CHAPTER FOUR

INTER FRAME BASED IMAGE ANALYSIS

4.1 Introduction

The term inter frame refers to a sequence of particular intervals through the simulated frame set. These intervals determined by implementing a predefined fixed step over the frame sequence. For any object in the camera view, the inter frame intervals started when the particular object appears in the camera view for the very first time and finished when this object leaves the current scene. While, the term inter frame based analysis is defined as extracting a set of features from object motion through its appearance in the camera view based on inter framing concept scene. Hence, each interval defines new values for the board of object motion attributes. An obvious example of this type of attributes is the distance crossed by the object of interest. The reasons for implementing a time threshold are listed below:

- Converting the timing of the extraction process from image frame bases into per second bases.
- Measuring the selective attributes based on a certain step result in more considerable for the measured values and that's because the ignorable differences in the measured values between the successive frames.
- In the other hand, implementing a suitable time step maintains the details of the object motion.

Recalling the reasons for using a time step, each 25 successive frame defines updated new values for the board of inter frame based attributes for the particular object under study. Three motion attributes extracted from objects motions are identified in the board of inter frame based attributes as follows:

- Crossed Distance.
- Object Velocity.
- Motion direction.

The next sections discuss the inter frame attributes in more details based on the same simulation scenarios discussed in the previous chapter, and then explain the outcome of the presented results from a video interpretation point of view.

4.2 Crossed Distance

The crossed distance for the objects of interest extracted from image sequence is one of the useful tools for describing the behavior of the objects motion. Beside its own significance in the motion understanding field, measuring the crossed distance is an essential computation level in order to calculate the object velocity which it considered a powerful feature for examining the object activities.

The crossed distance for the objects of interest relays on the concept of inter frame based analysis where the calculation process occurred based on a predefined step equal to the capturing device frame rate. In this work, 25 frames are implemented as fixed time step. However, the crossed distance describes two aspects exhibited by the objects motion. The first aspect considers the amount of space, in image pixels; crossed by the object of interest in the current scene per second bases, while the second aspect discusses the accumulated distance and it used to describe the maximum amount of space in image pixels, crossed by the object of interest over the time from the beginning of the motion.

The mathematical base for computing the crossed distance is relied on estimating the differences between the current and the previous center of mass coordinates in the image plane. Equation (4.1) describes the mathematical models dedicated to calculating the crossed distance.

$$d_i^N = \sqrt{(\bar{x}_i - \bar{x}_{i-1})^2 + (\bar{y}_i - \bar{y}_{i-1})^2} \quad (4.1)$$

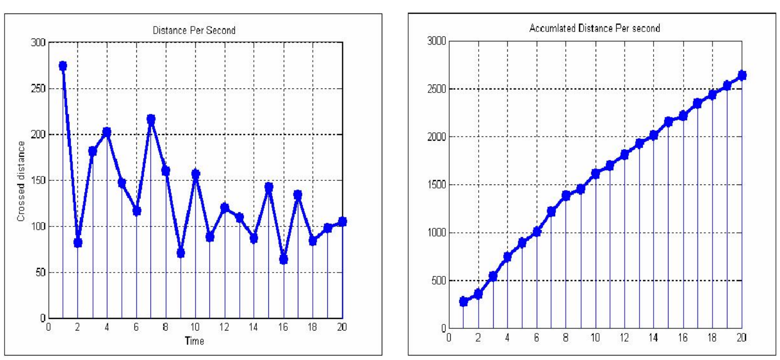
$$D^N = \{d_1, d_2, d_3, ..., d_i, ..., d_M\} \quad (4.2)$$

$$A_i^N = \sum_{i=1}^{M} d_i^N \quad (4.3)$$

Where, d_i^N describes the distance crossed in interval i by the objects number N, $\bar{x}_i$ and $\bar{y}_i$, are the current Centroid location, $\bar{x}_{i-1}$ and $\bar{y}_{i-1}$, are the previous centroid location, M is a number of intervals, D refers to a vector containing the crossed distances over the time intervals. A, refers to a vector containing the Accumulated crossed distances over the time. The rest of this section is devoted to illustrate the experimental results of measuring the crossed distance and the accumulated distance gained from the different case studies.

4.2.1 Case Study I

This case study is coped with a ball hanged by string and moved freely in the space. The attempt here is to extract the distance crossed by the ball during 20 second, 500 frame of video stream.



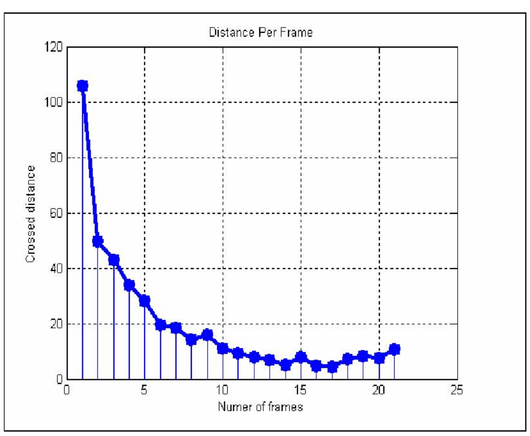
(i) (ii)

Figure 4.1: The crossed distances during the ball motion. (i) The crossed distance per second bases. (ii) The accumulated distance per second bases.

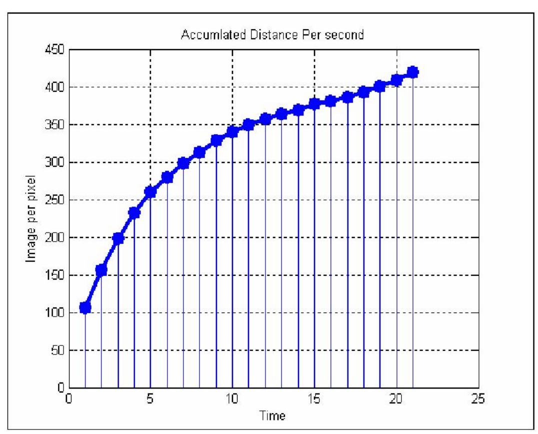
Figure 4.1 shows the crossed distances for the ball during its motion. The 20 second length of this video sample is divided into 19 measuring intervals and the results are 19 measured distances during the ball motion. The X axis refers to the time and y axis stands for the crossed distance measured by the number of pixels. Shown in Figure 4.1 (i) the ball started its motion by crossing the highest distance during the first interval 275 pixels as a result of the shift in the location of the center of mass for the ball, after that the crossed distance decreased to 80 pixels during the second interval. The distance graph continued to behave like a sin wave due to the ball motion, which resembles the simple pendulum movement. The total distance crossed by the ball during 20 second shown in Figure 4.1 (ii) is equal to 2500 pixels.

4.2.2 Case Study II

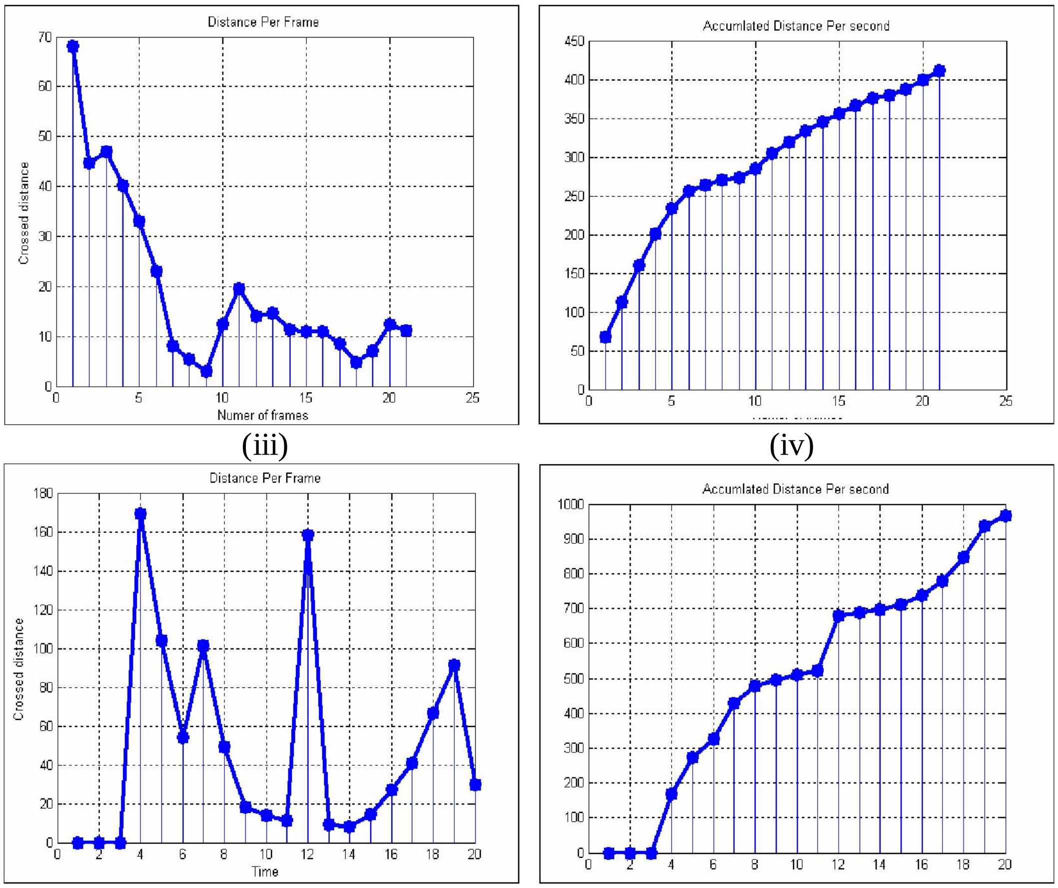
Three different video sequences are used in this case study to describe different single human motion aspects; each one of these video samples contains 530 frames. The total time for each video sample is 20 second. The promise in this section is to compare the crossed distances for the three agents participated in this scenario. Figure 4.2 presents the simulation results for the crossed and accumulated distance for the single human case study.



(i)



(ii)



(iii) (iv)

(v) (vi)

Figure 4.2: The crossed distance for case study II. (i) The crossed distance for the first agent. (ii) The accumulated distance for the first agent (iii) The crossed distance for the second agent. (iv) The accumulated distance for the second agent. (v) The crossed distance for the third agent. (vi) The accumulated distance for the third agent.

The first agent started his motion by crossing the highest distance 110 pixels, and then the crossed distances for this agent decreased tell it reached 17 pixels by the end of simulation time. The total distance crossed by this agent during the simulation time comes from Figure 4.2 (ii) and it's equal to 420 pixels. The second agent started his motion by crossing the highest distance 68 pixels, then the crossed distances for this agent decreased tell it reached the minimum value less than 5 pixels, after that the crossed distances started to increase again in random manner due to exhibited motion, tell it reached12 pixels by the end of simulation time. The total distance crossed by this agent during the simulation time comes from Figure 4.2 (iv) and it's equal to 410 pixels. The last agent started his movement after 3 second from the beginning of the capturing process. This agent crossed the highest distance above 170 pixels during the first second in his movement, after that the crossed distances for this agent decreased tell it reached 15 pixels and a sudden increase is occurred, the reason for that is the particular agent spent some time while he was running out of the camera view, so the distance is calculated based on the last location before he left the scene in the first location after he appeared again for the second time. Finally that the crossed distances started to increase again in random manner tell it reached 25 pixels by the end of simulation time. The total distance crossed by this agent during the simulation time comes from Figure 4.2 (vi) and it's equal to 980 pixels.

From the presented scenarios it can be observed that the third agent crossed the longest distance in the shortest time which considered as strong evidence about his high velocity, where the next part in this chapter is going to discuss objects velocities in more details. The second agent crossed the shortest distance in the longest time which considered evidence about spending some time without exhibiting any motion. The first agent appears to exhibit a normal behavior due to the suitability of the crossed distance.

4.2.3 Case Study III

Three different video sequences are used in this case study to describe various motion behaviors for two agents walking; each one of these samples consists of 530 frames. The total time for each sample is 20 second. Figure 4.3 shows the crossed distances gained from the experimental results for the first video samples in this case study.

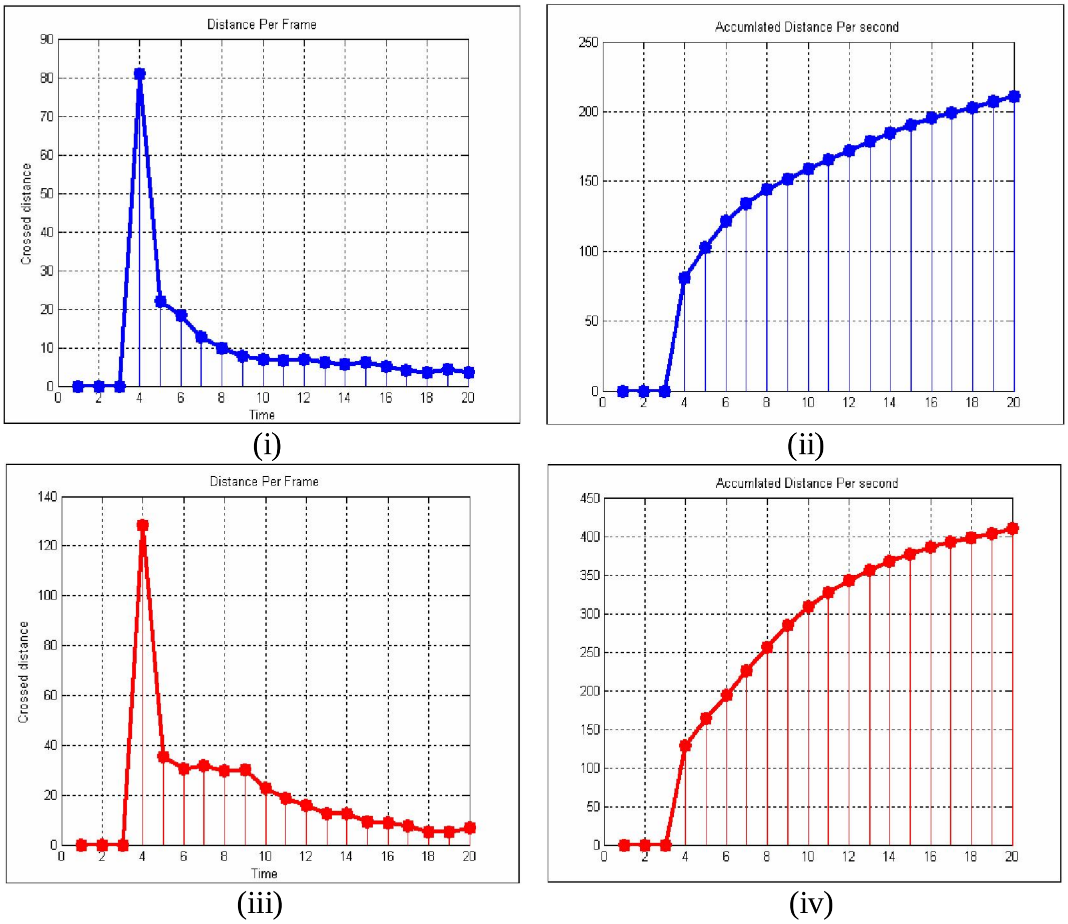


Figure 4.3: The crossed distance for the first scenario of case study III. (i) The crossed distance for the first agent. (ii) The accumulated distance for the first agent. (iii) The crossed distance for the second agent. (iv) The accumulated distance for the second agent.

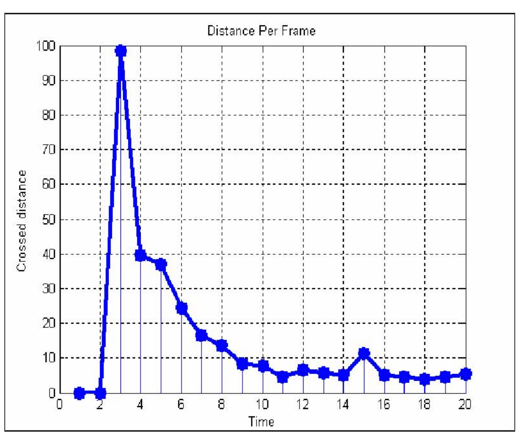
From the figure, the crossed distances for each agent in the simulation scenario can be observed as follows:

The first agent started his movement after three seconds after the start of the capturing process (the blue graphs). He started his motion by crossing distance equal to 80 pixels. The crossed distance for this agent started to decrease in random manner due to exhibited motion till it reached 4 pixels by the end of simulation time. The total distance crossed by this agent during the simulation time comes from Figure 4.3 (ii) and it’s equal to 210 pixels. The second agent started his movement also after 3 second from the beginning of the capturing process; he started his motion by crossing distance equal to 130 pixels, and then the crossed distances started to decrease randomly till it reached 6 pixels by the end of simulation time. The total distance crossed by this agent during the simulation time comes from Figure 4.3 (iv) and it’s equal to 420 pixels.

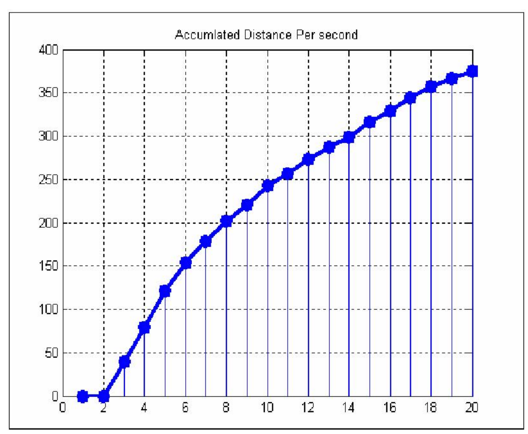
From the presented case studies it can be said the second agent crossed the longest distance, while, the first agent crossed the shortest distance. Both of the agents spent the same amount of time in the camera view. These results suggest that the second agent moved faster than the first agent. The next part in this chapter will introduce new evidence regarding objects velocities.

Figure 4.4 below shows the crossed distances gained from the experimental results for the second video samples where the agents walk in the same direction and exhibit slightly differences in their motion velocities compared to the first scenario.

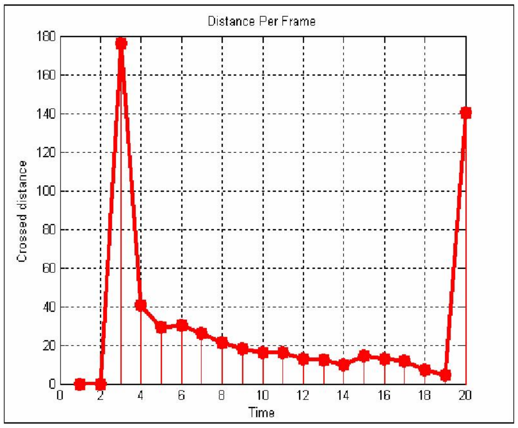
From Figure 4.4 presented below, the first agent started his motion after two second from the beginning of the capturing process; he started his motion by crossing distance equal to 100 pixels, and then the crossed distances started to decrease randomly till it reached 8 pixels by the end of simulation time. The total distance crossed by this agent during the simulation time comes from Figure 4.4 (iii) and it’s equal to 375 pixels.



(i)



(ii)



(iii)

(iv)

Figure 4.4: The crossed distance for the second scenario of case study III. (i) The crossed distance for the first agent. (ii) The accumulated distance for the first agent. (iii) The crossed distance for the second agent. (iv) The accumulated distance for the second agent.

The second agent started his movement also after two second from the beginning of the capturing process, he started his motion by crossing distance equal to 180 pixels, then the crossed distances for this agent started to decrease randomly tell it reached 5 pixels due to exhibited motion, finally the agent under study shows a sudden increasing in the presented crossed distance. The total distance crossed by this agent during the simulation time is shown in figure 4.4 (iv) and it's equal to 440 pixels.

From the presented results, the second agent crossed the longest distance, while, the first agent crossed the shortest distance. Both of the agents spent the same amount of time in the camera view. As the previous video sample denotes, these results suggest that the second agent moved faster than the first agent and it introduces the requirements for evaluating the objects velocities.

Figure 4.5 shows the crossed distances gained from the experimental results for the third video samples where the two agents walked toward each other.

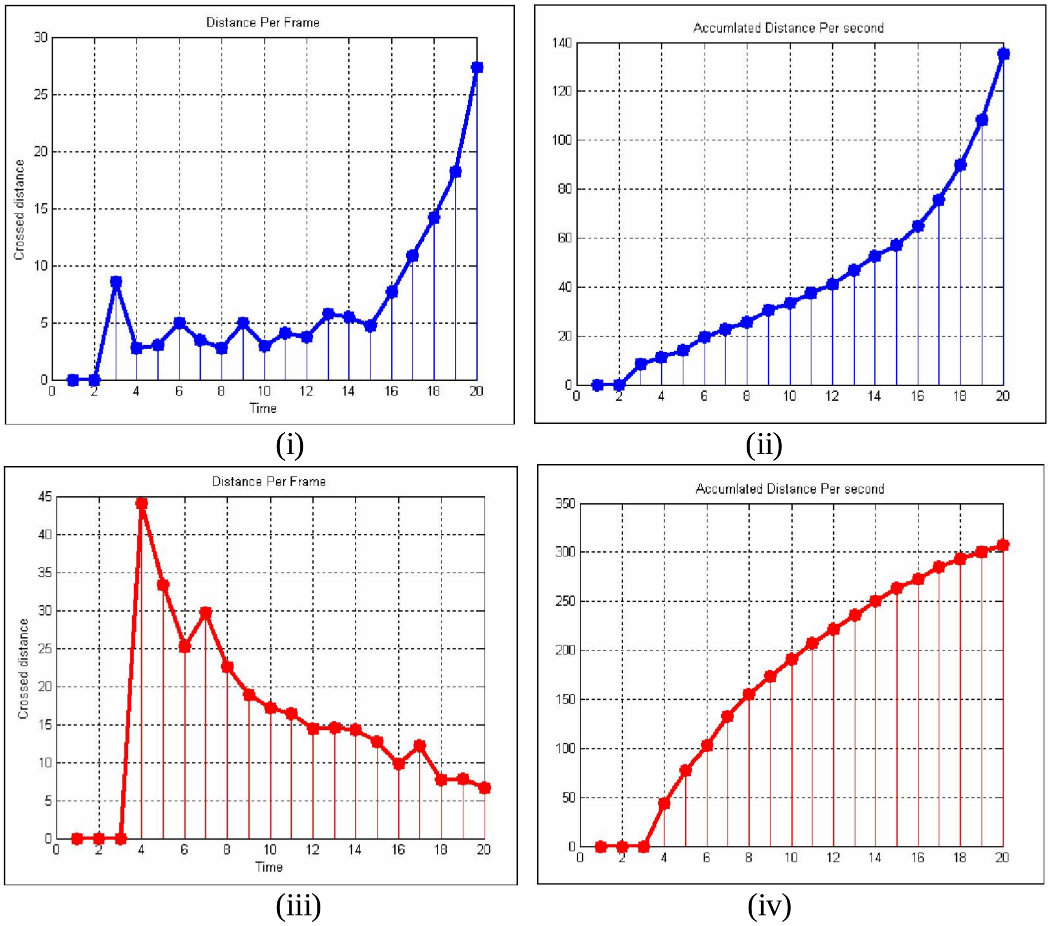


Figure 4.5: The crossed distance for the third simulation scenario of case study III (i) The crossed distance for the first agent. (ii) The accumulated distance for the first agent. (iii) The crossed distance for the second agent. (iv) The accumulated distance for the second agent.

From Figure 4.5, the first agent started his movement after two seconds from the beginning of the capturing process, he started his motion by crossing distance equal to 9 pixels, and then the crossed distances for this agent increased randomly till it reached 28 pixels by the end of the simulation time. The total distance crossed by this agent during the simulation time comes from Figure 4.5 (ii) and it's equal to 138 pixels.

The second agent started his motion after three second from the beginning of the capturing process, he started his motion by crossing the highest distance equal to 45 pixels, and then the crossed distances for this agent started to decrease randomly tell it

reached 8 pixels by the end of simulation time. The total distance crossed by this agent during the simulation time is shown in figure 4.5 (iv) and it’s equal to 310 pixels.
The presented results shows that, the second agent crossed the longest distance 370 pixels, during its appearance in the camera view 17 second, while, the first agent crossed the shortest distance 225 pixels, during its appearance in the camera view 18 second. As the previous video samples denote, these results suggest that the second agent moved faster than the first agent and it introduces the requirements for evaluating the objects velocities.

4.3 Object Velocity

The most significant attributes in this work is the velocity exhibited by the object of interest. The importance of calculating the objects velocity comes from the consideration of the velocity as fundamental tool for assessing the objects**.** Objects with high velocities are more active and more interesting from a security point of view and thus having more suspicious behavior. The mathematical base for computing the object velocity in this work is relied on the simple physics rule of evaluating objects velocities, where, the velocity is equal to the crossed distance divided by the time. In more details the calculation of object velocity is based on the computed distance divided by the time of the interval which it equal to 1 second.

$$v_i^N = d_i^N / T \tag{4.4}$$

$$V^N = \{v_1, v_2, v_3, ..., v_i, ..., v_M\} \tag{4.5}$$

Where, V^N is a vector containing the velocity values in for object number N during the simulation time. N, is a person index, M is a number of intervals, v_i^N the velocity in interval i, d_i^N the distance crossed in interval and T is the time required to cross the particular distance. The rest of this section is dedicated to illustrate the experimental results gained from the different simulation scenarios. The following section is dedicated to illustrate the experimental results gained from the different simulation scenarios.

4.3.1 Case Study I

As mentioned earlier, the concentrate of a non human case study is a ball hanged by string and moved freely in the space. The stab is to extort the velocity of the ball during its movement from the video stream. The total length of this sample is divides into 19 measuring intervals based on inter frame based analysis concepts. The outcome of segmenting the video into intervals is 19 sequence values for the measured velocities. Figure 4.6 below shows the velocity of the ball during its motion.

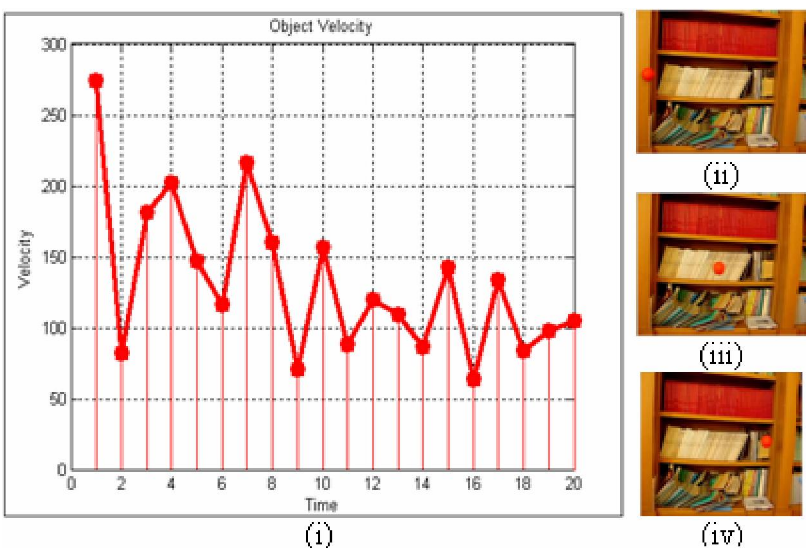
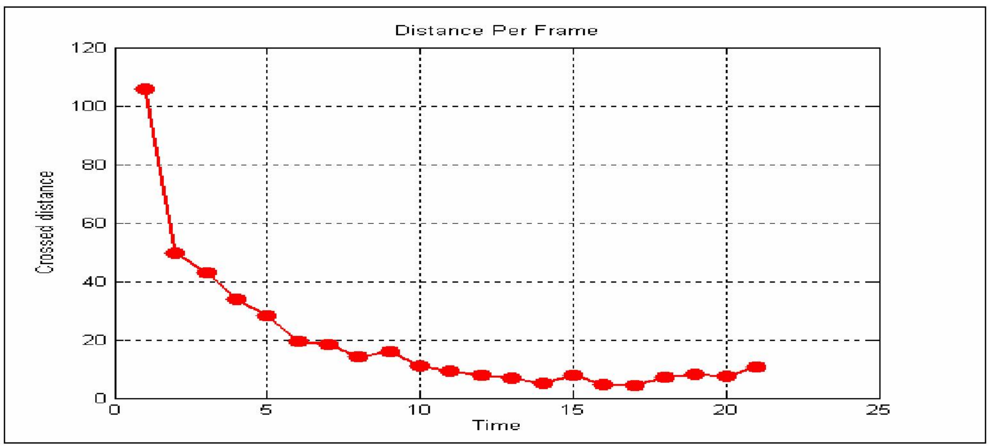


Figure 4.6: The ball velocity.

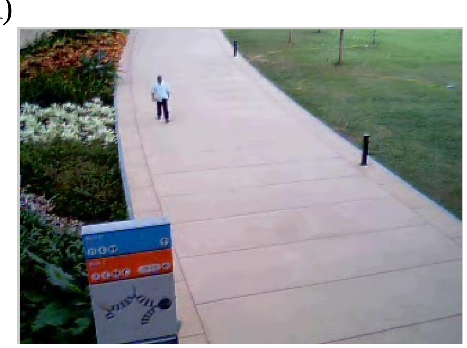
With reference to figure 4.6, the x axes refer to the time and y axes stands for the object velocity. From the figure the ball started by the highest velocity during the first interval, after that the ball velocity decreased during the second intervals. The velocity graph continued to increases and decreases randomly due to the ball motion.

4.3.2 Case Study II

Three different video sequences are used in this case study to describe different motion aspects. 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 attempt in this section is to compare the velocities for the three agents participated in this scenario. Figure 4.7, Figure 4.8 and Figure 4.9 shows the measured velocities gained from the experimental results.



(i)

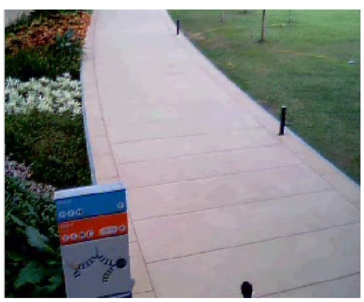


(ii) (iii)

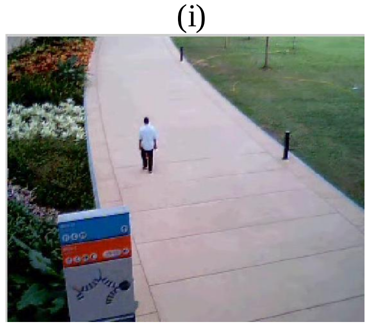
Figure 4.7: The velocity for the first video sample in case study II. (i) The velocity graph for the first video sample in single human case study. (ii) High velocity level. (iii) Low velocity level.

Figure 4.7(i) shows the velocity of the first agent where he started his motion by showing the highest velocity that is 110 pixels per second. The velocity for this agent decreased till it reached 17 pixels per second during the last second in the simulation time. While Figure 4.7 (i & ii) show the image plane location where the object exhibited the high and low velocity level respectively.

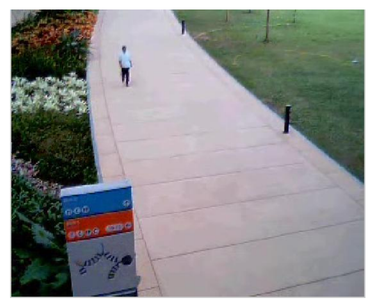
(i)



(ii)



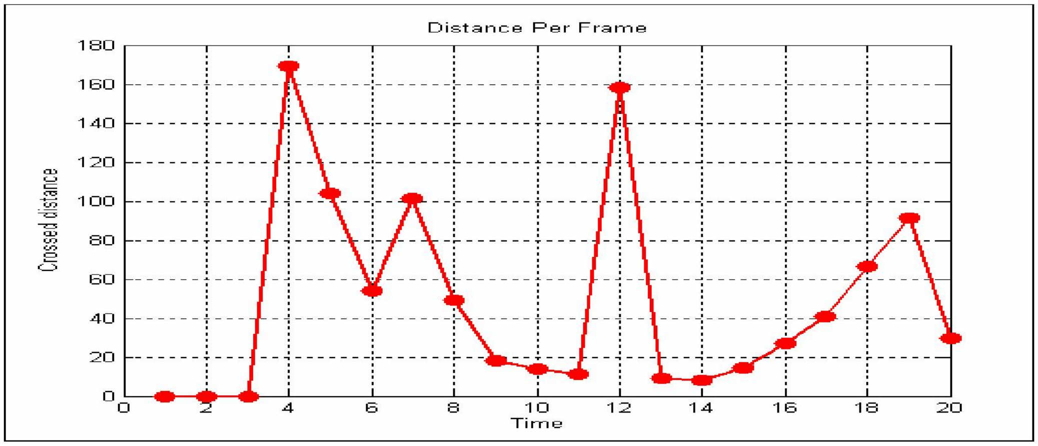
(iii)



(iv)

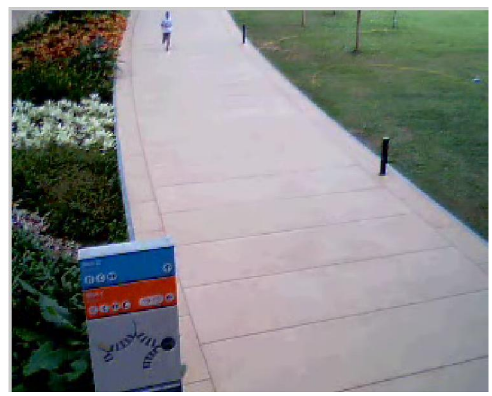
Figure 4.8: The velocity for the second video sample in case study II. (i) The velocity graph for the second video sample in single human case study. (ii) High velocity level. (iii) The lowest velocity level. (iv) Low velocity level.

Figure 4.8 (i) shows the second agent started his motion by showing the highest velocity that is 68 pixel per second, then the velocity shown by this agent decreased till it reached the minimum value that is less than 5 pixel per second, after that the velocity started to increase again in random manner due to exhibited motion, till it reached 12 pixel per second during the last interval in the simulation time.



(iii)

(ii)

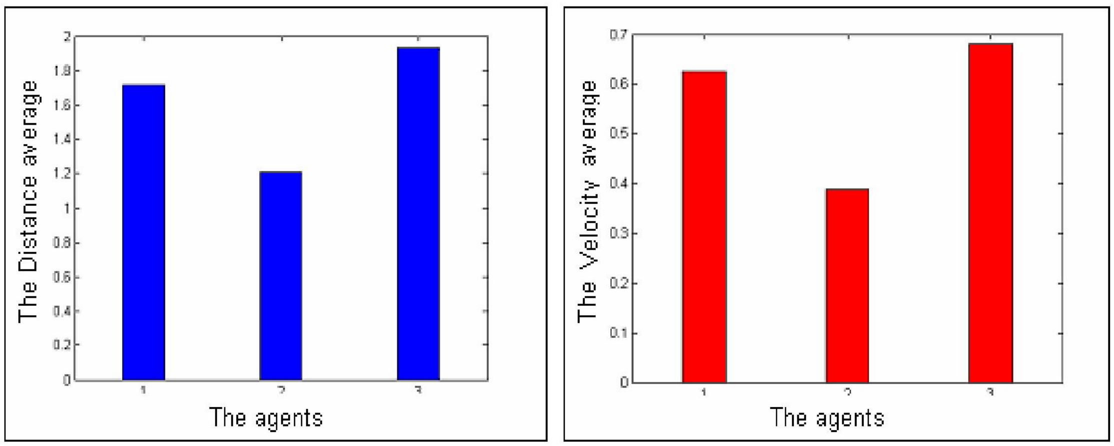


(iii)

Figure 4.9: The velocity for the third video sample in case study II. (i) The velocity graph for the third video sample in single human case study. (ii) High velocity level. (iii) Low velocity level.

Figure 4.9(i) shows the last agent started his movement after 3 second from the beginning of the capturing process and he started his motion at the highest velocity that is above 170 pixels per second during the first second, after that the velocity decreased till it reached 15 pixels per second. Finally that the velocity started to increase again in random manner till it reached 25 pixels per second during the last interval in the simulation time.

From crossed distance and object velocity results for single human case study can compute an average values for the distance and velocity [Altahir A. Altahir et al, 2008a]. Figure 4.10 shows the results of these averages, and the next paragraph take this concept with more details.



(a) (b)

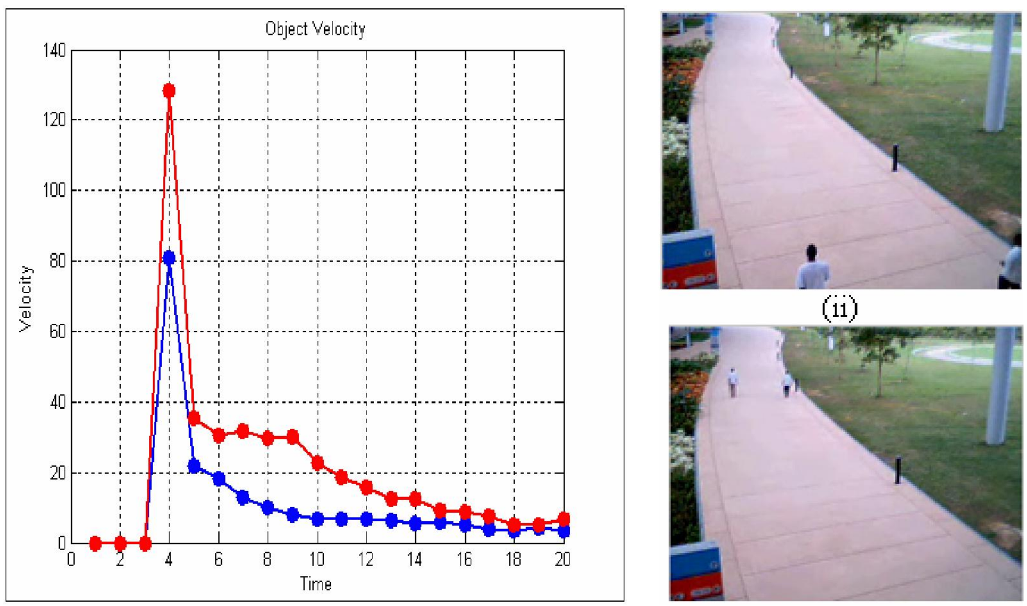
Figure 4.10: Crossed distance and velocity averages.

The blue bars (left plot) show the distance average and the red bars (right plot) show the velocity average for the agents participated in this case study. From figure 4.10(a), can observed that the crossed distance average for agent 1 is 1.72, for agent 2 is 1.21 and for agent 3 is 1.03. These values denote that agent 2 crossed the shortest distance in the longest time period while agent 3 crossed the longest distance in the shortest time period. Figure 4.10(b) confirms the observations mentioned in the previous section, where can conclude the highest velocity was gained by agent 3 and the lowest velocity was gained by the second agent.

4.3.3 Case Study III

Three different video sequences are used in this case study to describe different motion aspects. The first video sample dedicated for two humans walking slowly in the same direction. The second sample describes two humans walking with slight velocity differences compared to the first one; the last sample talks about two agents walk toward each other.

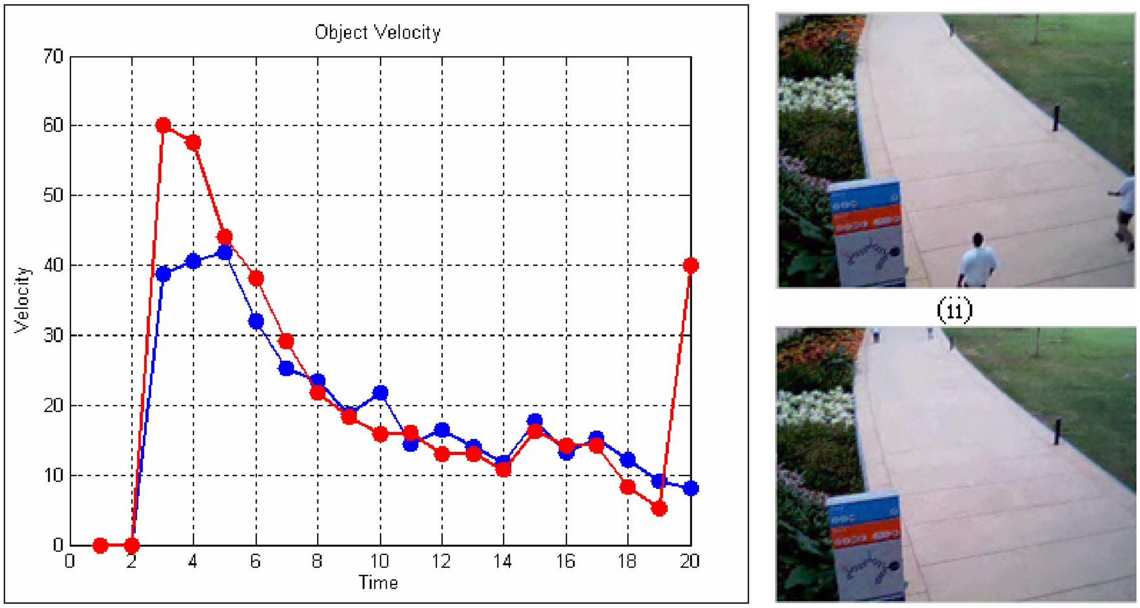
Figure 4.11, 4.12 and 4.13 show the simulation results. Each subfigure presents the velocity values for two agents participated in the particular video sample. From Figure 4.11, one can analyze and compare the crossed distances for each agent in the simulation scenario which observed the following:



(i) (iii)

Figure 4.11: The velocity results for the first video sample in case study III. (i) The velocity for the two agents participated in the first video sample. (ii) Low velocity level.. (iii) High velocity level.

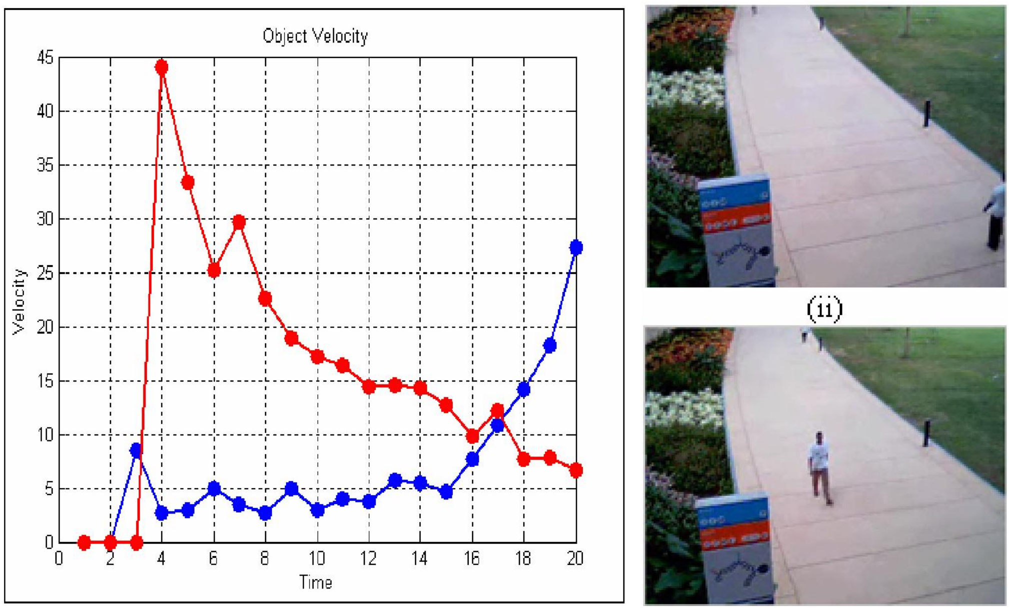
The first agent started his movement after 3 second from the beginning of the capturing process (the blue graphs), he started his motion by velocity equal to 80 pixels per second, then the velocity started to decrease in random manner due to exhibited motion tell it reached below 10 pixels per second, after 20 second of motion. The second agent started his movement after 3 second from the beginning of the capturing process (the red graphs), he started his motion by velocity equal to 120 pixels per second, then the velocity started to decrease in random manner due to exhibited motion tell it reached below 15 pixels per second, after 20 second of motion



(i) (ii) (iii)

Figure 4.12: The velocity results for the second video sample in case study III. (i) The velocity for the two agents participated in the second video sample. (ii) Low velocity level. (iii) High velocity level.

The first agent started his movement after 2 second from the beginning of the capturing process (the blue graphs), he started his motion by velocity equal to 40 pixels per second, then the velocity increased till it reached 44 pixels per second, after that the measured velocity started to decrease in random manner due to exhibited motion till it reached below 10 pixels per second, after 20 second of motion. The second agent started his movement after 2 second from the beginning of the capturing process (the red graphs), he started his motion by velocity equal to 60 pixels per second, then the velocity started to decrease in random manner due to exhibited motion till it reached below 10 pixels per second after 19 second of motion.



(i) (iii)

Figure 4.13: The velocity results for the third video sample in case study III. (i) The velocity for the two agents participated in the third video sample. (ii) High velocity level. (iii) Low velocity level.

The first agent started his movement after 2 second from the starting of the capturing process (the blue graphs), he started his motion by velocity equal to 9 pixels per second, then the velocity started to increase randomly due to the motion aspects 27 pixels per second, after 20 seconds of motion. The second agent started his movement after 3 second from the starting of the capturing process (the red graphs), he started his motion by velocity equal to 45 pixels per second, then the velocity started to decrease in random manner due to exhibited motion till it reached below 10 pixels per second, after 20 second of motion.

4.4 Motion Direction

Motion direction attribute is capable of providing basic information about the estimated direction of the objects motion. For example, if a person starts walking towards a forbidden zone or security-sensitive area, the motion direction gives an early warning to the security operators to deal with this case. In addition to that, this attributes has a promising future in case of implementing this study in traffic monitoring, where each car in the highway must follow the road directions.

The mathematical base for computing the motion direction is relied on calculating the gradient of the center of mass coordinates, which it can be thought of as a collection of vectors pointing in the direction of increasing values.

$$\nabla L_x = \frac{\partial x}{\partial t} \tag{4.6}$$

$$\nabla L_y = \frac{\partial y}{\partial t} \tag{4.7}$$

Where L is the position function, x and y stand for the coordinates of the center of mass and n is the number of frames and t is refers to the time. This step followed by representing the collection of the calculated variations in the values of the position function as vectors pointing towards the estimated direction of the object of interest. The next section presents the gained results from the simulation scenarios regarding the motion direction in more details.

4.4.1 Case Study I

Through out this case study we coped with a ball hanged by string and moved freely in the space. The attempt here is to estimate the motion direction exhibited by the ball during 20 second, 500 frame of video stream. The motion direction is found based on calculating the gradient of the center of mass coordinates for the ball locations over the time then representing the collection of the variations in the values of the center of mass function as vectors pointing at estimated direction of the ball motion over the time. Figure 4.10 below displays the direction of the ball motion.

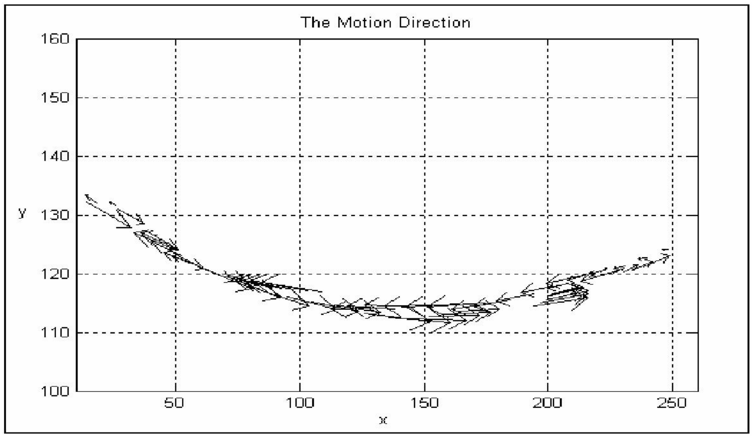
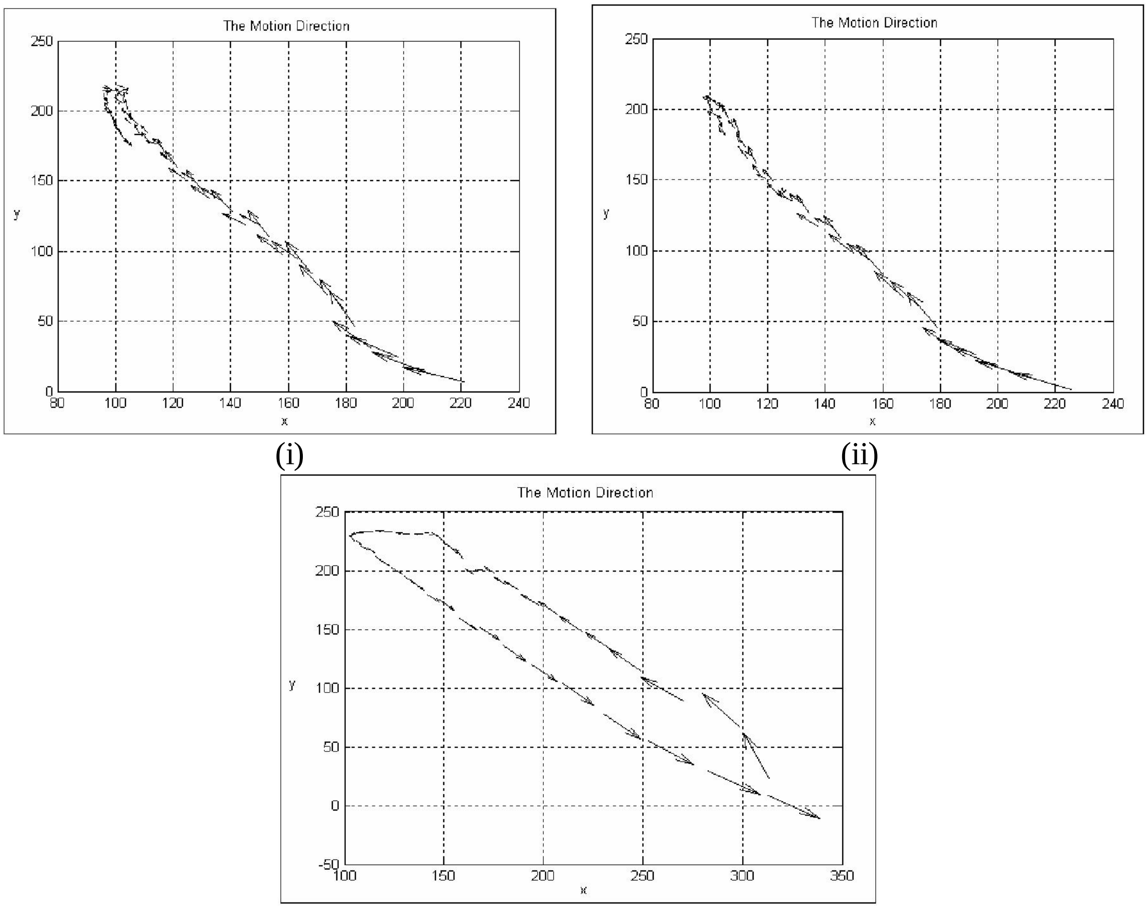


Figure 4.14 displays the direction of the ball motion

The figure shows the direction of the ball and by recalling the previous results, it's obvious that the ball started its motion from the far right part of the scene and it moved toward the other side of the scene while during that it tended to slightly lower a bit before the mid of the scene after that it continued its motion heading toward the far left of the scene and during that part of the ball motion it tended to slightly higher a bit.

4.4.2 Case Study II

Throughout the case studies the research interest are in three different single human motion aspects. The attempt here is to estimate the motion direction exhibited by the each agent in the scenario under study. The motion direction is found based on calculating the gradient of the center of mass coordinates for the agent locations over the time then representing the collection of the variations in the values of the center of mass function as vectors pointing at estimated direction of the agent motion. Figure 4.10 below displays the direction of the agents' motion.



(i) (ii)

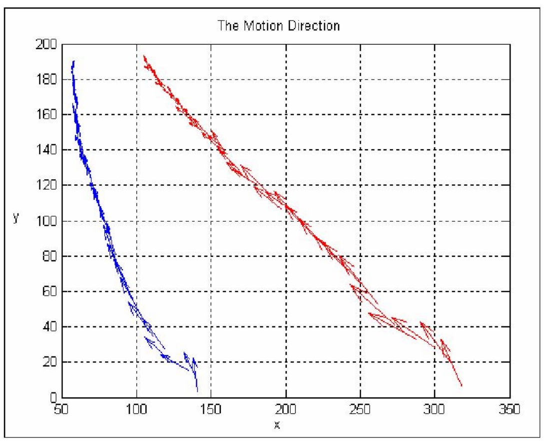
(iii)

Figure 4.15: The motion direction results for case study II. (i) The motion direct for the first agent. (ii) The motion direct for the second agent. (iii) The motion direct for the third agent.

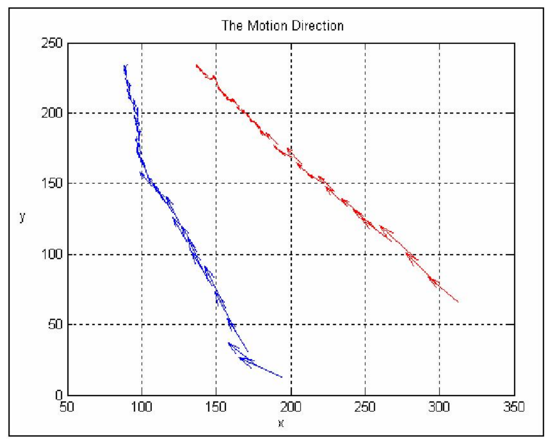
Figure 4.15 shows the direction of the agents motion in the three video samples, where the first agent started his motion from the lower right corner of the scene and he moved toward the upper left corner and after that he turned around and headed toward the lower right corner again, same as the first agent the second agent started his motion from the lower right corner of the scene and he moved toward the upper left corner and after that he turned around and headed toward the lower right corner again, while the last agent headed toward the upper left corner and before he reached it he changed his direction toward the lower right corner and when the simulation finished he was going outside the camera view.

4.4.3 Case Study III

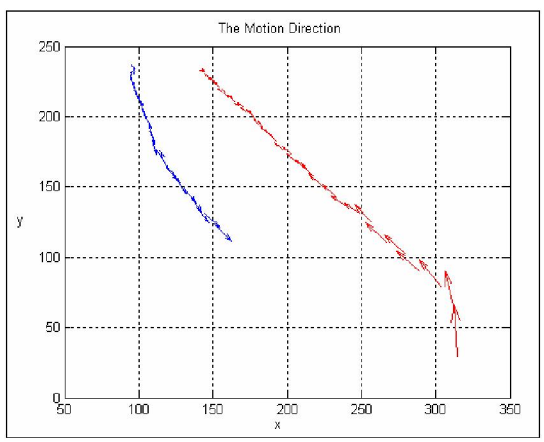
In this case study it coped with three different two human motion aspects. The motivating here is to estimate the motion direction exhibited by the each agent in the scenario under study. The motion direction is found based on calculating the gradient of the center of mass coordinates for the agent locations over the time then representing the collection of the variations in the values of the center of mass function as vectors pointing at estimated direction of the agent motion. Figure 4.16 below displays the direction of the agents' motion.



(i)



(ii)



(iii)

Figure 4.16: The motion direction results for case study III. (i) The motion direct for the agents in the first video sample. (ii) The motion direct for the agents in the second video sample. (iii) The motion direct for the agents in the third video sample.

Figure 4.16 shows the direction of the agent’s motion in the three video samples, where the agents in the first and the second video samples shows the same motion direction behavior where, the agents in the first video sample headed toward the upper left corner same as the agents in the second video sample. The third video samples explain the importance of the motion direction feature where the direction feature in this sample determined that the agents participated in this sample headed toward each other. Finally, the motion direction attribute considered as a complementary feature for the board of attributes extracted in this work.

4.5 Summary

This chapter illustrated the term of inters frame based analysis. The time unit described here in this chapter is converted from per frame bases into per second bases and each second represent a single measuring interval. This chapter also presents the extraction of the attributes belongs to inter frames board. Finally the experimental results gained from the simulation scenarios are explained and interpreted from a security point of view. The next chapter discuss briefly on how to combine all this attributes (both full frame and inter frame) to create a triggering system to catch event of interest and optimized the storage of video stream data obtained from surveillance system.