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Dealing with Occlusion with Partial Visibility

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ABSTRACT

Object tracking is a process that follows a specific object through some consecutive frames of images to determine the movement of that object relative to the other objects of those frames. Simply, tracking is the problem of estimating the trajectory of an object in the image plane as it moves around a scene. Depending on the tracking domain, a tracker can also provide partial and full object occlusions along with the other features. Here the problem with occlusion is being focused. It is experimented that if the color and texture features are applied then after occlusion object can be tracked. But sometimes it fails to detect the objects after occlusion. In this experiment we tried to include the partial visibility information of an object individually and along with these factors and has tried to proof that with this extra information we can project a better and more realistic trajectory of the object being tracked both before and after the occlusion. For this purpose a new and a very simple algorithm has been proposed which is able to track objects before and after occlusion even if the color and texture do not come up to scratch. Some experimental results are shown along with several case studies trough which the effectiveness of the proposed algorithm is explored.

Keywords: *Object tracking, Occlusion, Partial visibility*

1. INTRODUCTION

Surveillance systems now days are becoming very popular and an essential part of any organizations around the world. In some cases it's used in home security purpose as well. In all of these systems the main concept behind the scene is object tracking. Object tracking is an important task within the field of computer vision. It is a process where an object is being distinguished through a specific procedure. The explosion of high-powered computers, the availability of high quality and inexpensive video cameras, and the increasing need for automated video analysis has generated a great deal of interest in object tracking algorithms.

There are three major steps in video analysis [1]:

a. Tracking of such moving objects from frame to frame.
b. Analysis of the object tracks to recognize their behavior
c. Detection of the moving objects.

The use of object tracking is relevant in the tasks of motion-based recognition (human identification based on gait, automatic object detection), automated surveillance (monitoring a scene to detect suspicious activities or unlikely events), video indexing (automatic annotation and retrieval of the videos in multimedia databases), human computer interaction (gesture recognition or eye gaze tracking for data input to computers), traffic monitoring (real-time gathering of traffic statistics to direct traffic flow), and vehicle navigation (video-based path planning and obstacle prevention potentiality)

In a video sequence the first thing that needs to be done is to track the number of objects and identify each of them separately. A number of features can be used for this purpose namely size, shape, color and area of an object. But at times while tracking an object some complexity may occur. The reasons [1] can be loss of information because of projection of the 3D world on a 2D image, noise in images, complex motion of the object, non–rigid or articulated nature of objects, partial and full object occlusions, the complex shapes of the object, the illumination scene changes, and lack of real-time processing requirements.

Occlusion is one of problems in object tracking. If an object is visible and moving, and then suddenly it is not visible any more, mainly because it might be behind another object, then this scenario can be considered as occlusion. The occlusion may occur fully or partially. In the case of occlusion it becomes little complicated to identify one particular object of interest. To overcome this problem, a number of research works are observed. Some works have applied color, texture, motion analysis and other methodologies. In some works multiple objects can be tracked in real time in dynamic scenes along with occlusion handling using the motion based features [2]. Objects partially visible while occluded can provide some information about the location of that object. In this paper we have included this *partial visibility* of an object to trace its center and then project a trajectory based on its previous and later movements.

The main objective of this paper is to propose an algorithm to track object before and after the occlusion and find its complete trajectory while taken into consideration partial visibility. When partial occlusion occurs and a little portion of an object is visible, our proposed algorithm can provide a better and more realistic trajectory of the tracked object. The proposed algorithm can be an effective part of a surveillance system for security purposes.

The paper is organized as follows: In Section 2 some related works are described. Section 3 describes the methodology of the proposed system. Section 4 describes the implementation procedure along with the tools and the components used. In Section 5 the impact of the proposed method at different scenarios has been visualized and described along with the limitations. Section 6 concludes the paper.

2. LITERATURE REVIEW

Some related works are presented in this section. More precisely the works related to object tracking under occlusion are focused here. In [3] the authors have proposed a probabilistic framework for off-line tracking of multiple objects. A guaranteed correct solution will be there where at each time step a small amount of deterministic candidates is generated. The proposed algorithm involves deterministic solution in distinction with particle filter methods.

Occlusion may occur either partially or fully. Based on this partial occlusion in [4] the authors presented an approach which automatically detects and tracks multiple, partially occluded objects. In [5] the authors presented an approach to deal with the occlusion problem explicitly with the measurement on object distance and power. The system has the compensation of low cost and low complexity that can be comprehended in real time system. When one object is moving around the frame and being occluded by other objects, standard manifold modeling techniques, in other words, principal components analysis, factor analysis, locally linear embedding, try to report for global motion and occlusion.

In [6] the authors illustrated how factor analysis can be integrated into a generative model of layered, 2.5-dimensional vision, to jointly locate objects, resolve occlusion ambiguities and gain knowledge of models of the outward show manifolds of objects. The authors in [7] has presented an efficient texture-based method for modeling the background and detecting moving objects from a video sequence. Each pixel is modeled as a group of adaptive local binary pattern histograms that are calculated over a circular region around the pixel. The authors of [8] proposed a real-time system for multiple objects tracking in dynamic scenes. The system is able to cope with long-duration and complete occlusion without a prior knowledge about the shape or motion of objects. The proposed system can track multiple objects with long-duration and complete occlusion.

In [9] the authors have proposed an algorithm for occlusion handling in the jam-packed video scenes. The algorithm utilizes the properties of un-decimated wavelet packet transform (UWPT) coefficients and texture analysis to track random objects. The authors in [10] have presented a method for tracking objects through occlusions based on a level set technique. Here they have considered two cases considered. First one is that the object is blocked by another one of a different color. The second one is-the object is blocked by another one of the same color. A new approach toward target representation and localization, the central component in visual tracking of non-rigid objects, is proposed by the authors in [11]. The feature histogram-based target representations are regularized by spatial masking with an isotropic kernel [14]. An efficient, new algorithm is described by the author in [12] based on the mean shift algorithm. The mean shift algorithm robustly finds the mode (peak) of probability distributions.

The authors in [13] have proposed a method for object tracking using prototype-based deformable template models. To track an object in an image sequence, they use a criterion which combines two terms: the frame-to-frame deviations of the object shape and the fidelity of the modeled shape to the input image. An application is described of the visual serving approach to robot positioning with respect to an object and to target tracking by the authors of [15]. After briefly discussing how the task function approach can be applied to tasks which include the use of visual features, the authors give a simplified control expression which explicitly takes into account the case of moving objects. The Continuously Adaptive Mean Shift Algorithm (CamShift) is an adaptation of the Mean Shift algorithm for object tracking that is intended as a step towards head and face tracking for a perceptual user interface. In [16] the authors have reviewed the CamShift Algorithm and extend a default implementation to allow tracking in an arbitrary number and type of feature spaces.

An attempt to achieve a high level of interaction between a real-time vision system capable of tracking moving objects in 3-D and a robot arm with gripper that can be used to pick up a moving object is described by the authors in [17]. The goal is to build an integrated sensing and actuation system that can operate in dynamic as opposed to static environments. The system built addresses three distinct problems in using robotic hand-eye coordination for grasping moving objects: fast computation of 3-D motion parameters from vision, predictive control of a moving robotic arm to track a moving object, and interception and grasping. In [18] the authors have presented a system that electromagnetically tracks the positions and orientations of multiple wireless objects on a tabletop display surface. The system offers two types of improvements over existing tracking approaches such as computer vision. First, the system tracks objects quickly and accurately without susceptibility to occlusion or changes in lighting conditions. Second, the tracked objects have state that can be modified by attaching physical dials and modifiers.

The authors in [19] exploited the localized prediction paradigm for power-efficient object tracking sensor network. Localized prediction consists of localized network architecture and a prediction mechanism called dual prediction, which achieves power savings by allowing most of the sensor nodes stay in sleep mode and by reducing the amount of long-range transmissions. In [20] the authors formulated a stereo matching algorithm with careful handling of disparity, discontinuity, and occlusion. The algorithm works with a global matching stereo model based on an energy-minimization framework. The authors in [21] have proposed a new method for object tracking in image sequences using template matching. To update the template, appearance features are smoothed temporally by robust Kalman filters, one to each pixel.

In [22] the authors have presented a method of tracking objects through occlusions using appearance models. These models are used to localize objects during partial occlusions, detect complete occlusions and resolve depth ordering of objects during occlusions. This paper presents a tracking system which successfully deals with complex real world interactions. The authors in [23] have focused on motion tracking and show how one can use observed motion to learn patterns of activity in a site. Motion segmentation is based on an adaptive background subtraction method that models each pixel as a mixture of Gaussians and uses an online approximation to update the model. In [24] the authors have presented in the work that describes a tool for object tracking, notes insertion, and information retrieval, applicable to MPEG-2 sequences.

The authors in [25] have presented a fast semi-automatic semantic object-tracking algorithm for digital video. The proposed method consists of two steps, namely, intra-frame object extraction and the inter-frame object tracking. One of the goals in the field of mobile robotics is the development of mobile platforms which operate in populated environments and offer various services to humans. For many tasks it is highly desirable that a robot can determine the positions of the humans in its surrounding. In [26] the authors have presented a method for tracking multiple moving objects with a mobile robot. We introduce a sample-based variant of joint probabilistic data association filters to track features originating from individual objects and to solve the correspondence problem between the detected features and the filters [26]. In [27] the authors have proposed an approach that uses a vacant reference image for object extraction through image difference [11]. The reference frame is updated incessantly by a background updating module taking into account the detected objects.

The authors in [28] have proposed a fast and strong approach for detecting and tracking of moving objects. This proposed method is based on using lines computed by a gradient-based optical flow and an edge detector. In [13] the authors have proposed an novel approach of tracking bi-directional objects. In the paper, they present a novel approach to key frame-based tracking, called bi-directional tracking. In the paper, they have presented a bi-directional tracking approach based on trajectory segment analysis. Curved target object trajectories are successfully extracted by trajectory segment analysis and connected by the occlusion reasoning algorithm. With a trajectory segment representation, more challenging visual tracking tasks can be well handled. The authors in [30] have proposed a tracking method which tracks the complete object regions, adapts to changing visual features, and handles occlusions. Tracking is achieved by evolving the contour from frame to frame by minimizing some energy functional evaluated in the contour vicinity defined by a band. This approach has two major components related to the visual features and the object shape.

3. PROPOSED METHOD

To track an object in the proposed method three features are used. These are (i) Shape information, (ii) Previous trajectory, and (iii) Partial visibility. The feature extraction method is described in the following sections whereas the algorithm is presented in Figure 1 and Figure 2.

3.1 Extract the shape information

Contour tracking or silhouette tracking is one of the most promising techniques in the area of object tracking. Dynamic filtering can be used in amalgamation with a modal-based flexible shape model to track an articulated non-rigid body in motion. The method was used to track the silhouette of a walking pedestrian in real time. The active shape model used was generated automatically from real image data and incorporates variability in shape due to orientation as well as object flexibility. Kalman filter is used to control spatial scale for feature search over successive frames. Iterative refinement allows accurate contour localization where feasible. The shape model incorporates knowledge of the likely shape of the contour and speeds up tracking by reducing the number of system parameters.

Color, texture and motion features are also used in some works however not in combination with shape information. So in this work along with the color and texture features we have proposed an algorithm to get the shape information of an object in a very simple and easy way. First of all, the contour of the object is being tracked. Then the center of the contour is identified. From the center eight significant distances are computed. Based on these eight distances the object is being tracked from frame to frame before and after the occlusion. The algorithm and graphical representation is presented next.

3.2 Extract the texture feature

Sometimes object tracking based on color becomes unreliable. If there are more than one object in a scenario having the same color it is difficult to separate them based on color only. This difficulty can be lessened by using other features that are less responsive to such image alterations. Texture, which has not enjoyed major attention in tracking applications, provides a good option to enhance the power of color descriptors. A good survey to different texture features is available in [28].

In this paper we have used co-occurrence matrix as the texture feature to reveal the surface of an object. The main characteristic of this co-occurrence matrix is that it is going to keep track of each of its consecutive pair of bits. Thus it is able to keep the pattern of a specific object based on which one the object can be tracked from frame to frame. The inclusion of texture feature makes tracking method more reliable and the chance of failure is reduced to some extent.

3.3 Extract partial visibility

In most of the previous studies the partial visibility feature was not included. This partially visible information can give a better idea of where the object might be while occlusion occurs. As we don't know where the object is at that time, we are predicting its path from the point occlusion occurs [29], to the point when occlusion finishes. But while in occlusion if we can have partial information of where the object is, we can make better projections taking in mind the partial visible information. So in this case we try to scan the whole frame while our object is in occlusion and try to identify if some part of that object is visible or not. We extract the center point of the object from each frame and store it. So whenever the object might be partially visible we get that information as well and store the information of the center point. While we project the path of the object we include this mid point in the trajectory and thus get a better and more realistic path of the object while in occlusion.

```
Function main ()

   1. read the video file
   2. fix a  frame to start with
   3. read the frame to start with
   4. turn the RGB color image into grayscale image
   5. resize the frame
   6. initialize the variables
   7. Loop
      7.1 begin
      7.2 read the next frame
      7.3 turn the RGB color image into grayscale image
      7.4 resize the image frame
      7.5 get the difference between the two frames
      7.6 figure out the moving objects in the frames
      7.7 find the center of the objects.
      7.8 store the coordinate of the center point
      7.9 keep the record of the latest frame in img0
      7.10 repeat until the last frame of the video
      7.11 end loop
   8. eliminate the values those are of no interest.
   9. call fit_path(x,y) to project the path of the variable

End of function main ()
```

Figure 1: The Main function algorithm

```
Function fit_path(x,y)

   1. take input x and y as the coordinate of the center point
   2. set up figure to receive datasets and fits
   3. plot data originally in dataset "Path (smooth)
   4. nudge axis limits beyond data limits
   5. create fit "Path Fit"
   6. fit this model using new data
   7. done plotting data and fits.  Now finish up loose ends

End of fit_path()
```

Figure 2: The algorithm to fit the path

4. EXPERIMENTAL SETUP

Several different cameras are being used to take the video sequences. For implementation MATLAB image processing toolbox is being used. As objects sometimes people sometimes some objects has been used. Descriptions are given here in this chapter. Some of the video clips are taken by the Panasonic MV-300 Mini DV Camcorder. The Panasonic MV-300 Digital Camcorder is a feature packed video camera that doubles as a still camera. It offers 3 CCD for high quality image reproduction, a 10x optical Leica lens with 700x digital zoom, 3.1 Megapixel still image recording and Optical Image Stabilizer (OSI) to reduce shake from the image. Recording is done on a miniDV tape or directly to a PC. The camera includes a color viewfinder and 2.7" LCD display. Navigation of menus is accomplished with a one-finger joystick. [30]. We have used Image Processing Toolbox.

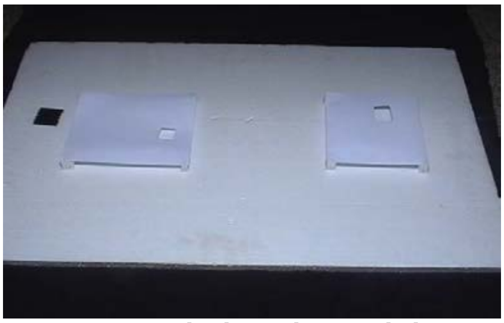

Figure 3: The object is being tracked

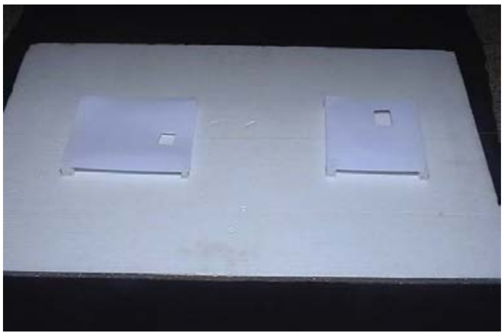

Figure 4: Object under occlusio

We have used the experimental setup is Figure 3 to track the object. Figure 3 indicates this tracking. Whenever the occlusion occurs it detects the occlusion. In figure 4 this is shown. While in occlusion the object is not visible. Now if partial visibility occurs then the object will reappear partially. And then full occlusion will occur again. Figure 5 shows the partial visibility.

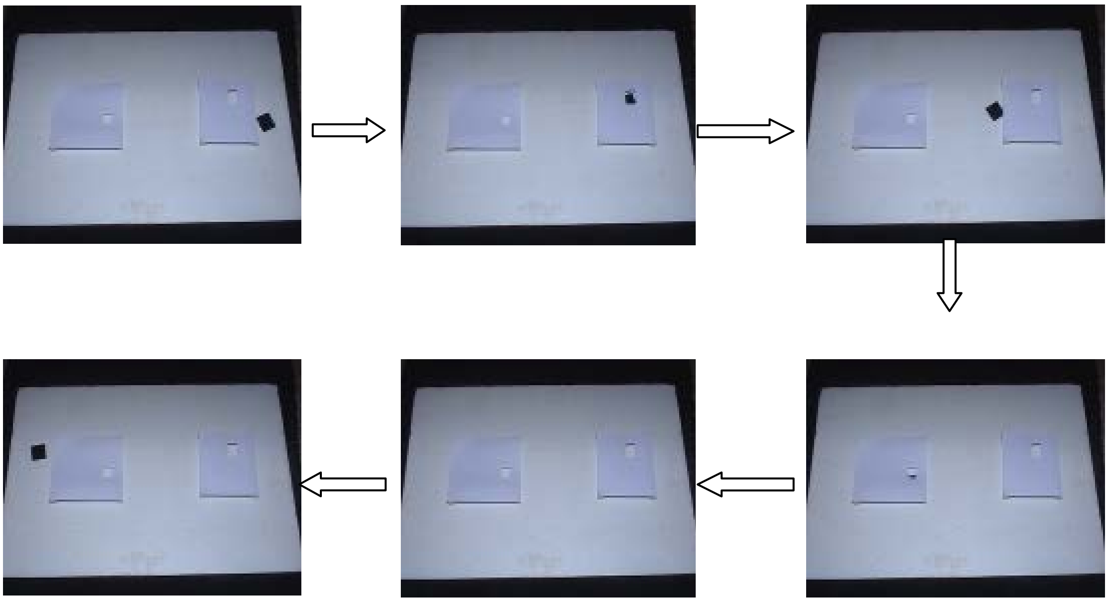

Figure 5: The scenario with partial occlusion

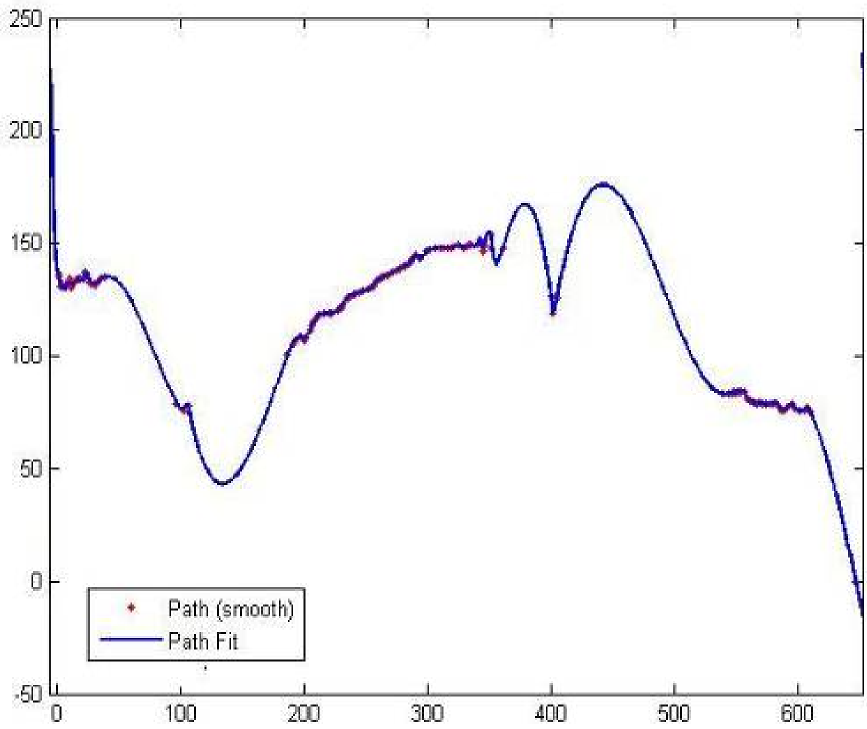

Figure 6: The projected trajectory

5. EXPERIMENTAL RESULTS

This sub chapter can be divided into some different cases based on the shape, size and moving directions of the objects. Based on these terms the result differs. The number of object present in this scenario is a random sized object. The object can be of any color. Occlusion occurs both partially and fully. The object is moving from right to left.

Using shape information we can successfully track the object before and after the occlusion occurs. In case of partial occlusion we can identify the object successfully. In the parts where the object is fully occluded we successfully managed to propose a realistic trajectory of its path.

The graphical representation is available in figures 5 show the sequence of the object. And eventually 6 show the projected trajectory for the object.

5.1 Experiment one

The number of object present in this scenario is a random sized object. The object can be of any color. Occlusion occurs both partially and fully. The object is moving from right to left.

Using shape information we can successfully track the object before and after the occlusion occurs. In case of partial occlusion we can identify the object successfully. In the parts where the object is fully occluded we successfully managed to propose a realistic trajectory of its path.

The graphical representation is available for Case 1. Figures 7 show the sequence of the object. And eventually 8 show the projected trajectory for the object.

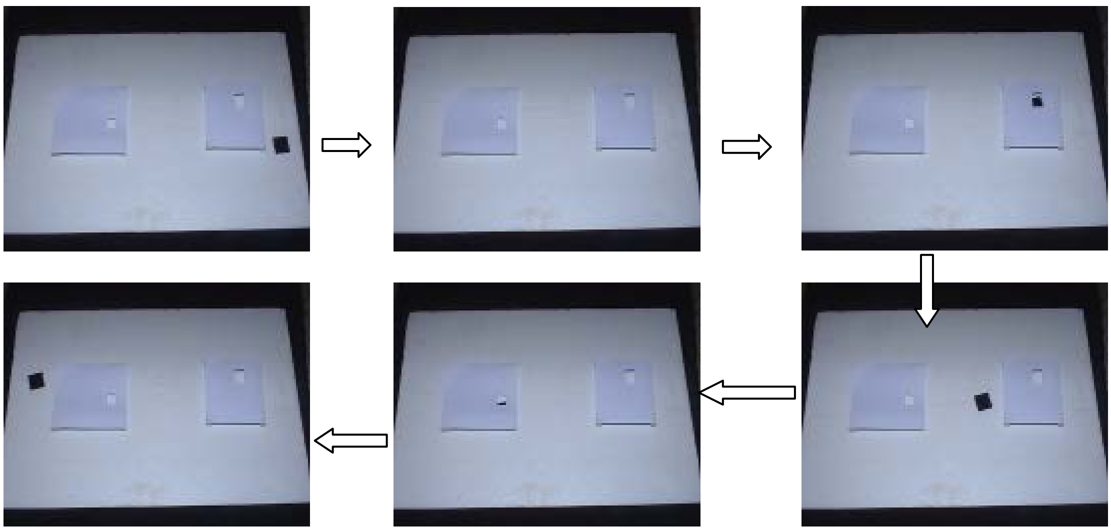

Figure 7: The sequence of images from '0013.avi'

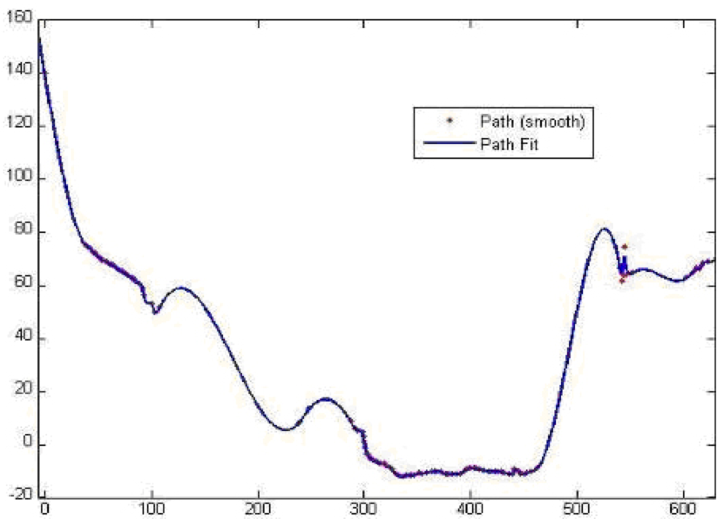

Figure 10: The projected trajectory for '0017.avi'

5.3 Experiment three

The number of object present in this scenario is a random sized object. The object can be of any color. Occlusion occurs both partially and fully. The object is moving from right to left.

Using shape information we can successfully track the object before and after the occlusion occurs. In case of partial occlusion we can identify the object successfully. In the parts where the object is fully occluded we successfully managed to propose a realistic trajectory of its path.

The graphical representation is available in figures 11 show the sequence of the object. And eventually 12 show the projected trajectory for the object.

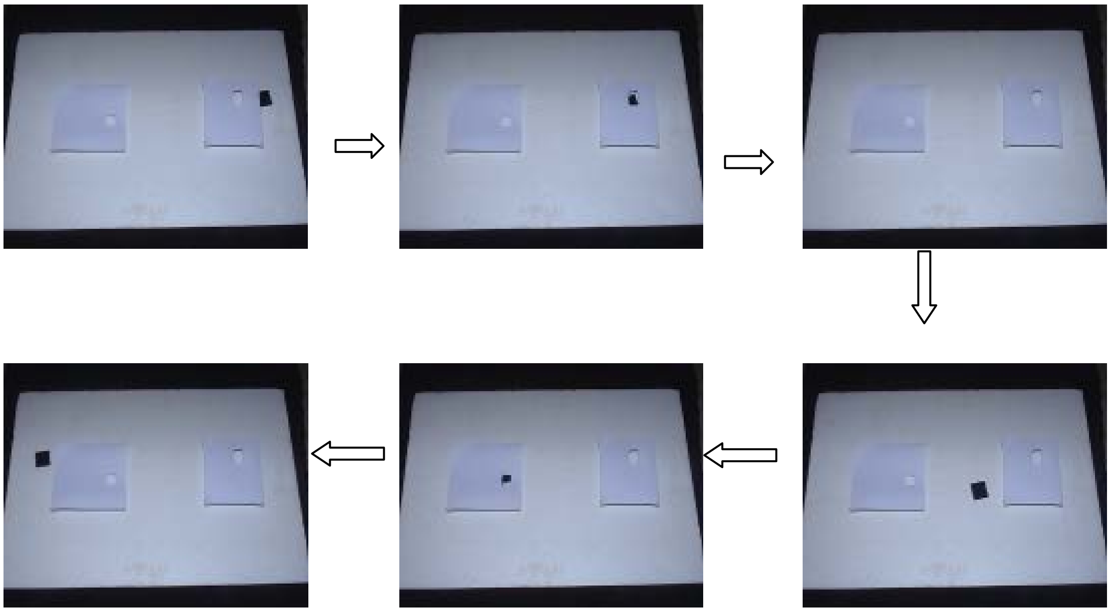

Figure 11: The sequence of images from '0020.avi'

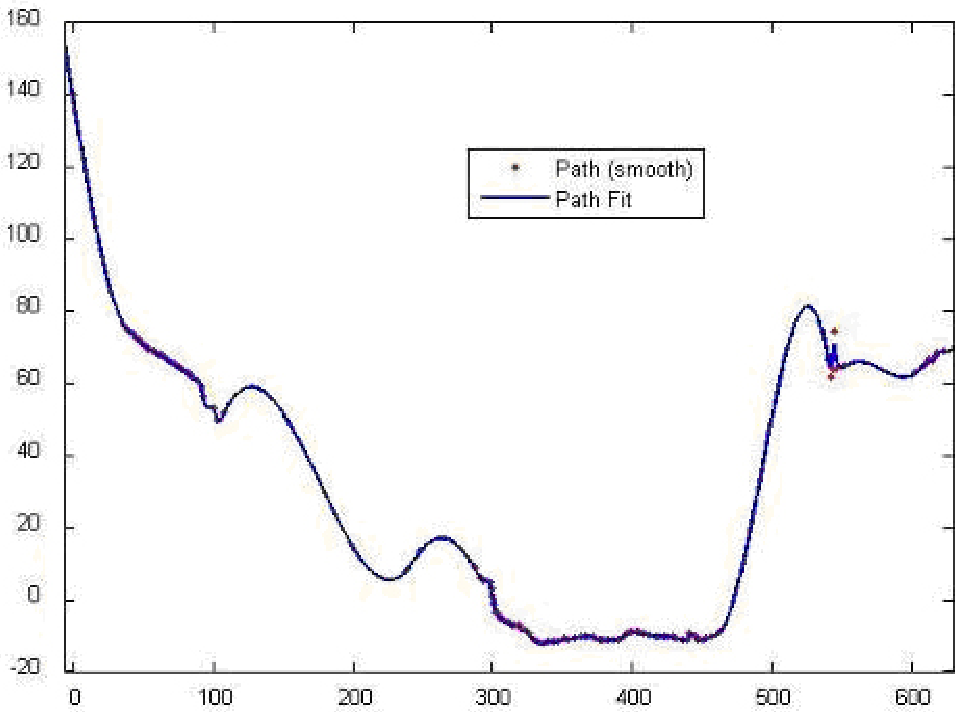

Figure 12: The projected trajectory for '0020.avi'

5.4 Experiment four

The number of object present in this scenario is a random sized object. The object can be of any color. Occlusion occurs both partially and fully. The object is moving from right to left.

Using shape information we can successfully track the object before and after the occlusion occurs. In case of partial occlusion we can identify the object successfully. In the parts where the object is fully occluded we successfully managed to propose a realistic trajectory of its path.

The graphical representation is available in figures 13 show the sequence of the object. And eventually 14 show the projected trajectory for the object.

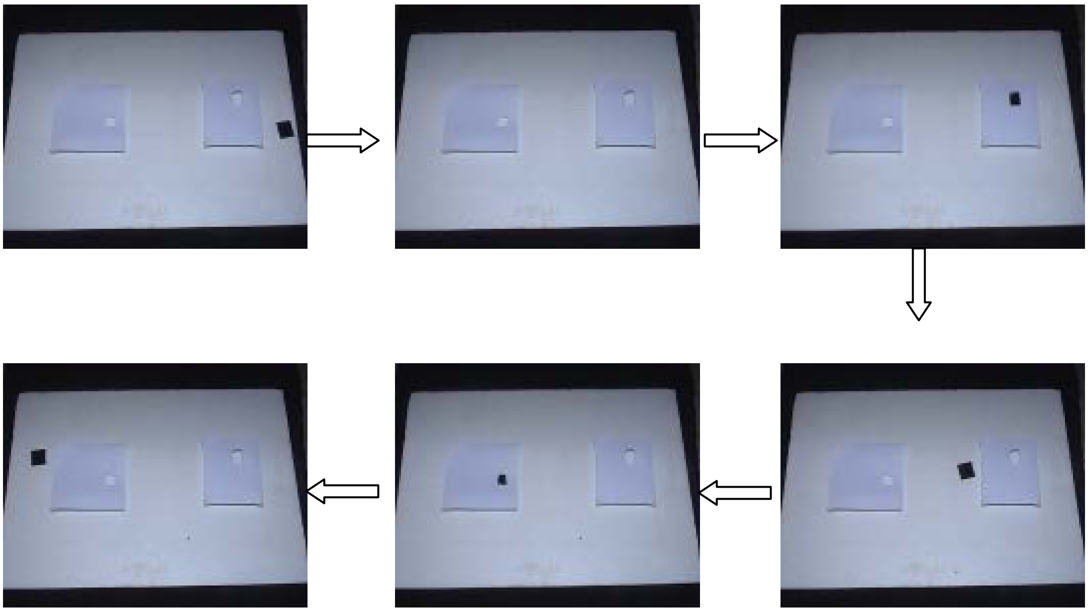

Figure 13: The sequence of images from '0016.avi'

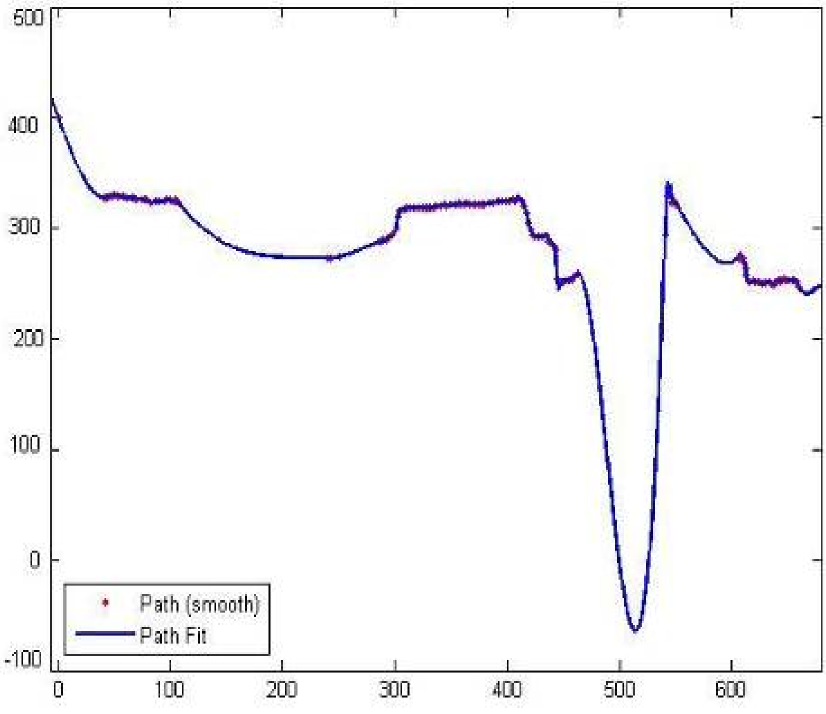

Figure 14: The projected trajectory for '0016.avi'

6. CONCLUSION

Object tracking is a process that follows a specific object through some consecutive frames of images to determine the movement of that object relative to the other objects of those frames. Simply, tracking is the problem of estimating the trajectory of an object in the image plane as it moves around a scene. Depending on the tracking domain, a tracker can also provide object-centric information, such as orientation, area, or shape of an object. Tracking objects can be complex due to-loss of information caused by projection of the 3D world on a 2D image, noise in images, complex object motion, no rigid or articulated nature of objects, partial and full object occlusions and so on. A. K. Jain, Y. Zhong nad S. Lakshmanan has proposed a general object localization and retrieval scheme based on object shape using deformable templates [32]. Prior knowledge of an object shape is described by a prototype template which consists of the representative contour/edges, and a set of probabilistic deformation transformations on the template. A Bayesian scheme, which is based on this prior knowledge and the edge information in the input image, is employed to find a match between the deformed template and objects in the image. Computational efficiency is achieved via a coarse-to-fine implementation of the matching algorithm. Our method has been applied to retrieve objects with a variety of shapes from images with complex background. The proposed scheme is invariant to location, rotation, and moderate scale changes of the template.

Here the problem with occlusion is being focused. It is experimented that if the color, texture and motion are applied then after occlusion object can be tracked. In this experiment we tried to include the shape of an object along with these factors and trying to proof that with the same color, texture and motion if two object's shape information is taken then these two objects can be detected after the occlusion occurred. After some experiments on some different cases it is revealed that though in some cases the system fails, but is some situations it is working better than the other features which indicate that it can be a very effective tracking system with one of the simplest algorithms.

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