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Moving Objects Tracking in Real Time Video and Plotting their Path of Movement

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Abstract

This paper presents an algorithm to track moving objects in a real time video and to store co-ordinate values of the centroid of those objects in a vector for future use. Finally paths of those moving objects are plotted using the stored co-ordinate values. The proposed algorithm in this paper is based on background subtraction where tracking objects is performed in a sequence of video frames and its processing mainly consists of two main stages: isolation of objects from background in each frames and association of objects in successive frames to trace them. In this approach, moving objects can be tracked accurately, then an accurate record of their motion can be made and their path of movement can be plotted. Such tracking system is required in sensitive areas such as bank, departmental stores, parking lots and country border to determine whether one or more human beings engaged are suspicious or under criminal activity. Experimental results, which demonstrate the system's performance, are also shown in this paper.

Keywords

Object Tracking, Moving Objects, Reference frame, Current frame, Background Subtraction, Inter-frame Differentiation(IFD), Laplacian Filter.

1. Introduction

As described in [4], the visual surveillance technique has its numerous applications including traffic monitoring, human activity surveillance, people counting and other commercial applications [4].

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The similarity in all these applications is that the method of extraction of moving objects from the video sequence is considered to be the key operation and in all of these cases, stationary cameras are used to track activities at outdoor or indoor sites [1]. But, the video based object tracking method deals with non-stationary image stream that changes over time. For this dynamism in the nature of the operation, real time moving objects tracking is a challenging task in computer vision research area [2].

According to [2], the algorithms that are prevalent deal with object tracking in a predefined and well controlled environment. This research work tries to examine the difficulties of video based tracking through stepwise analysis of these issues. While a single image provides a snapshot of a scene, the different frames of a video taken over time represents the dynamics in the scene, making it possible to capture motion in the sequence. Video based tracking mainly deals with non-stationary image streams, with a changing background with time. Tracking objects is performed in a sequence of video frames and according to [2], its processing mainly consists of two main stages: separation of objects from background in each frame and connecting those objects in successive frames to trace them.

Three methods was proposed in [3] for object tracking. These methods are template-based, probabilistic and pixel-based. Pixel-based method is one of the useful methods for object tracking. This method has been proved to provide fruitful results against the background interfusion methods. As depicted in [3], this category is effective enough in the failure detection and automatic failure recovery.

In computer vision, detection and tracking moving objects and plotting their path of movement in video sequences is a very critical task. Possible applications are as follows:

A) Visual surveillance: A human action recognition system processes image sequences captured by video cameras through monitoring sensitive areas such as bank, departmental stores, parking lots and country border to determine whether one or more human beings engaged are suspicious or under criminal activity.

B) Content based video retrieval: In this technique, a human behavior understanding system scans an input video, and an action or event specified in high-level language. This application has very significant applications in different sports events for a quick retrieval of important events.

C) Precise analysis of athletic performance: This is related to the video analysis of any athletic action as an important tool for sports training and it has no intervention to the athletic.

In all these applications, fixed cameras are used with respect to static background and a common approach of background subtraction is used to obtain an initial estimate of moving objects [3].

The rest of this paper is organized as follows: Section 2 summarizes the related works, Section 3 deals with work description and Section 4 describes detail designing of entire wok, Section 5 presents implementation of the work, experimental results are given in Section 6 and Finally, conclusion and future work are discussed in section 7 followed by references.

2. Related work

There have been much research work in the field of object detection and tracking in videos over the past decades. Some of them are as follow:

Tushar S. Waykole and Yogendra Kumar Jain [1] proposed a new method for detecting and tracking of moving objects in video, combining the basic background subtraction method with the spatiotemporal analysis. The proposed method is faster and efficient. But it can't resolve the problems of locating multiple moving objects separately in the real time scenarios.

Md. Zahidul Islam, Chi-Min Oh and Chil-Woo Lee [2] proposed another approach where particle filtering is used in video based object tracking. Here, system of particle filter is based on shapes from distance transformed edge features. A Template is created instantly by selecting any one object from the video scene by a rectangle. Initialization is necessary to start tracking process. This approach can track only one object at a time. It can't track multiple objects.

Priti P. Kuralkar and Prof. V.T.Gaikwad [3] proposed an algorithm where an approach on "Human Object Tracking using Background Subtraction and Shadow Removal Techniques" was analyzed. In this approach a moving object can be successfully tracked and its shadow can be removed. But author didn't propose any way to recognise whether that object is a human figure and how to track multiple objects.

Seema Kumari, Manpreet Kaur and Birmohan Singh [4] presented an algorithm to perform moving object tracking for video surveillance systems. The proposed approach extracts the foreground from the input video effectively and tracks the moving object. An alarm is raised as the moving object is detected and tracked in the system. The proposed approach is unable to remove shadows, classify objects and remove false alarm.

Soma Datta, Debotosh Bhattacherjee and Pramit [5] proposed an approach on "Path Detection of a Moving Object". In this proposed approach, selective correlation is used to detect a moving object. The method provides a good accuracy but it is time consuming technique also. It can detect path of a single moving object but not of multiple objects.

Ritika, Gianetan Singh Sekhon [6] proposed a technique to track moving object from a video using consecutive frame evaluation. It is capable of plotting the movements of object through videos if the background is changed at any instant.

Hitesh A Patel and Darshak G Thakore [7] proposed an approach where Object tracking of any single moving object has been successfully implemented using Kalman filte. The system works on videos of indoor as well as outdoor environment taken using static camera under moderate to complex background condition but can't track multiple objects at a time.

S.Vijayalakshm and D.Christopher Duraira [8] proposed a method where moving objects detection and tracking is performed based on various threshold methods. Object detection is performed by using background subtraction with Alpha method and morphological operations. To find the path of moving object, feature point tracking approach is applied.

Abhishek Kumar Chauhan and Prashant Krishan in [9] proposed the Gaussian Mixture Model (GMM) and Optical Flow method successfully applied in a continuous image. Authors used GMM approach as the main tracking algorithm, with morphological and median filtering to remove noise. GMM can be used in the context of a complex environment while Optical Flow can be used for quick calculation with simple background.

Om Prakash, Manish Khare, Chandra Mani Sharma and Alok K. Singh in [10] presented a Daubechies Complex Wavelet transform based tracking algorithm. The proposed algorithm is simple to implement and capable to track the moving object in video sequences with stationary and varying background.The limitation of the algorithm is that the object size, shape should not change much between successive frames and object should move with approximate constant velocity between successive frames.

Mohammed Sayed and Wael Badawy [11] presents a novel motion estimation method for mesh-based video motion tracking. The method called mesh based square-matching (MB-SM) motion estimation method.

Falah E. Alsaqre and Yuan Baomng [12] presented an algorithm to perform moving object tracking for video surveillance systems. The moving objects extracted by the background subtraction method. It used two basic information structures such as a list of all active moving objects and their features and information about matching.

Dhar P.K., Khan M.I., Gupta A.K.S., Hasan D.M.H. and Kim J.M [13] had proposed an enhanced edge localization mechanism and gradient directional masking to detect moving object in video surveillance system. The appropriate directional masking was used to detect moving object.

In this paper, we have proposed the moving object detection as well as object tracking and plotting their path of movement by using the Background Subtraction(BS) method. In the proposed surveillance system single static camera is connected with the space under the observation. The paper provides an effective method for moving object detection and tracking with the stationary background scene. In our proposed methodology, first the videos are separated as frames and pre-processing methods are used for colour conversion and to subtract the foreground object from the background after the selection of a reference frame. The moving object is detected by determining variations in pixels. The moving object is then tracked by constructing the bounding box. Center coordinate values of each object in each frame are kept in a vector for path plotting process.

3. Work Description

Background Subtraction (BS) is a powerful mechanism for identifying changes in the video sequence in a Video surveillance system where human activity usually requires people to be detected [4]. Background Subtraction algorithm computes the absolute difference between the current image and a static background image and compares each pixel to a threshold [1]. Pixels belong to the same object should have the same label. This can be accomplished by performing a connected component analysis. All the connected components are computed and are considered as active regions if their area exceeds a given threshold value. This step is usually performed after a morphological filtering to eliminate isolated pixels and small regions [1]. Detection and tracking of moving objects from a video sequence is a fundamental and critical task. The background subtraction method is a common and simplest approach which identifies the moving objects from the portion of video frames that differs significantly from the background model [4].

According to the main objective of our work, the moving objects are to be tracked and based on that the path of each moving object is to be separately plotted. Video based moving objects tracking and path plotting system consists of several sequential processes. These processes are described in a step-wise way as follows:

Step 1 To get a stationary background as a reference image.
Step 2 To **c**ompare every frame of video with this reference image.
Step 3 To check whether there is any significant difference in the number of pixels from the reference Image.
Step 4 To draw a conclusion based on the result obtained in **Step 3** regarding the entry of an object.
Step 5 To begin the whole tracking process by calculating the centre and the rough size of the entering object and track it using a green

boundary box after the entry of the 1st object using an algorithm called ***Inter-Frame Differentiation (IFD)*** **algorithm.**

Step 6 To detect whether there is any 2nd object entering by checking the number of non-stationary pixels which are too far from the centre of the first object.

Step 7 To confirm that there is a second object entering if the result obtained in Step 6 is too large.

Step 8 To continue tracking process by calculating the centre and the rough size of the entered object and track it using green boundary box separately from the 1st one.

The next figure depicts the overall architecture of the system:

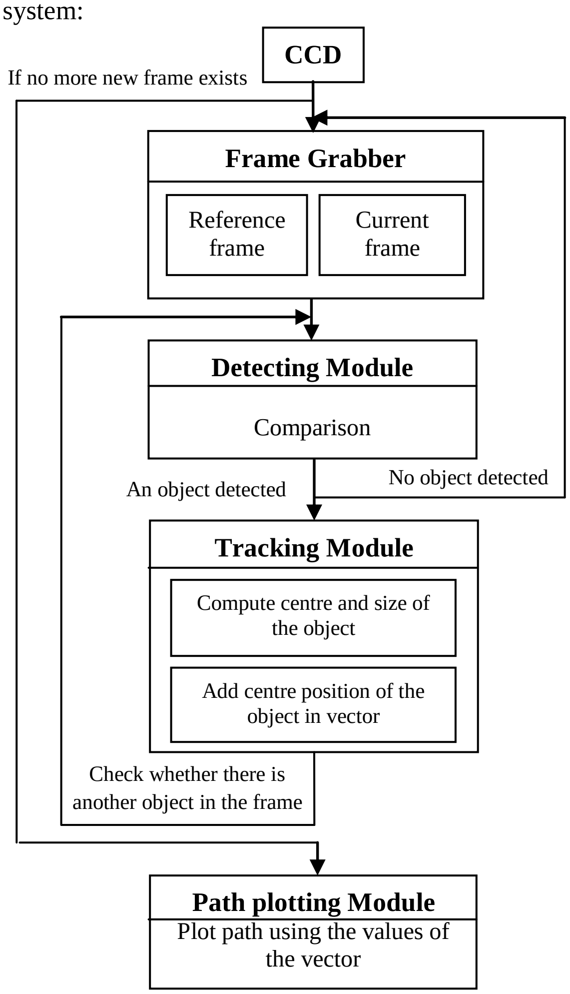


Figure 1: Background Subtraction based moving object Detection, Tracking and Path plotting System's architecture

[**Charge-coupled device (CCD)** image sensors are widely used in professional, medical, and scientific applications where high-quality image data is required.]

Step 9 To calculate the centre co-ordinate position of each entered object and to add those positions in a vector.

Step 10 To draw path of each object's movement using the content of the obtained vector at the end.

4. Detailed Design

The entire work is divided into several modules like image acquisition, colour image to gray image conversion, enhancement of the image, object detection and path plotting. These four modules are proposed by [5] and are as follows:

A. Image Acquisition: First step is Image Acquisition. Bit map formatted images are extracted from the video file, where frame speed is 25 frames per second.

B. Colour image to Gray Image Conversion: The acquired images are in RGB format, which takes huge computational time, so RGB image is converted into gray image using NTSC format using the following matrix operation:

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{vmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.274 & -0.322 \\ 0.211 & -0.523 & 0.312 \end{vmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (1)$$

Y = Luminance, **I** = Hue and **Q** = Saturation.

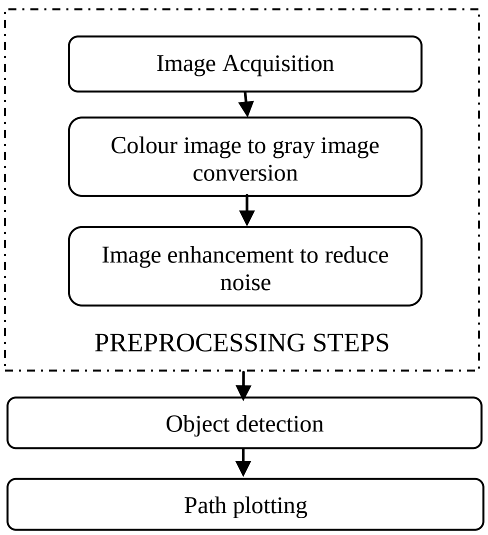


Figure 2: Block diagram of entire design.

C. Image Enhancement: Due to low quality videos or low light, it has been observed that the images extracted from the frames are not with clear-edged, i.e., those images are slightly hazy. This type of noise is removed by using second derivative image enhancement method which is called Laplacian Filter [14]. The Laplacian value of a pixel is denoted by $\nabla^2 f(x, y)$ and can be defines as follows:

$$\nabla^2 f(x,y) = \frac{\partial^2}{\partial x^2} f(x,y) + \frac{\partial^2}{\partial y^2} f(x,y) \tag{2}$$

$$\frac{\partial^2}{\partial y^2} f(x,y) = f(x,y+1) + f(x,y-1) - 2f(x,y) \tag{3}$$

$$\frac{\partial^2}{\partial x^2} f(x,y) = f(x+1,y) + f(x-1,y) - 2f(x,y) \tag{4}$$

Finally,

$$\nabla^2 f(x,y) = f(x+1,y) + f(x-1,y) + f(x,y+1) + f(x,y-1) - 4f(x,y) \tag{5}$$

This expression is implemented at all points (x, y) of the image through a method called convolution.

D. Object Detection and Path Plotting: Here is the algorithm to detect objects to track them and plot their respective path of movement.

Algorithm: Object detection and path plotting.

Step 1 Let $\mathbf{I_{BASE}}$ be the base image (reference image) where moving object is not present. Let $\mathbf{I_{NEXT}}$ be the next image where moving object is present, but background is same with the base image.

Step 2 The base image, $\mathbf{I_{BASE}}$ is converted from RGB to greyscale.

Step 3 Laplacian filter is applied on that greyscale image to enhance the image. The result is stored as $\mathbf{I_1}$.

Step 4 For each frame $\mathbf{I_{NEXT}}$, the following steps are executed until no more new frames in the video frame set is found:

a) The current frame $\mathbf{I_{NEXT}}$ is read.
b) The current frame image, $\mathbf{I_{NEXT}}$ is converted from RGB to greyscale.
c) Laplacian filter is applied on that greyscale image and the result is stored as $\mathbf{I_2}$.
d) After applying Laplacian filter that current frame image $\mathbf{I_2}$ is subtracted from the reference frame image $\mathbf{I_1}$ pixel by pixel i.e. the operation ($\mathbf{I_1} - \mathbf{I_2}$) is performed.
e) After subtraction, the resultant image is converted into its equivalent binary form. Let this new image is $\mathbf{I_{2B}}$.
f) Very small unnecessary structures called noise are removed from $\mathbf{I_{2B}}$ and the result is stored as $\mathbf{I_3}$.
g) The area and centroid of each remaining structure in $\mathbf{I_3}$ are computed.
h) If the area is not empty then it identifies the presence of one or more than one moving objects in that video frame. Thus, the detection process is completed.
i) Each detected moving object is then tracked separately by green bounding box.
j) The centre co-ordinate of each tracked object is computed and stored in a vector named **XY**.

Step 5 These discrete points stored in **XY** vector are plotted at the end. So, finally the path of the moving objects from the different frames is identified.

Step 6 Stop.

5. Implementation

Since to develop the entire system involves many tasks, this has been divided into several stages. It's a repetitive process.

A. Initial considerations: It involves the system specifications, i.e., both the hardware as well as software specifications. The proposed algorithm is implemented and tested on Matlab 2012a with operating system windows 7. A webcam is needed to capture the real time video to work on.

B. Functional design: The functional property of the project should be decided at this stage, i.e., how the input will affect the output. The input of this system is a video frame sequence .The output is a video frame sequence where each moving object is pointed by a green bounding box and a graph representing paths of moving objects.

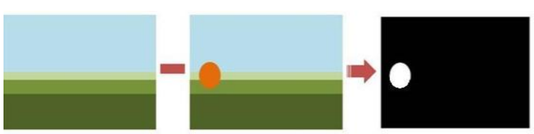
C. Development of algorithm: In this stage of implementation an algorithm is to be developed to reach the goal of the work. The steps of the algorithms should be feasible and optimistic in nature. The algorithm should be able to achieve all the functional requirements of the work. This stage is an important part of the work and definitely followed by functional specification because functional designs can only be semi-realized by this stage.

D. Coding: In this stage, MATLAB R2012a is used for coding as this is an efficient tool for the video and image processing based tasks.

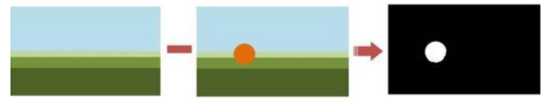
E. Analyzing the outputs and testing the system: Now in this stage the outputs of the developed system are tested to see whether the system is working according to its functional design and specification.

6. Experimental results

This work has been started off from performing some initial operations on a number of frames where a ball was moving from left side to the right side. At first, a background modelling is performed to yield a reference model. This reference model is used in background subtraction in which each video sequence is compared against the reference model to determine possible variation. The variations between current video frames to that of the reference frame in terms of pixels signify existence of moving objects [3]. Figure 3 shows that initial operation. In 1st case the background subtraction operation was performed on Frame 1(reference frame) and Frame 2(current frame) to get Result 1 and in 2nd case background subtraction operation was performed on same reference frame, Frame 1 and next frame, Frame 3 to get Result 2. In both cases a static background was used. This work was able to subtract two colour images to get only the moving ball shown in Result 1 and Result 2. Results of background subtraction are shown below:



Frame 1 Frame2 Result 1



Frame 1 Frame 3 Result 2

Figure 3: Background subtraction operation

The variation which also represents the foreground pixels are further processed for object localization, tracking and path plotting.

Figure 4 to Figure 10 are used to illustrate the proposed algorithm. Figure 4(a) is a reference image taken from video. The Result of Step 2 is shown in Figure 4(b). Figure 4(c) is the result of applying Laplacian filter in Figure 4(b). Figure 5(a) is a next frame from video frameset after applying Step 4(a). Figure 5(b) is the result of applying Step 4(b) on Figure 5(a) and Figure 5(c) is the result of applying Step 4(c) on Figure 5(b).

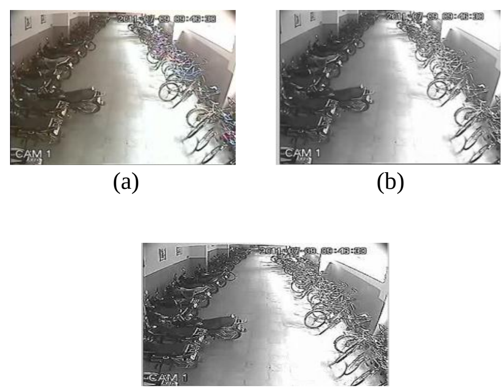
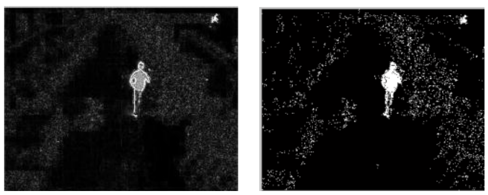


Figure 4: (a) After applying Step 1, I_{BASE} looks like (b) After applying Step 2 on I_{BASE}. (c) After applying Step 3, I_1 looks like.

(c)

Figure 5: (a) After applying Step 4(a), I_{NEXT} looks like. (b) After applying Step 4(b) on I_{NEXT}. (c) After applying Step 4(c), I_2 looks like.

The result of Step 4(d) is shown in Figure 6(a) where Subtraction **(I_1 - I_2)** is performed. Figure 6(b) is a binary form of Figure 5(a) after applying Step 4(e). In Figure 6(b) there is a huge number of unnecessary points, these points are called noise. The result of noise removal after applying Step 4(f) on Figure 6(b) is shown in Figure 6(c). Finally, objects are detected after applying Step 4(h) on Figure 6(c) and are tracked using bounding box after applying Step 4(j). Center coordinate of each tracked object in the current frame is stored in a vector named XY. So that, in future paths of objects' movement can be plotted using that vector.

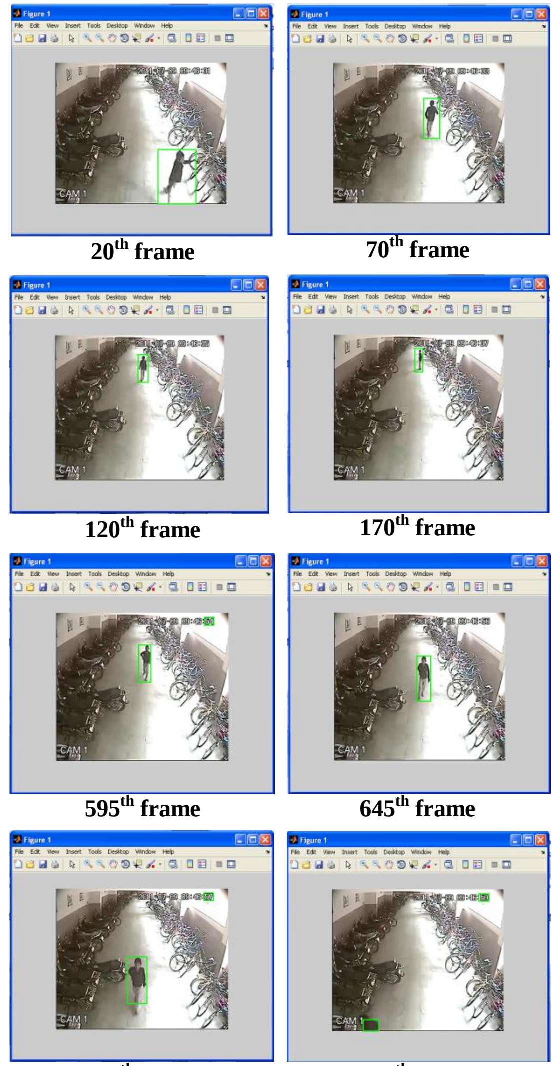


(a) (b)

(c)

Figure 6: (a) $I_1 – I_2$ is performed. (b) After applying Step 4(e) I_{2B} looks like. (c) After applying Step 4(f) I_3 looks like.

Experiment 1: The proposed algorithm is applied in the "cycle_thief.vid" video clip of frame size 320 X 262 and the tracking results are observed on various frames. Figure 7 shows tracking process of a single moving object where a cycle thief is walking around from one corner to another corner in front of a CCTV camera. Tracked object is bounded by a green bounding box. Figure 8 shows the plotted path of the single moving object after tracking process shown in Figure 7 which is plotted by using the stored value of the vector (XY) as discussed in our proposed algorithm. The plot shows the movement of the thief in the video. In Figure 8(a) path is plotted on the reference frame of the video. Figure 8(b) shows plotted path on a separate graph where X-axis represents the width and Y-axis represents the height of the video.



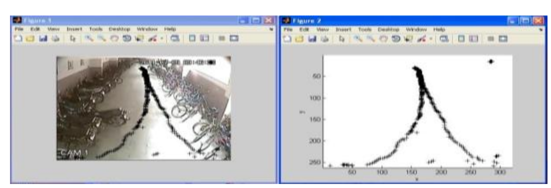
20th frame **70th frame**

120th frame **170th frame**

595th frame **645th frame**

670th frame **720th frame**

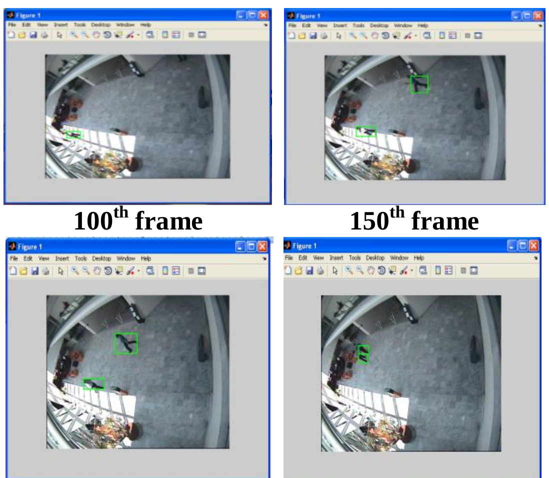
Figure 7: Tracking of a single moving object in cycle thief video clip.



(a) (b)

Figure 8: Plotted path of the moving object in cycle thief video clip (a) plotted path on the reference frame (b) plotted path on a separate graph.

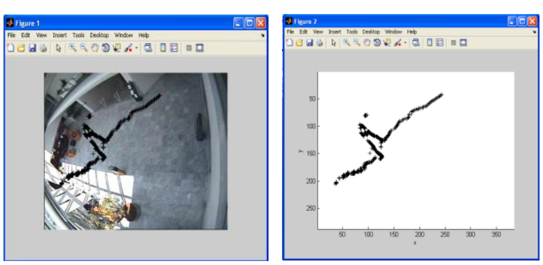
Experiment 2: The proposed algorithm is applied in the "Meet_WalkTogether1.vid" video clip [15] of frame size 384 X 288 and the tracking results are observed on various frames. Figure 9 shows tracking process of multiple moving objects where two people meet and shake hands and then walk together in front of a CCTV camera. Tracked objects are bounded by green bounding box. Figure 10 shows the plotted path of multiple moving objects after tracking process shown in Figure 9 which is plotted by using the stored value of the vector (XY) as discussed in our proposed algorithm. The plot shows the movement path of two people in the video. In Figure 10(a) path is plotted on the reference frame of the sample video. Figure 10(b) shows plotted path on a separate graph where X-axis represents the width and Y-axis represents the height of the video clip.



100th frame **150th frame**

200th frame **500th frame**

Figure 9: Tracking of multiple moving objects in the sample video clip.



(a) (b)

Figure 10: Plotted path of the multiple moving objects in sample video clip (a) plotted path on the reference frame (b) plotted path on a separate graph.

7. Conclusion and Future Work

In this paper, the proposed approach is capable of tracking all moving objects and can find out path corresponding to each moving object with accuracy in a real time video. Background subtraction method is a common, effective and simplest approach which identifies the moving objects from the portion of video frames that differs significantly from the background model. This system has been tested on a variety of video clips and very satisfactory results have been obtained.

There are so many possibilities to extend our work in future such as to identify the nature of each object, colouring each path with different colour to identify each of them uniquely. In this paper, the proposed algorithm works only on a reference image which does not contain any object i.e. containing background without any moving object and the next frame image with same background is subtracted from that reference image to detect existence of an object. There is a possibility to extent our work such as to develop a new approach where the system still works when the reference image already contains a moving object.

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