Erosion operation is done to remove any unwanted noise in the residual image. While dilation operation is aiming to fill the holes inside blobs, result in more solid blobs. After the system performed morphological operations, blobs that formed will go through filtering process.

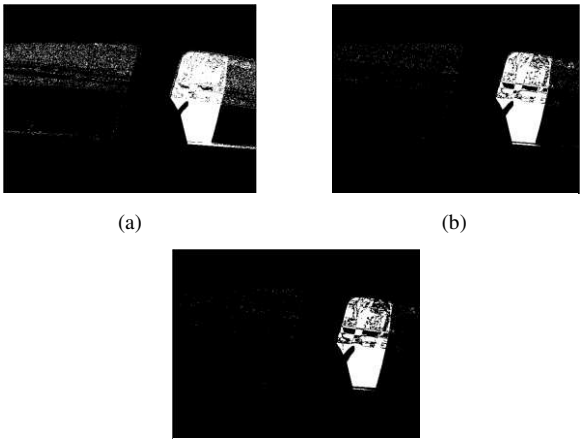
Information such as blob position and width-length ratio is utilized in blob filtering process. Filtering through ratio is used with assumption that human object will possess bigger height value compare to the width. Blob position is determined using the location of its centroid. The system will removed a blob that does not intersect with lower boundary of ROI. This step was based on assumption that object that does not intersect with lower boundary is located on "safe distance" from the vehicle. The system will monitor the position of the centroid to classify whether an object is moving or stay still object.

System will run head-shoulder similarity check when there is a blob that keeps static for certain period of time. Similarity check is based on predefined head-shoulder shape which described using chain code [10, 11]. These two chain code series is compared using Chain Code Histogram and Chain Code Distance Vector.

III. EXPERIMENTAL RESULT

At the beginning of the process, the system will received stream of video input which will be converted into grayscale color space. ROI will be defined to specify the extracted area and determine the position of an object relative to the vehicle. It will allow the system to be more efficient and robust. Color balancing is applied before background subtraction mechanism which compensate the variation of intensity in the current and reference frame. Binary residual image will be produced from this motion detection stage. Sample result of residual image is shown in Fig. 3.

Beside noises reduction, the effect of different threshold value also can be seen in the main blob or silhouette of the person. In residual image with higher threshold value, more holes are observed on the blob. Less holes or more compact blob is seen on residual image with smaller threshold value. This shows that threshold value needs to be determined by compensating between noise and compactness of the blobs. In this work, threshold value of 30 is used. This value was based on several tests and consideration to sufficiently remove noises and preserve meaningful information.

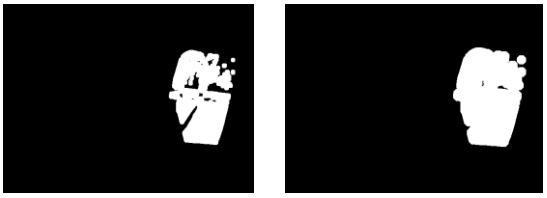


(a) (b)

(c)

Fig. 3 Residual image with various threshold value: (a) t = 10, (b) t = 30, (c) t = 50

The residual image then went through morphological and filtering process. Morphological operation used here is dilation followed by erosion. Filtering process is using several criteria such as ratio between height and width of the blob, blob size and blob position compared to upper and lower boundary of ROI. Sample result of morphological operation is showed in Fig. 4, while there are still some holes and crack, but the blob can be considered sufficient to represent the moving object on the scene.



(a) (b)

Fig. 4 Eroded image with: (a) disk size of 12, (b) disk size of 6

A scene where there is a person walking beside the monitored a vehicle is illustrated in sequence of frames as shown in Fig. 5. In this outdoor environment, color balancing becomes important feature since the difference of light intensity across the scene is likely to happen and affect the motion detection algorithm. The person walk and stop in front of the vehicle's window for a moment. At the time an object stand still for a pre-defined moment in front of the window, the system will perform a head-shoulder check and record the current scene. The recorded scene is displayed in centralized website monitoring system.

In Fig. 6, sequence of frames is shown to illustrate the moving object detection where there is two meaningless moving objects and one suspicious activity. In this video, there is a motorcycle that pass by and a car that moving out form its car park (at the upper-right position). These kind of movement not happened near the vehicle, so the system will ignore these movement as they are less possible to do any harm to the monitored vehicle. The other movement recorded is movement of a person that walk beside the car and look inside the car. This action can be categorized as suspicious activity that possibly do any harm to the vehicle.

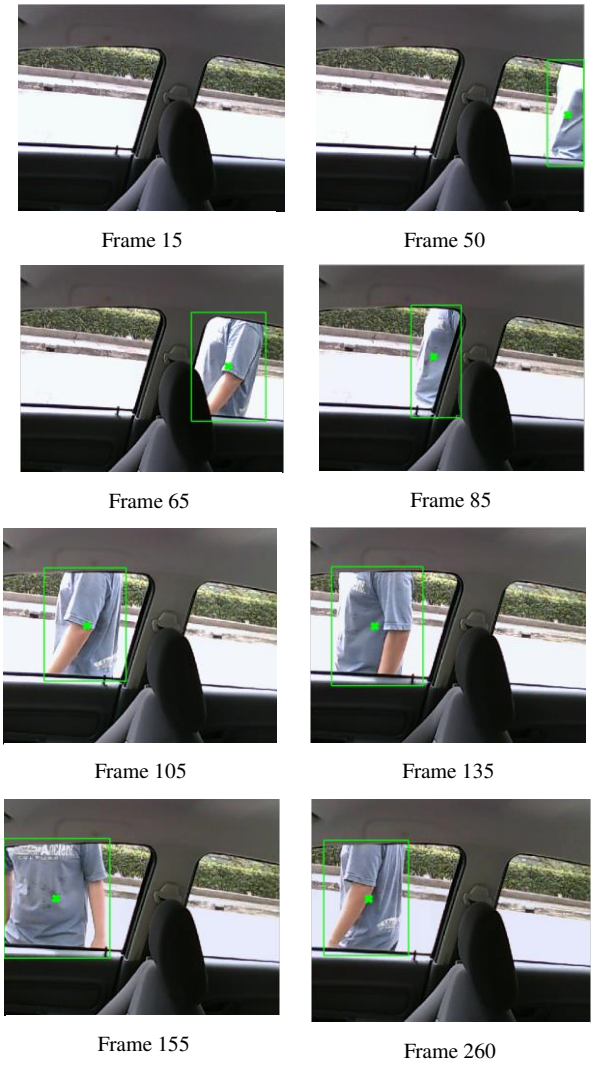


Fig. 5 Moving human object passes by the vehicle

The motion detection is based on monitoring the position of blob's centroid. Centroid is used since it marks the central point of the blob, therefore slight changes in blob shape or position will not cause many changes in centroid position. The centroid is recorded and compared frame by frame. When centroid of a blob remains relatively at the same place, system will start to mark it as a possible suspicious activity around the vehicle.

Centroid monitoring may enable the system to keep track the object around the vehicle, but it is not enough to conclude that certain object can be categorized as suspicious activity. Therefore the system employs head and shoulder detection which is done using chain code. Chain code will provide the series of code to the system which describe the boundary line of a blob. The problem may arise when boundary shape is has similar shape as reference shape or it has chain code series that has similar code with reference code. Therefore, predefined similarity value is set to 40% similarity index. This value is set to still able to capture the blob that actually has head – shoulder on it, but has not similar chain series.

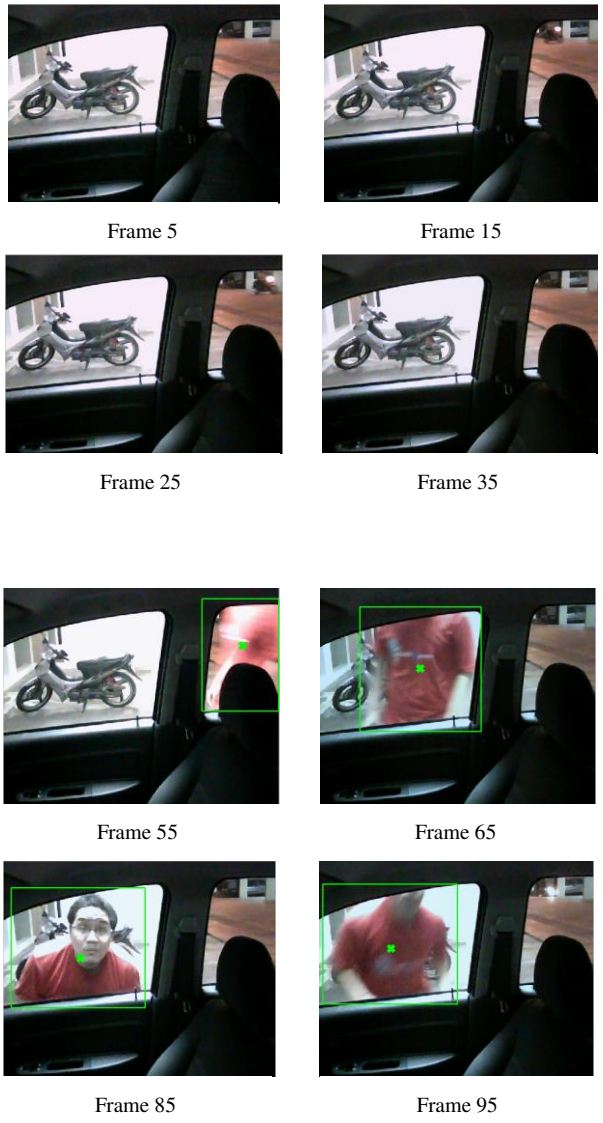


Fig. 6 Moving human object passes by, along with other moving vehicle and motorcycle

When series of chain code satisfy the similarity level, the system will categorize the blob of having head and shoulder on it. Any detected head will be stored as a database for further action.

IV. Conclusions

Image processing algorithms have been implemented to build a real-time vehicle surveillance system. The surveillance system was based on background subtraction and chain code to detect head shoulder shape. Motion detection with background subtraction produced sufficient result although it is sensitive to lights and shadow. Shape comparison result is quite satisfying and enough to be used in shape detection.

Some recommendations for future works can be used to improve the system in the future development. In motion detection stage, the system can be improved to be more robust especially in facing change of lights and shadow. Improvement also could be done in blob analysis stage by employing other filtering criteria. Detection scheme may employ face detection or combine with face recognition. Warning system through SMS also can be integrated into the system. Thus, any detected head will be captured and sent to the vehicle's owner.

The surveillance system also may use GPS to enhance the surveillance system. Other possible improvement is integration between vehicle surveillance systems. This integration will create such a surveillance network among the vehicle which may provide information when the respective vehicle cannot provide.

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