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# Knowledge Extraction from Objects Trajectory

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***Abstract ---*** Observing people is currently one of the most active application areas in computer vision. This strong interest is driven by a wide spectrum of promising applications in many areas such as virtual reality, smart surveillance, perceptual interface, etc [1]. This paper presents the concept of knowledge extraction from object trajectory. A fixed camera is used to capture video data in an enclosed environment. Three video samples are utilized in this study and the promise is to differentiate between these motion types based on information extracted from motion trajectory.

***Keywords*** – object trajectory, knowledge extraction.

## I. INTRODUCTION

THE capability of automatically monitor human activities using computers in security-sensitive areas such as airports, borders …etc is great interest to the police and military [1]. Moreover, creating such abilities will save tremendous human effort in sorting and retrieving images or video sequences. This paper presents a robust approach of knowledge extraction from object trajectory, and then implementing this knowledge to characterize the motion patterns.

Detecting and tracking single human in enclosed environment considered as initial preparation for this work. The main goal of this part is to provide the essential information about the location of the human in each frame in order to generate the trajectories. To collect such information, we need to detect and track the human through a sufficient number of frames. Detecting process utilized using static background subtraction approach to segment each frame into foreground regions {human} and background [2]. In the tracking part we implement a constrained tracking approach to achieve the point's correspondence over the frame sequence. The series of the points over the frame sequence obtained from extracting the center of mass location for the moving objects from a binary image. The correspondence operation is built on evaluating the distance between the new position of the object of interest and a reference point, the previous step followed by comparing the obtained distance with the measured distance between the previous position of the object and the same reference point. The evaluation considers each two close measured distances refers to the same trajectory of a particular object.

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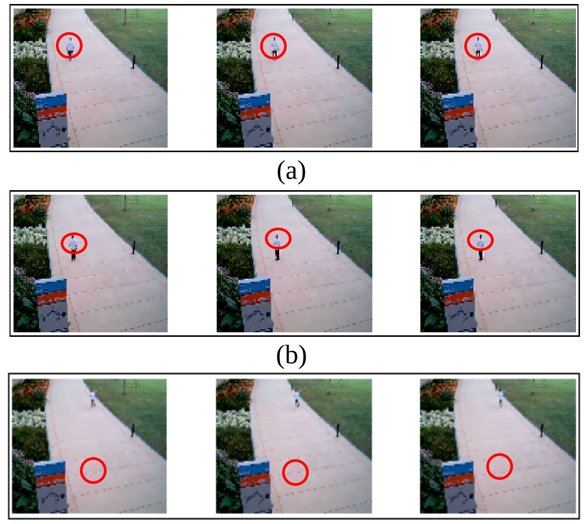


(a)

(b)

(c)

Figure 1: a- Single human walking. b- Single human walking then stopping. c- Single human running**.**

Three different video sequences are used to describe different movement aspects; each one of these video samples contains 530 frames. The total time for each video sample is 20 second; Figure (1) shows three successive frames from each motion category. The final goal for this paper is to differentiate between these motion aspects based on extracted knowledge from the object trajectory.

The paper is organized as follows where the next section talks about the human detection and tracking. Section 3.0 explains extracting the object location and trajectories. The discussion comes in section 4.0. The last section gives a brief conclusive overview and the future direction for this work.

## II. HUMAN DETECTION

Detecting moving object in a video sequence is a crucial part of any video contained analysis applications. In this work the detecting process is required due to the need of extracting the pixels distribution and the object velocity, where the detection process is realized based on static background subtraction method created by [4]; to segment each frame into foreground regions {moving objects} and background { the static scene}. The detection process usually followed by thresholding the resulted image with a fixed threshold to evaluate the image pixels. After that the background image is updated, and a closing widow is utilized for manipulating the subtracted result.

## III. OBJECT TRAJECTORY

There are different ways to specify the position of a certain object in a sequence of images such as using its enclosing rectangle or the center of the object area. In order to construct the trajectory; the position of the object during the frame set is required. In this study, the position of an object in a particular frame is defined based on the center of the object region. The center of the white pixels area in binary images is the same as the center of mass if we consider the intensity at a point as the mass at that point. To calculate the position of the object, we used a set of equation mentioned in [R. Jain et al, 1995]:

$$\bar{x}\sum_{i=1}^{n}\sum_{j=1}^{m} B(i,j) = \sum_{i=1}^{n}\sum_{j=1}^{m} j\,B(i,j)$$
$$\bar{y}\sum_{i=1}^{n}\sum_{j=1}^{m} B(i,j) = \sum_{i=1}^{n}\sum_{j=1}^{m} i\,B(i,j) \tag{1}$$

Where $\bar{x}$ and $\bar{y}$ are the coordinates of the center of the region. Thus, the position of an object is:

$$\bar{x} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{m} j\,B(i,j)}{A}$$
$$\bar{y} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{m} i\,B(i,j)}{A} \tag{2}$$

The position calculated using first order moments is not necessarily an integer and usually lays between the integers values of the image array indices.

The calculated values are rounded to the nearest integers. Each new coming frame describes an updated version of the object position in the image plane. This position is defined based on the variation in the object area over the time, which in turn is a direct result of the object motion. However the variation occurred in the rows and columns of pixels in the image plane and corresponding the x-coordinates and y-coordinates in the trajectory plane. The time unit per variation event is an image frame, so each frame defines the object location at a particular time instance. The equation below lists the x and y coordinates for the center of mass, starting from the first frame (where the object appears in the camera view for the very first time) till the last frame (where the object leaves the camera view). Capital x refers to the x coordinates and capital y refers for the set of y coordinates:

$$X = \{\bar{x}_1, \bar{x}_2, \bar{x}_3 \ \ldots\ \bar{x}_n\}$$
$$Y = \{\bar{y}_1, \bar{y}_2, \bar{y}_3 \ \ldots\ \bar{y}_n\} \tag{3}$$

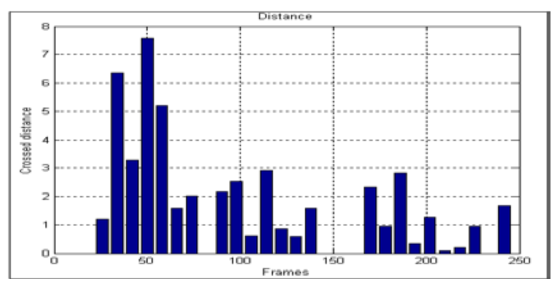
Where $X$ & $Y$ is the set of x and y coordinates of the object trajectory over the time and $n$ is the number of simulated frames. The rest of this section is dedicated to illustrate the experimental results gained from the different simulation scenarios.

## IV. DISTANCE

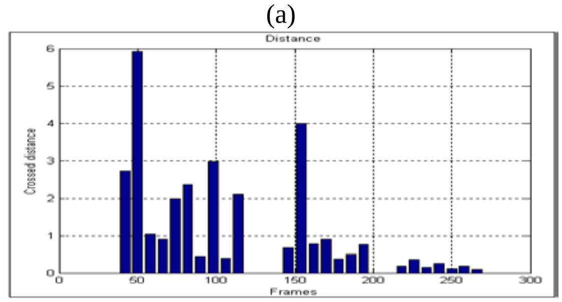
The crossed distance is counted as one of the basic tools when we come to classify the human motion. In order to express the crossed distance we need to implement a kind of step between successive frames. The advantage from using such steps is in the most cases computing the crossed distance per frame produce ignorable differences between the frames. The concept of defining steps to improve the expected result is known as inter frame based analysis. In this paper 10 frames used as fixed step [11, 12]. Figure (6) shows the results of measuring the crossed distance, while the distance is derived from the differences between the center of mass points through the frame set. Eq (3) express this idea:

$$D^k = \{d_1, d_2, ..d_i, ..d_n\}$$
$$d_i = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \tag{3}$$

Where $D^k$ a vector containing the crossed distance, $k$ is a person index, $d_i$ the distance crossed in frame $i$ , $x_1$ and $y_1$ the previous Centroid location, $x_2$ and $y_2$ is the current Centroid location and $n$ the number of frames. Zero values in Figure (6) means the person is static, long bars correspond to long distance and vise versa.



(a)



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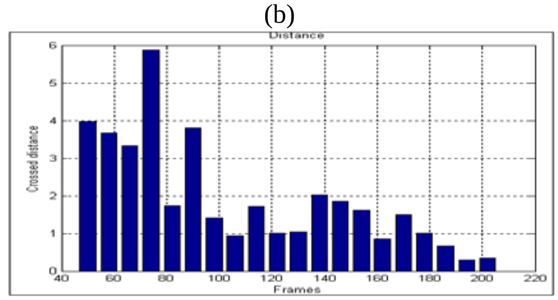


(c)

Figure 2: Distance per every 10 frame

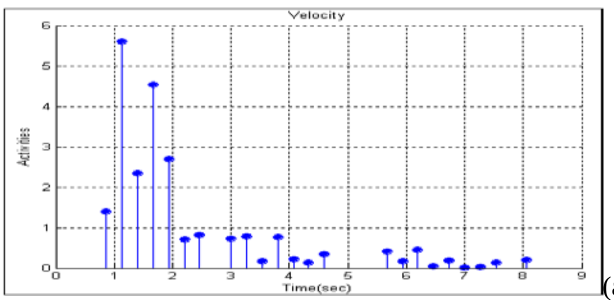
## V. VELOCITY

Object velocity is found based on deriving the distance and time parameter based on inter-frame analysis. Figure 7 shows the estimated moving object interest's velocity. This measurement gives an idea of interest about human activity in a certain time according to the equation:

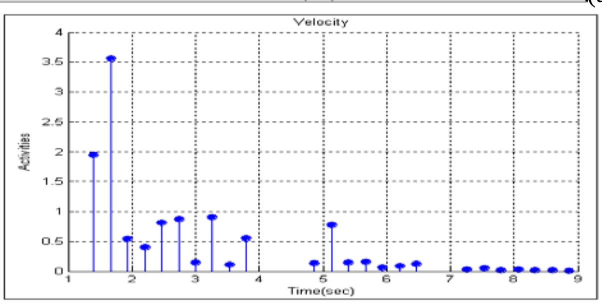
$$V^k = \{v_1, v_2, \ldots v_i \ldots v_n\} \tag{4}$$

$$v_i = d_i / t_i$$

Where $V^k$ vector containing the velocities, $v_i$ the velocity in frame $i$.



(a)



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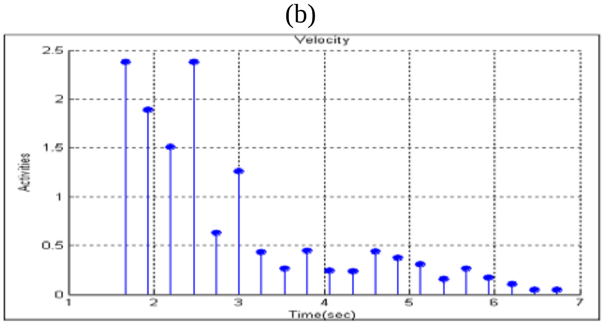


(c)

Figure3: Velocity

## VI. DISCUSSION

Three different video sequences are used in this case study to describe different motion aspects; each one of these video samples contains 530 frames. The total time for each video sample is 20 second [3]. The first video sample dedicated to describe a single human walking, the second sample describes a single human walking then he stopped for a while after that he started walking again, while the last video sample talks about a single human running. The next sections provide a detailed description regarding the trajectories extracted from these three motion aspects.

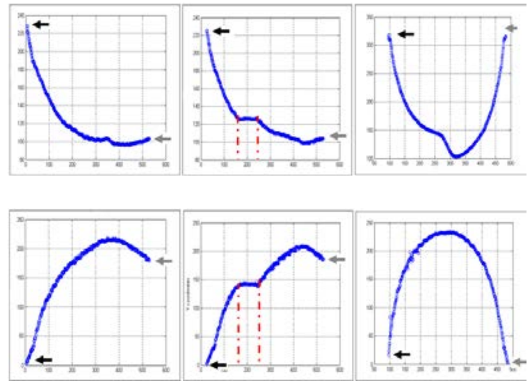
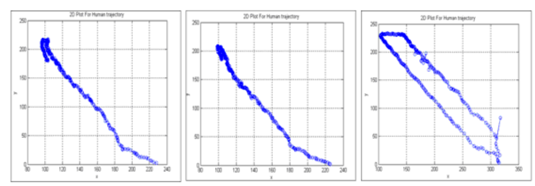

(a) (b) (c)

Figure 4: X - Y coordinates variation for the three single human motion aspects.

The first type of trajectory representation graph in this case study is considers the variations of the x and y coordinates for the center of mass of the white area over the frame sequence.


(i) (ii) (iii)

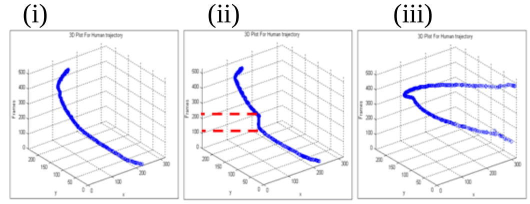

(vi) (v) (iv)

Figure 5: Two & three dimension trajectory for the three single human motion aspects.

Figure 3 consists of three sub graphs and illustrates the variations occurred to x and y coordinates over the frame sequence, where the black arrows refer to the very first arrival of the object while the gray arrows refer to the point where the particular agent leaved the camera view or the end of simulation time. Figure 3.4(i) describes a single agent walking, the trajectory started with low density which refer to low frequency, after that and with the simulation time going the trajectory points density started to increase which stands for high frequencies. From the same figure we are able to observe that the object did not leave the scene till the end of simulation time. Figure 3.4(ii) discusses a single agent walking and stopped for awhile {the part of the trajectory assigned by a dashed in red line correspond to the frame indexes for this period of time} then he started walking again.

Figure 3.4(iii) illustrates the trajectory of a single human running, where it's so obvious that the density of the trajectory points increased when the agent turn a round and it started to decrease again when he started running. From the previous figures we able to conclude by the following the x and y coordinate variation graphs had the ability to differentiate between static objects and dynamic objects, but it hadn't such ability to evaluate the exact motion velocity. The last trajectory representation in this case study is shown in Figure 3.5 below; where Figure 3.5(i, ii, iii) illustrates the two dimension trajectory for the same motion aspects, while Figure 3.5(iv, v, vi) shows the three dimension trajectory for the three motion aspects.

## VII. CONCLUSION

This work consider as a precursor for later a more specific application work which involves intruder detection using pixel manipulation and attributes of the moving objects (or object of interest).

The future work will build on these basic ideas and further investigation involves multi-object movement attributes in indoor/outdoor environment.

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