Vision-based Detection and Tracking of Moving Target in Video Surveillance

Sabri M. A. A. Ahmed
College of Computer Science & Information Technology
Sudan University of Science and technology
Khartoum, Sudan
sabri_alamin@hotmail.com

Othman O. Khalifa
Electrical and Computer Engineering
International Islamic University Malaysia
Malaysia
khalifa@iium.edu.my

Abstract— **In this paper a real-time detection and tracking of moving targets is presented. The scheme involved four phases. Phase one: Object segmentation which used to identify the foreground objects from the background by using background subtraction based on temporal differencing and finding the average background model. Phase two: Object recognition used to identify the foreground objects that should be tracked by using simple blob detection. Phase three: Object representation which takes the outcome from phase two. It computes the recognized object to be tracked. Phase 4: Object tracking that used Kalman filter. The results show that the tracking system is capable of target shape recovery and therefore it can successfully track targets with varying distance from camera or while the camera is zooming.**

Keywords-component; video surveillance; detection; tracking; moving images, object detection.

I. Introduction

All Intelligent video surveillance makes it possible that the computer can automatically locate, recognize and track the monitoring changes by the automatic analysis of image sequences which is captured by cameras in natural conditions. A generic video processing framework for smart algorithm is shown in Figure 1. This framework provides a good structure for Robust Vision-based Moving Target Detection and Tracking System because it can be consider as a surveillance applications.

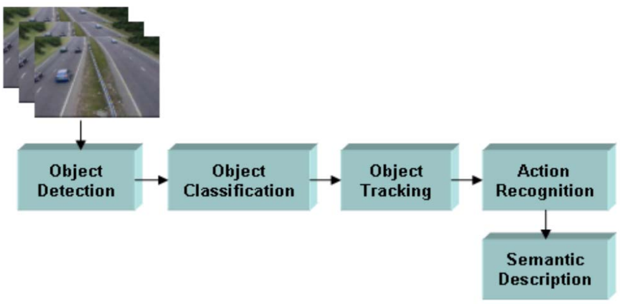

Figure 1: A Typical Framework for Video processing Techniques

Each application needs different requirements to use smart video processing by efficient way. However, the common first step between all applications is finding regions that correspond to moving objects. Motion detection is a difficult problem to process reliably because the challenges changes in scenes such as motion of trees and rain; so there are many techniques used for moving object detection are background subtraction, optical flow, statistical methods and temporal differencing [1]. The main goal of these techniques is: segmentation of an image, or video stream, into object vs. non-object regions. This is based on matching regions of interest to reasonably detailed target models. Another requirement of these systems is, in general, to have a reasonably large number of pixels on target [2].

Background subtraction is a common technique used for motion segmentation in static scenes. To detect moving regions this technology subtracts the current image pixel-by-pixel from a reference background image that is created by averaging images over time in an initialization period. The pixels where the difference is above a threshold are classified as foreground. After creating a foreground pixel map, some processing operations are performed to reduce the effects of noise and enhance the detected regions. With new images over time the reference background is updated to adapt to dynamic scene changes [2].

The simple version of this scheme where a pixel at location (x, y) in the current image It is marked as foreground if

$$|I_t(x,y) - B_t(x,y)| > T \qquad (1)$$

is satisfied where T is a predefined threshold. The background image Bt is updated by the use of an Infinite Impulse Response (IIR) filter as follows [2]:

$$B_{t+1} = \alpha I_t + (1 - \alpha)B_t \qquad (2)$$

The foreground pixel map creation is followed by morphological closing and the elimination of small-sized regions.

Although background subtraction techniques perform well at extracting most of the relevant pixels of moving regions even they stop, they are usually sensitive to dynamic changes when, for instance, stationary objects uncover the background (e.g. a parked car moves out of the parking lot) or sudden illumination changes occur [2].

II. Proposed Solution

Generally, there are four phases involved in this framework, which are starting Phase one: Object segmentation which used to identify the foreground objects from the background by using background subtraction. Phase two: Object recognition used to identify the foreground objects that should be tracked by using simple blob detection. Phase three: Object representation this phase takes the results of phase two; object recognition, after that computes the required date for each recognized object. Phase 4: Object tracking this phase used to tracking detected object by using Kalman filter method by using results of the phase three to track the location and extent of the object

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being tracked [8] . These phases are depicted in the Figure bellow.

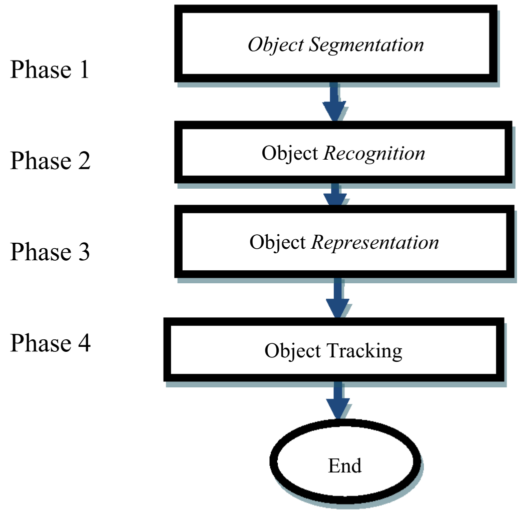


Figure 2 shown the phases of framework

III. FRAME WORK DESIGN

As we have seen above framework that contents 4 main phases. The following subsections will describe each phase briefly.

A. Phase 1: Object Segmentation

Segmentation is the process of separating the foreground objects from the background of the video **s**equence [8]. The updated background model used this formula:

$$B_t = \gamma u_t + (1 - \gamma) B_{t-1} \qquad (3)$$

where $\gamma \in [0,1]$ is a learning rate parameter.

The pixels in each frame are classified as either background (0) or foreground (1) by a simple a threshold values:

$$F_t = \begin{cases} 1 & if\ |u_\tau - B_\tau| \\ 0 & otherwise \end{cases} \qquad (4)$$

Finally, the foreground image is cleaned a little to close small gaps:

$$F_t := F_t \circ D_p \qquad (5)$$

where $\circ$ is the morphological closing operation and D_p is a disk of radius p.

B. Phase 2: Object Recognition Or Detection

Recognition or detection identifying which objects are of interest to the tracking based on simple blob detection [8]. Blob detection refers to mathematical methods that are aimed at detecting regions in a digital image [9]. Blob detection was used to obtain regions of interest as the "recognized" object to be tracked [8].

C. Phase 3: Object Representation

This phase takes the results of phase 2 object recognition; then computes the date for the recognized object to be tracked. A bounding Box of a size of each blob will be shown.

D. Phase 4: Object Tracking

This phase used to tracking detected object by using Kalman filter method depend on the phase 3 results to track the plocation and extent of the object being tracked [8][10][11][12]. Kalman filter were used which is Point Tracking method used to detected single object in sequence of frames base on this rule: if f and h are linear functions and the initial state X and noise have a Gaussian distribution then the optimal state estimate is given by the Kalman Filter: prediction and correction Prediction: this step uses the state model to predict the new state of the variables:

$$\bar{X}^t = DX^{t-1} + W$$
$$\bar{\Sigma}^t = DX^{t-1}D^T + Q^t \qquad (6)$$

where D is the state transition matrix which defines the relation between the state variables at time t and $t-1$. And Q is the covariance of the noise W.

Correction: this step used the current observations Z_t to update the object's state:

$$K^t = \bar{\Sigma}^t M^T [M\bar{\Sigma}^t M^T + R^t]^{-1}$$
$$X^t = \bar{X}^t + K^t \underbrace{[Z^t - M\bar{X}^t]}_{\upsilon} \qquad (7)$$

$$\Sigma^t = \bar{\Sigma}^t - K^t M \bar{\Sigma}^t \qquad (8)$$

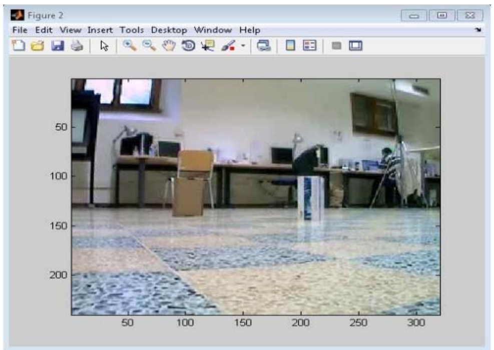
where v is called the innovation, M is the measurement matrix, and K is the Kalman gain.

The final phase in the processing of the framework is the visualization. It is an option phase useful to provide a minimal visualization to see and follow the performance of tracking and it was applied in two stages. The first stage of visualization was implemented by simply displays the current frame showing the current detection of tracked object by using rectangle with red color and current estimation of tracked object by using rectangle with green color. The second stage of visualization was implemented by displaying only object that is tracked by a crop the area around it in video and then displays cropped area in a separate figure or window. This visualization useful on focusing on the tracked object and ignore many useless details on the video.

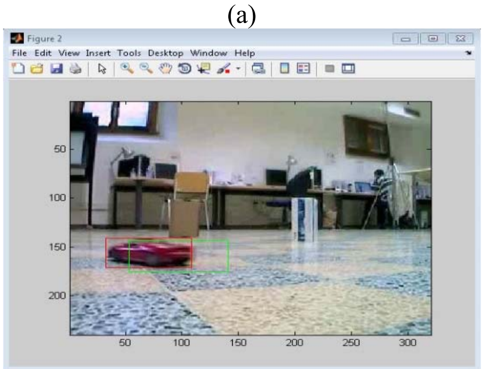
IV. IMPLEMENTATION AND RESULTS

Depending on the framework we used Matlab 2009a with three videos recorded from surveillance cameras; the green rectangle shows the prediction or estimation position of tracked objects in the frame and the red rectangle show the current position of tracked objects in the frame.

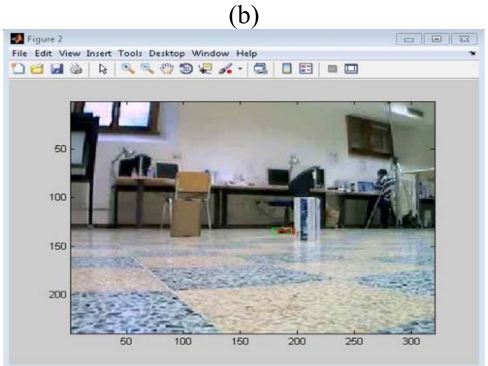
The first video is recorded under laboratory conditions download from [10]. The video contains a single moving target: a red car. The videos are taken from a number of viewpoints and are specifically designed so that background subtraction can work well on them. The results in Figure 3 Shows the results movement of the car can be detected perfectly.



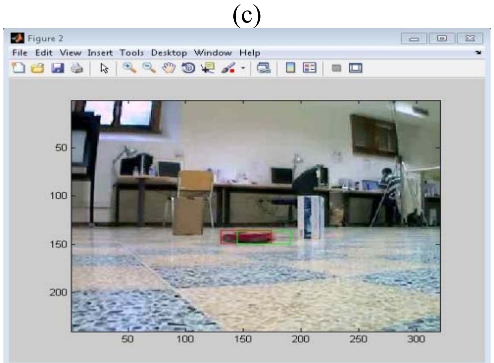
(a)



(b)



(c)

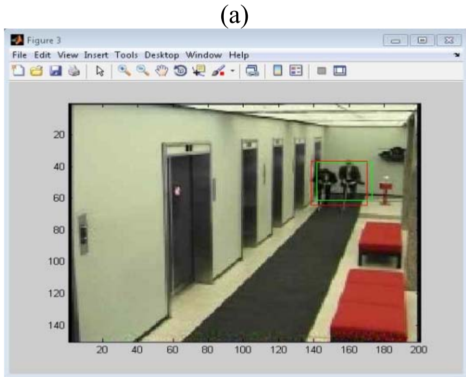


(d)

Figure 3: The movement of car can be detect perfectly. In (a) shows the background image and in (b), (c), (d) shows the detect object by using red rectangle and estimation position of object by using green rectangle

The second video is recorded from a surveillance camera in the hotel. They contain a multiple target movement three persons. The videos are taken from a hall where two persons running in it; without specifically designed for the environment. The results in Figure 4 Shows the movement can be detected in the beginning; and when an uproar movement the framework could not determine the movement of those objects.

(a)



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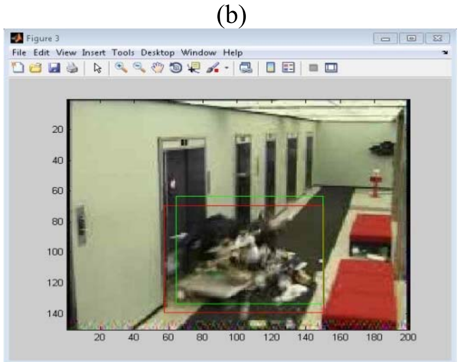
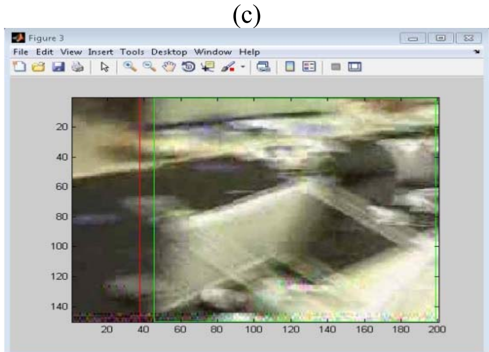


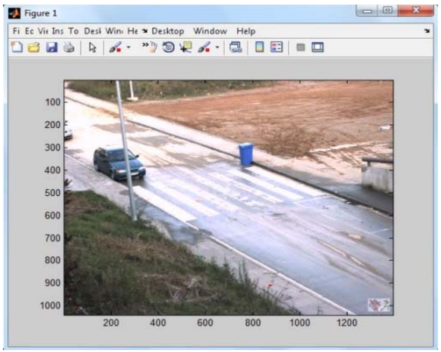
(c)



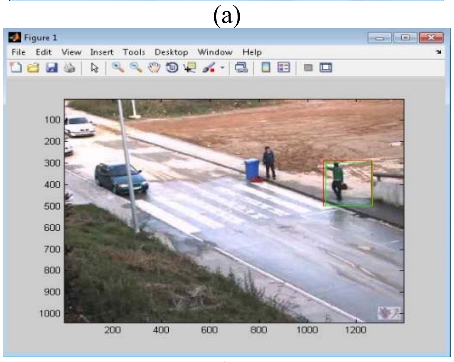
(d)

Figure 4 The movement can be detect from surveillance camera in hotel Figure 4.a shows the background image and (b), (c), (d) shows the detect object by using red rectangle and estimation position of object by using green rectangle

The third video, as shown in Figure 5, is recorded from a surveillance camera in the street. They contain a multiple target movement two persons and two cars. The videos are taken from a street where two persons walking on the sidewalk; without specifically designed for the environment.



(a)



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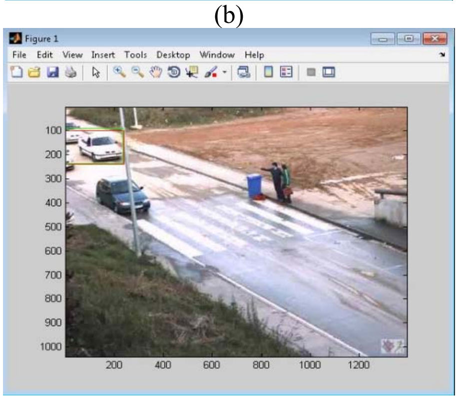
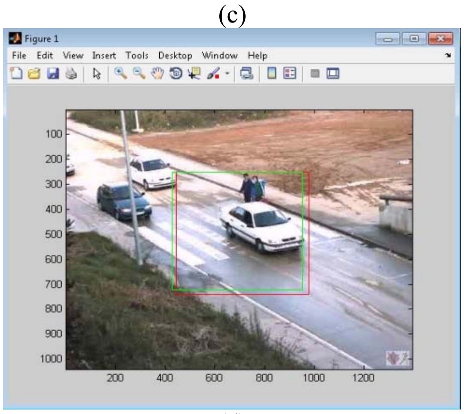


(c)



(d)

Figure 5. The movement can be detect from surveillance camera in street (a) shows the background image and (b), (c), (d) shows the detect object by using red rectangle and estimation position of object by using green rectangle

V. CONCLUSION

Moving target detection and tracking is an important research field of video processing for its great potential in Military and Civil applications. In this paper the proposed framework can used to detect important objects and ignore the others based on size; and tracked the object movement in the video. The results shown that the tracking can work well on a single object and give good results; even when the part of the target object is hidden behind another object.

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