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Multiple Object Detection and Tracking in Dynamic Environment using Real Time Video

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ABSTRACT

Video surveillance is an active research topic in computer vision that tries to detect, recognize and track objects over a sequence of images and it also makes an attempt to understand and describe object behavior by replacing the aging old traditional method of monitoring cameras by human operators. Object detection and tracking are important and challenging tasks in many computer vision applications such as surveillance, vehicle navigation and autonomous robot navigation. Object detection involves locating objects in the frame of a video sequence. Every tracking method requires an object detection mechanism either in every frame or when the object first appears in the video. Object tracking is the process of locating an object or multiple objects over time using a camera. The 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 key steps in video analysis, detection interesting moving objects, tracking of such objects from each and every frame to frame, and analysis of object tracks to recognize their behavior. The main reason is that they need strong requirements to achieve satisfactory working conditions, specialized and expensive hardware, complex installations and setup procedures, and supervision of qualified workers. Some works have focused on developing automatic detection and Tracking algorithms that minimizes the necessity of supervision. They typically use a moving object function that evaluates each hypothetical object configuration with the set of available detections without to explicitly compute their data association.

Keywords: *KF – Kalman Filter, OF- Optical Flow, GMM- Gaussian Mixture Model*

I. INTRODUCTION

Object tracking is a procedure of movement estimation in computer vision application we present a combined multiple object tracking technique for a video. A video is a frame by frame sequence of images. Optical flow is a flexible representation of visual motion that is particularly suitable for computers for analyzing digital images. In this work the Horn & Schunck method is used to find the optical flow vectors which in turn pave a way for the detection and tracking of the single moving object in a video. Kalman filter removes the noise that effects a background subtracted image and predicts the position of an object accurately. A combination of Optical flow and Kalman filter method is designed in order to attain an accurate object tracking system. The accuracy of occluded object in dynamic background is promising compared to simple background subtraction. The experiments are conducted on different videos to prove the efficiency and the results are discussed.

Tracking systems have served well in the field of video surveillance, militarily guidance, robot navigation, artificial intelligence and medical applications during the last two decades. It’s vigor to the variability in the visual by dynamic, over the top environment.

In many cases, there are multiple objects to track. The motion based object tracking can be partitioned into two sections.

1. Moving object detection from one frame to another.
2. Analysis of tracked objects and Handling the occlusion

Tracking uniform movement was effortlessly done by the background commonly implemented background modeling however of non-uniform movement was tricky. Background subtraction or foreground detection is the extraction technique or the detection of moving objects in recordings or static foundations.

The majority of the movement of image is uniform in nature and it could acquire the on tracking. Gaussian mixture model is a background subtraction procedure that monitors objects in uniform or non-uniform movement.

After the extraction of object from closer view of image, object limitation made utilization of this procedure. The prediction and correction of objects were finished with the Kalman filter or linear quadratic estimation. It is a calculation utilized for object tracking to predict an object detected location to take noisy measures and to relate numerous objects. The appropriation of the speed of objects in an image of video frame is known as optical stream.

To describe and evaluate the movement objects in a video stream there by movement based object detection and tracking systems can obtained by optical flow. The challenging task in tracking multiple objects was difficult when the objects are occluded. Optical flow algorithm overcomes this risk. The execution of tracking relies on upon the exact feature extraction and the position of the moving objects from the continuous video. Multiple objects can be tracked simultaneously using Kalman filter and optical flow algorithm. We presented improved optical flow algorithm which not only gives better accuracy but also handles occlusion in a video. So, improved optical flow algorithm is found to be more promising as it gives better accuracy in less computation. Visual surveillance systems can be manual, partially autonomous, or fully autonomous. Manual systems require video data to be monitored by human observers. Partially autonomous systems analyze video content automatically but still require human input for some monitoring analysis tasks. Fully autonomous systems are capable of performing surveillance task on different levels. This includes low-level task such as motion detection and high-level task such as event detection. With state-of-the-art techniques, the goal of present visual surveillance systems is to assist human operators with identification of important events in videos and to manage real-time alarms in a proactive manner.

Our proposed methods for background subtraction, object tracking, and crowd flow estimation for applications in visual surveillance. We consider robustness and computational cost as the major design goals of our work. And responding to them in a timely manner

1. To set up a system for automatic segmentation and tracking of moving objects in stationary camera video scenes, which may serve as a foundation for higher level reasoning tasks and applications.

2. To make significant improvements in commonly used algorithms. Finally, the aim is to show how to perform detection and motion-based tracking of moving objects in a video from a stationary camera.

3. To analyze segmentation algorithm to detect the multiple objects. To analyze some tracking method for tracking the single objects and multiple objects.

II. RELATED WORK

The research conducted so far for object detection and tracking objects in video surveillance system are discussed. Tracking is the process of object of interest within a sequence of frames, from its first appearance to its last. The type of object and its description within the system depends on the application. During the time that it is present in the scene it may be occluded by other objects of interest or fixed obstacles within the scene. A tracking system should be able to predict the position of any occluded objects.

Year	Title	Author Name	Process	Method Used	Contribution	Limitation
2013	Vehicle Detection and Tracking using the Optical Flow and Background Subtraction	Prof. Paygude S.S, Dr.VyasVibha and Chaple Manisha	Implemented	Background Subtraction and Optical flow	The distance traveled by the vehicle is calculated using the movement of the centroid of the car over the frames and the speed of the vehicle is estimated.	In Dynamic environment, The tracking system were not accurate.
2014	Real-time multiple Objects Tracking with Occlusion Handling in Dynamic Scenes	Tao Yang, Stan Z.Li, Quan Pan, Jing Li	Implemented	Object Segmentation and Splitting and Merging	In this paper, objects are detected in the real time video with long duration occlusion handling under different conditions indoor and outdoor in changing background.	During Occlusion handling, the merging and splitting process will cost the accuracy rate. It works on videos which have 15-20 fps not more than that.
2014	Motion Detection Based on Frame Difference Method	Nishu Singla	Implemented	Motion detection and Frame Difference	This paper presents a new algorithm for detecting moving objects from a static background scene based on frame difference.	System Works on the motion based detection which is not good for real time object detection. Multiple Objects cannot be detected.
2015	Real-time moving object tracking in video processing	Payal Ranipa, Kapildev Naina	Proposed	Background Subtraction and DML Bysian method	In this paper, human motion detection and tracking for real-time Security system was formulated which increases the efficiency of the system.	Failed to implement the same.
2016	Precise Human Motion Detection And Tracking In Dynamic Environment	Moiz A. Hussain, G. U. Kharat.	Implemented	Kalman Filter and Dual frame Difference method.	This paper Implemented a precise method to overcome the problem of unsteady camera and varying illumination condition	Fails to handle the occlusion . Multiple object cannot be tracked. Time consumption is more for computation
2016	Multiple Object Tracking, learning and Detection Using P-N Learning Template Matching	Archana vilas Kshirsagar, Kanchan Doke	Implemented	P-N Learning technology using Template Matching	The proposed system provides better methodology than existing systems which keeps on comparing current template with existing template by applying threshold	As number of objects increases the performance of the system gets slow This method doesn't deal with occlusion Handling
2016	Multiple Vehicle Detection And Tracking in Dynamic Environment	D. Sudha, J. Priyadarshini	Proposed	Frame Splitting, Kalman Filter and Background Subtraction	The proposed solution combines the efficiency of the robust detection model with the benefits of dynamic environment	Implementation process is not completed.
2016	Multiple Object Tracking in Surveillance Video Using Color and Hu Moments	Chandrajit M, Girisha R and Vasudev T	Proposed	Color and Hu Moments and Nearest-Neighbor classifier with Chi-Square Dissimilarity method.	Object tracking is done by extracting the Color and Hu moments features from motion segmented blob and establishing the association of objects in successive frames	Occlusion Handling and shadow Elimination are not done Only benchmark datasets had been used for experiments

Table 2.1 Literature Survey

III. PROPOSED SYSTEM

1. **Video to Image Conversion:** We have to convert real time video into image to perform the process. Video is a collection of images. An image helps to process faster in the real-time video.

2. **Detecting the Multiple object in the image:** After extracting the images from video, we have to preprocess the images (frames) to detect the multiple object. Here we consider the human as objects.

3. **Removing the unwanted objects in the image:** Once human objects detected in the images we have to discard the unwanted objects in the images, may be its static or dynamic objects

4. **Tracking the real time objects:** After detecting the images, we have to track the multiple objects in the video until it disappears. This system works automatically without any human interference.

5. **Object detection and Tracking in Different environment:** Object detection in the different environment is very complex, we have to keep track on the environment, if we are detecting an object in day time, and the process is different as well as if you detecting an object in night time the process will be different. Because of conditions.

6. **Occlusion Handling:** It helps to keeps on the detected multiple objects separately in the real time dynamic environment.

System architecture is the conceptual model that defines the structure behavior and more views of a system. An architecture description is a formal description is a formal description and representation of a system. The first step begins when video is given as input to the image acquisition module. Here, the background subtraction and foreground detection modules is performed for each frame and frequently updated after each processing thus continuous image acquisition is performed and current frame

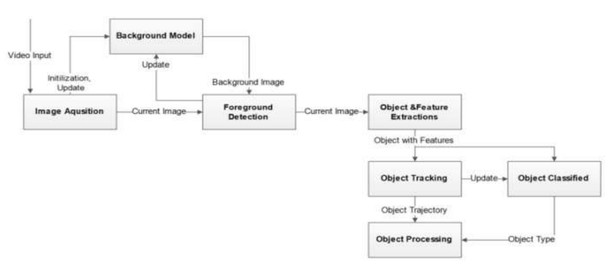

Figure 3.1 System Architecture

occlusion of object situation arrives, tracking process is passed to object processing module after tracking the tracked ID is displayed to the user.

IV. IMPLEMENTATION

KALMAN FILTER

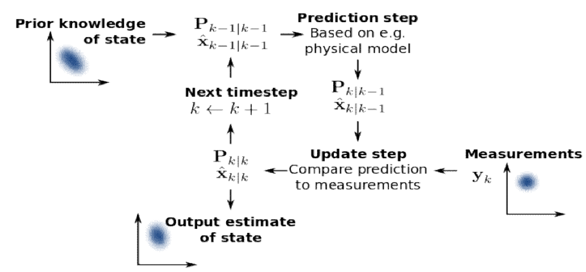

Figure 3.2 Representation of basic concept of Kalman filter

The Kalman filter keeps track of the estimated state of the system and the variance and the uncertainty of the estimate. The estimate is updated using a state transition model and measurements. $X_{k|k-1}$ denotes the estimate of the system's state at time step k before the k-th measurement Y_k has been taken into account; $P_{k|k-1}$ is the corresponding uncertainty.

Kalman filter, also known as linear quadratic estimation (LQE), is an algorithm that uses a series of measurements observed overtime, containing statistical noise and other inaccuracies, and produces estimates of unknown variables that tend to be more accurate than those based on a single measurement alone, by using Bayesian interface and estimating a joint probability distribution over variables for each timeframe. The filter is named after Rudolf E. Kalman, one of the primary developers of its theory.

Kalman filter has numerous applications in technology. A common application is for guidance, navigation, and control of vehicles, especially aircraft and spacecraft. Furthermore the Kalman filter is a widely applied concept in time series analysis used in the fields such as signal processing and econometrics. Kalman filters also are one of the main topics in the field of robotic motion planning and control, and they are sometimes included in trajectory optimization. The Kalman filter also works for modeling the central nervous system's control of movement. Due to the time delay between issuing motor commands and receiving sensory feedback, usage of the Kalman filter supports the realistic model for making estimates of the current state of motor system and issuing updated commands. The Kalman filter does not make any assumption that the errors are

Gaussian. However, the filter yields the exact conditional probability estimate in the special case that all errors are Gaussian-distributed.

Extensions and generalizations to the method hae also been developed, such as extended Kalman filter and the unscented Kalman filter which work on nonlinear systems. The underlying model is a Bayesian model similar to a hidden Markov model but where the state space of the latent variables is continuous and where all latent and observed variables have Gaussian distributions.

Kalman filter uses a system's dynamic model (e.g., physical laws of motion), known control inputs to that system, and multiple sequential measurements (such as from sensors) to form an estimate of the system's varying quantities (its state) that is better than the estimate obtained by using only one measurement alone. As such, it is a common sensor fusion data fusion algorithm.

When performing the actual calculations for the filter, the state estimate and covariance are coded into matrices to handle the multiple dimensions involved in a single set if calculations. This allows for the representation of the linear relationships between different state variables (such as position, velocity and acceleration) in any of the transition models or covariance.

As an example application, consider the problem of determining the precise location of a truck. The truck can be equipped with the GPS unit that provides an estimate of the position within a few meters. The GPS estimate is likely to be noisy; readings 'jump around' rapidly, though remaining within few meters of the real position. In addition the truck expected to follow the laws of physics, its position can be estimated by integrating its velocity over time, determined by keeping track of wheel revolution and the angle of steering wheel. This technique is known as dead reckoning. In this example, the Kalman can be a thought of as operating in two distinct phases: predict and update. In the predict phase the truck's old position will be modified according to physical laws of motion. In the update phase, a measurement of the truck's position is taken from the GPS unit. Along with this measurement come some amount of uncertainty and its covariance relative to that of the prediction from the previous phase determines how much the new measurement will affect the updated prediction.

Kalman filter provides an optimal estimate of its position at each time step. The optimality is guaranteed if all noise is Gaussian. Then the filter minimizes the mean square error of the estimated parameters (e.g. position, velocity). The Kalman filter is an online process, meaning that new observations are processed as they arrive. To formulate a Kalman filter problem, we require a discrete time linear dynamic system with additive white noise that models unpredictable disturbances. The Kalman filter tries to estimate the state a $\in R^n$ *of* that system which is governed by the vector difference equation:

$$a_{\bar{K}} = Xa_{k-1} + Yb_k + c_{k-1}$$
$$\mathrm{t_k} = \mathrm{Ia_k} + \mathrm{d_k}$$

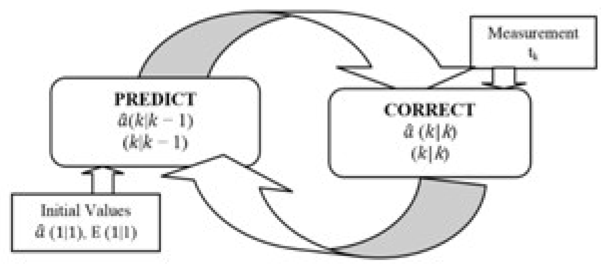

Figure 3.3 the Kalman filter Predict/Correct model

1. The prediction steps

- State prediction
- Error covariance prediction

2. The correction step

- Measurement prediction
- Residual
- Measurement prediction covariance
- Kalman gain
- State update
- Error covariance update

5.1.2 OPTICAL FLOW

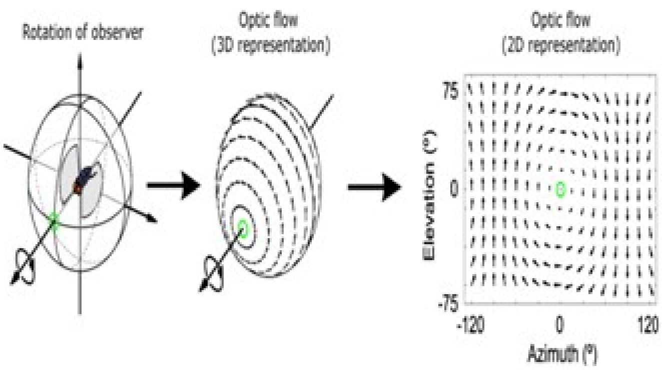

Figure 3.4 Optical flow representation

Optical flow experienced by a rotating observer (in this case a fly). The direction and magnitude of optical flow at each location is represented by the direction and length of each arrow.

Optical flow or Optic flow is the pattern of apparent motion of objects, surfaces and edges in a visual scene caused by the relative motion between an observer and a scene. The concept of Optical flow was introduced by the American psychologist James J. Gibson in the 1940s to describe the visual stimulus provided to animals moving through the world. Gibson stressed the importance of Optical flow for affordance perception, the ability to discern possibilities for action within the environment. Followers of Gibson and his ecological approach to psychology have further demonstrated the role of Optical flow stimulus for the perception of the movement by the observer in the world; perception of shape, distance and movement of objects in the world; and the control of locomotion.

The term Optical flow is also used by the roboticists, encompassing related techniques from image processing and control of navigation motion detection, object segmentation, time-to-contact information, focus of expansion calculations, luminance, motion compensated encoding, and stereo disparity measurement.

Motion estimation and video compression have developed as a major aspect of Optical flow research. While the optical flow field is superficially similar to a dense motion filed derived from the techniques of motion estimation, Optical flow is the study of not only the determination of the Optical flow field itself, but also of its use in estimating the three dimensional nature and structure of the scene, as well as the 3D motion of objects and the observer relative to the scene, most of them using the Image Jacobian.

Optical flow was used by robotics researchers in many areas such as; object detection and tracking, image dominant plane extraction, movement detection, robot navigation and visual odometry. Optical flow information has been recognized as being useful for controlling micro air vehicles.

The applications of Optical flow include the problem of inferring not only the motion of the observer and object in the scene, but also the structure of objects and the environment. Since the awareness of motion and the generation of mental maps of the structure of our environment are critical components of animal (and human) vision, the conversion of this innate ability to a computer capability is similar crucial in the field of machine vision.

Consider a five-frame clip of a ball moving from bottom left of a flied of vision, to the top right. Motion estimation techniques can determine that on a two dimensional plane the ball is moving up and to the right and vectors describing this motion can be extracted from the sequence of frames. For the purpose of video compression (e.g., MPEG) the sequence is now described as well as it needs to be. However, in the field of machine vision, the question of whether the ball is moving right or if the observer is moving to the left is unknowable yet critical information. Not even if a static, or patterned background were present in the five-fames, could we confidently state that the ball was moving to the right, because the pattern might have an infinite distance to the observer.

Optical flow estimation is used in computer vision to characterize and quantify the motion of objects in a video stream, often for motion-based object detection and tracking systems. It is the displacement field for each of the pixels in an image sequence. It is the distribution of the apparent velocities of objects in an image. By estimating optical flow between video frames, one can measure the velocities of objects in the video.

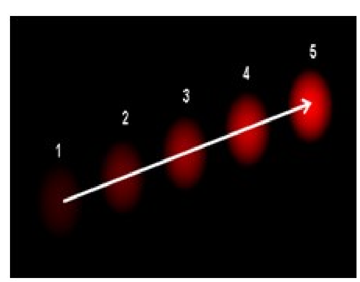

Figure 3.5 Five-frame clip of moving ball

In general, moving objects that are closer to the camera will display more apparent motion than distant objects that are moving at the same speed.

Representing a dynamic image as a function of position and time permits it to be expressed.

- Assume each pixel moves but does not change intensity.
- Pixel at location (x, y) in frame1 is pixel at (x+ Δx, y+ Δy) in frame2.
- Optic flow associates displacement vector with each pixel.

Input V 🡐 Real time Video

1. Extract horizontal and vertical components of optical flow with varied frame difference delay.
2. Find the mean for each frame.
3. Apply median filter for removal of noise.
4. Apply morphological close and erosion operation on each frame.
5. Estimate optical flow. The optical flow vectors are stored as complex numbers.
6. Compute their magnitude squared which will later be used for thresholding..
7. Compute the velocity threshold from the matrix of complex velocities.
8. Threshold the image.
9. Apply thinning to the Objects to fill the holes in the blobs.
10. Estimate the area and bounding box of the blobs.
11. Draw bounding boxes around the tracked objects.
12. Calculate and draw the motion vectors.
13. Display results with tracked videos.

V. Result Discussion

5.1 User interface

This module provides user interface to choose dataset or camera as options to detect and track the object in respective videos.

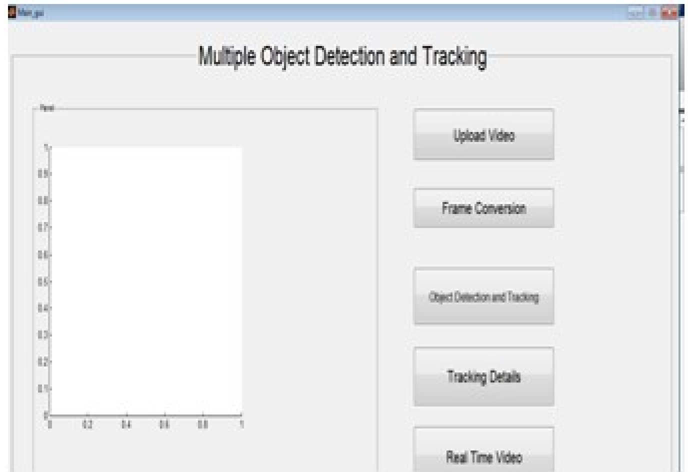

Figure 5.1 shows user interface

The user interface includes five pushbuttons which provide option to upload video from dataset, frame conversion, object detection, to know tracking details or to use integrated webcam to track objects in real time.

Module for uploading video

Once the main program is executed, the user is displayed with user interface as shown below. If the user wants to detect and track the objects from static video or dataset, the pushbutton named upload video is selected and any video of user choice is opened. The processor internally runs the video before proceeding further.

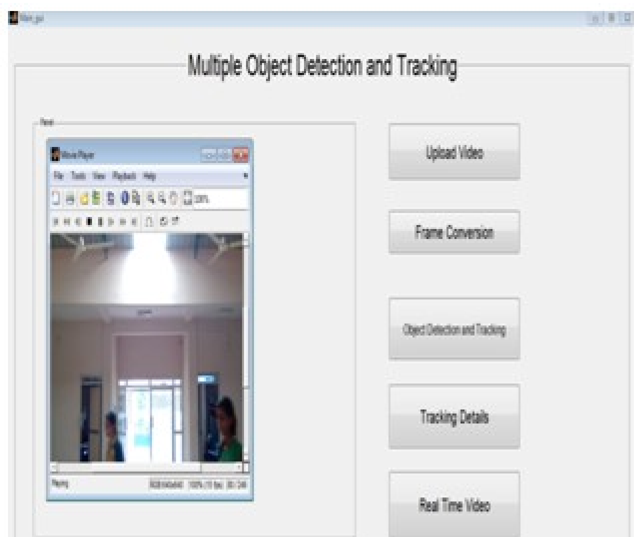

Figure 5.2 shows uploading video for tracking

5.2 Frame conversion process

If the user choice is to track the objects from static video or dataset then, the next step after uploading video is frame conversion process. Once the frame conversion pushbutton is pressed then the module related to frame conversion process is initiated. During frame conversion, the frames are stored in the folder created by the user which shows all the frames converted from video used for further processes. This folder which includes frames get refreshed and new frames are stored each time the frame conversion pushbutton is pressed by user.

Figure 5.3 shows frame conversion process

5.3 Object detection process

After frame conversion process is completed, the pushbutton named object detection and tracking is pressed which triggers the object detection module where the Kalman filter algorithm works and performs background subtraction and foreground detection. Each moving object detected will be assigned with the ID which can be used for future tacking purpose.

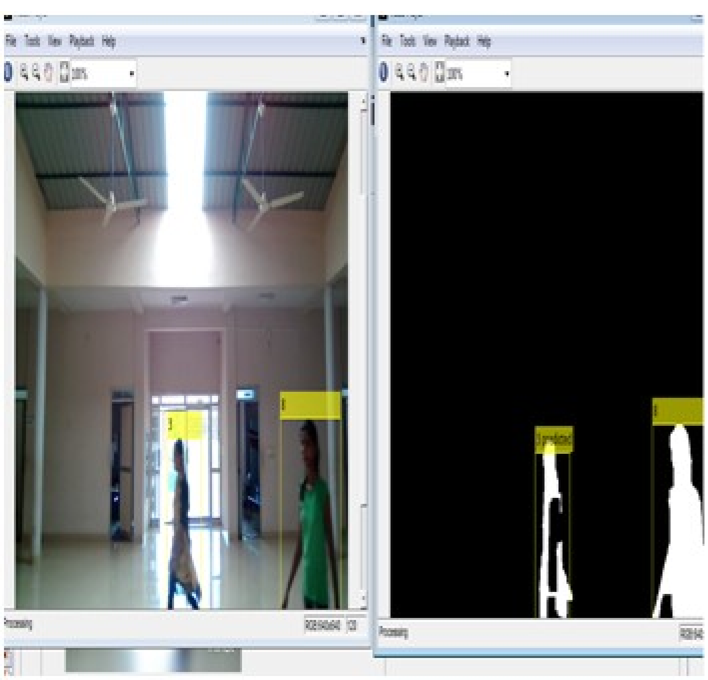

Figure 5.4 shows object detection process

5.4 Working of Kalman filter algorithm

Once the object is detected, the Kalman filter algorithms performs tracking in two major steps. In Prediction step, as soon as new object arrives into frame it compared with previous frame and if it is newly detected object, then it is assigned with unique ID. In Correction step, whenever the object in the frame disappears from frame its information is erased from list and if it re-enters the frame again, still it considered as new object and it is assigned with new ID.

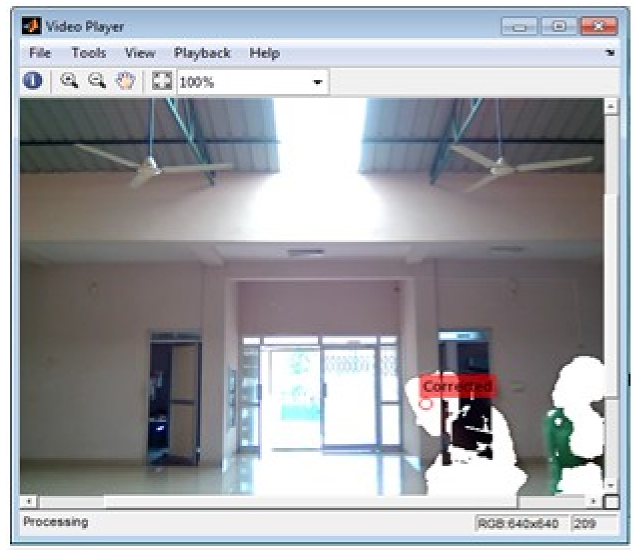

Figure 5.5 shows working of Kalman filter algorithm

5.5 Location of the detected object

After completion of prediction and correction step, the current frame is compared with the previous frame and the next predicted frame to get the current location of the detected objects and all locations where all the object moved.

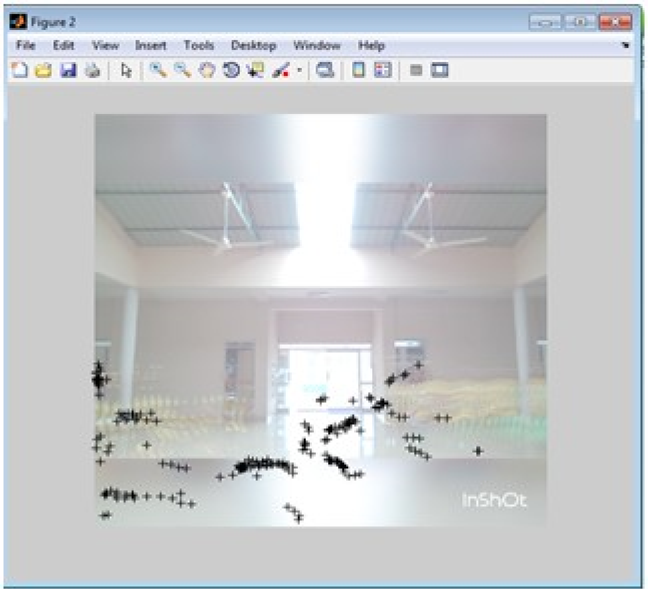

Figure 5.6 shows location of the detected object

5.6 Tracking details

As shown in the previous step, locations of detected objects are determined and using the details of previous steps, the trajectories of the detected objects are obtained. The tracking details are shown in the below Figure 5.6

5.7 Real time video tracking

All the above steps are performed for the static video or dataset. The experiment is performed for detecting and tracking objects in real time videos also.

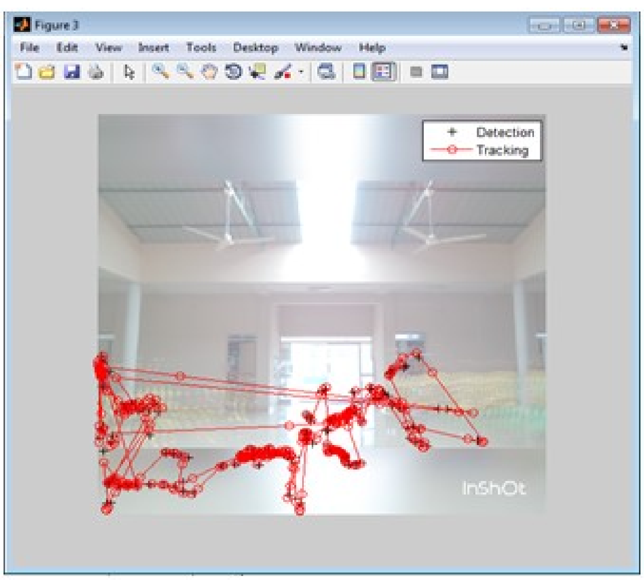

Figure 5.7 shows tracking details

The experimental results are as shown in the figure below.

Figure 5.8 shows real time video tracking

5.8 Real time object video tracking with occlusion handling

The below figure shows real time video tracking with occlusion handling in which though the objects are overlapped two different box are displayed for each object indicating there are two objects in the frame.

VI. CONCLUSION

This method improves the performance of motion segmentation algorithms. We consider robustness and computational cost as the major design goals of our work. Our methods are designed to be proactive and capable of processing the video stream for event analysis in real-time. However strength of Kalman filter is their ability to track object in adverse situation. Ideally they can assist human operators with identification of important events in videos and responding to them in a timely manner. Amongst the methods reviewed, improved optical flow algorithm is found to be more promising as it gives better accuracy in less computation time.

The present work can be extended further for the real time buffering by using novel tracking algorithms and comparing their performance accordingly to achieve more accuracy.

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