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Performance Evaluation Of Optical Motion-Based Object Detection And Tracking Using Background Subtraction In High-Resolution Video

Shakil Abdul Rajjak Shaikh, Dr. A, K. Kureshi
[1] *Phd Scholar, Matoshri College of Engineering & Research Center Nashik, India.*
[2] *Principal, MMANTC, Manoora Malegaon Nashik, India.*

Abstract

The technique for automatic detection and tracking of an object is an emerging area of research for video surveillance and traffic surveillance. For background subtraction, foreground detection and optical flow algorithm for object detection and tracking, the proposed technique uses a Gaussian mixture model (GMM). The initial step in this technique is to differentiate the foreground object i.e. the region or object of interest from background image which is obtained by GMM. For detection of objects in motion does not need a stored database, only it requires successive frames. The most widely used context subtraction is the simplest method for detecting moving objects from a video string. Now day's high-resolution imaging sensors/cameras are being used in areas of video surveillance like security at public places, vehicle traffic monitoring systems, military applications, and satellite imaging systems. Evaluating the quality of the object tracking system in high-resolution video for the simple tracking system is important. The proposed system is assessed as to the execution time required for a single frame. We performed a performance analysis of the proposed technique for different resolution video in this paper. The technique proposed is tested using i5 core CPU 1.80 GHz processor and 4 GB RAM

Keywords: *Gaussian mixture model, Optical flow, Background subtraction, Morphological operation etc*

1 Introduction:

An object tracking is a very immense and important area of research in the field of computer vision, it has been increasing the researcher's enormous keen interest is detection and tracking of an object in a video sequence. Video object tracking has got wide-ranging applications insecurity in different areas, security in banking applications, military area, video surveillance for security, etc. One of the major applications of object tracking in video surveillance for security purposes. Object tracking is very much essentials in religious places, market buildings, courts, train stations and airports for security point of view. Detecting region of interest in moving objects in video stream plays a very vital role in many computer vision applications. Object detection in a video stream is the estimation of detecting the moving targets in-frame sequence using an image processing method.

Moving object detection and tracking is moving object recognition and maintaining the position of the object in an image frame by frame. In the last decades, detection and tracking in a video sequence are the most demanding research areas and have been comprehensively investigated. Object detection process involves detecting an object in a video stream frames, but object tracking involves monitoring the spatial and temporal changes of the object in each frame. Using region-based image segmentation, context subtraction, temporal differencing etc., object detection can be achieved.

With the latest progression such as fast computation, increased resolution cameras and improvement of some innovative algorithms have assisted research scholars to overcome the limitations of modern techniques. Video analysis includes two major processes (1) identification of objects and (2) monitoring of objects. We consider the section or area of interest which is the foreground target in object detection. In this paper, for detection purposes, we used GMM and blob analysis. The technique of background subtraction differentiates between the background model of reference and the foreground (the region of interest) i.e. an object.

Background subtraction [30] is one of the important techniques for motion detection in the video stream from stationary cameras. The background frame is typically assumed as an unoccupied frame which does not comprise any object of interest. The background subtraction approach involves the process of motion detection in two main steps: create a background model and the detection of the foreground object. The first stream of video is transformed into a sequence of frames. The background frame is then produced using the GMM. This step is called as background modeling. The foreground or target is detected by using proper comparisons foreground from the produced background model. Further processing is done by filtration of the detected foreground by using techniques like morphological operations. This step increases the efficiency of the algorithm generating better results. Finally, the object or region of interest is extracted by estimating the optical motion vector and blob analysis. Today, the use of higher resolution image sensors (cameras) and high frame rates for wide-area video surveillance (VS) and other applications is growing for a day. This has increased demand or need to incorporate high-performance VS algorithms in high-resolution videos for real-time object tracking. It is essential to evaluate the performance of the object tracking system for the basic tracking system in high-resolution video. The prosed scheme is evaluated in terms of execution time required for one frame. We conducted a performance analysis of the proposed technique for different resolution video in this paper. Use of PC with i5 core, 1.80 GHz processor and 4 GB RAM to evaluate the proposed technique.

This paper addresses earlier object detection and tracking methods in section III. The proposed object detection and tracking system using the Gaussian Mixture Model (GMM) for context subtraction, foreground detection and optical flow algorithm for object detection and tracking as described in section
IV. Section IV discusses the application of the proposed system for different resolution images. Section V contains the findings and analysis of the proposed system. Eventually, the job is completed in section VI.

2 RELATED WORK

AyushBaral et al. [1] has done a rigorous review of motion-based object detection based on background subtraction. The author focused primarily on the problems which are encountered in applications such as video surveillance. The key issues encountered with this system is low-resolution scene in a frame so, it becomes difficult to monitor instances that occur concurrently in surveillance display due to some restrictions. There are many conditions like rain, mist, snowfall, dust and many other might disturb the surveillance system. Soukaina Chraa Mesbahi et al. [2] [18] proposed a system comprises of the GMM model [21] [23] and the optical flow technique to identify the movement of the head. It uses the MOG2 approach for background subtraction, with median filtering to reduce noise in a frame. The proposed system is highly accurate and has improved efficiency in detecting the car. The future work is a study based on different classifiers such as neural networks, SVM, DNN method.

Dongxiang Zhou et al.[3] introduced a new method combining background subtraction, temporal differentiation methods, and optical flow, which is appropriate in situations where the frame has many moving objects in different sizes. This method very accurately locates boundaries across the detected objects. This method had an acceptable performance on a real image sequence. Thammapong Dharamadhat et al. [4] presented an improved method for object tracking which combines background subtraction and Multi-resolution Critical point filters. This approach tracks 64*64 images at a rate moreover 0.1 fps. The future work of this method is to optimize the technique to track the number of frames/second and for high resolution of an image. One main enhancement of this algorithm will handle in changing environments such as tough situations (sudden illumination changes, dense shadow, etc.).

Yuewei Lin et al.[5][13] have proposed a new approach to detecting moving objects, which is especially capable of detecting objects with unusual movements. Especially, the background subtraction method is improved by incorporating a visual attention technique to differentiate the foreground and background. In addition, this method also introduced a SIFT-matching algorithm to resolve the scene's several local motions. The experimental results indicate that improving efficiency is more efficient in identifying objects with unusual movements. The average execution time per frame of resolution 1280x720 and 432x288 is 0.48 sec. and 0.17 sec respectively. Jae-chan Cho et al. [6] proposed a novel algorithm for moving object detection, which is capable of moving camera situations. An area-efficient hardware model based on FPGA for the proposed method can process video in real-time. The experimental results indicated the detector's accuracy is higher than current algorithms and it is capable of performing an algorithm in real time at 30 fps.

Neeraj and Akashdeep [7] presented a survey of different moving object detection methods and give comprehension pictures of the methods such as background subtraction, optical flow [34], feature-based object detection and blob analysis. Background subtraction can be capable of videos which doesn't have much occlusion, mainly when objects aren't overlapping with each other and when the camera is moving very smoothly or almost stationary. It is not possible to detect objects if the image contains fog and light intensity changes, shadows, very much lightening variations and when object movement is very slow. The optical flow method disposed to errors when the camera moves very fast and when an object moves very fast. Blobs are affected by noise and tracking blobs may not give the correct result when the object moves quickly. For the densely crowded region, it is difficult to detect objects using blobs analysis. Kengo Makino et al. [8] proposed a new method for object detection for moving cameras [35]. This method computes two scores, namely anomaly, and motion, to detect moving objects more accurately. Experimental results confirmed that the performance of this approach is improved in all respect. The future work of this strategy is to more effectively integrate the two scores then compare the results with other techniques.

Honghong Yang et al.[9][15] introduced a vehicle detection and counting approach for real-time video processing using sparse and low-level approximation. The result shows good performance of the proposed method and very good accuracy. Smitha Suresh et al.[10] reviewed and analyzed the most widely used methods for background subtraction. The Gaussian mixture model provides satisfactory results as opposed to other approaches, according to the practical approach. Ronan Sicre et al. [11] proposed object detection using an improved GMM model. The execution time for one frame of a 704x576 image, takes 0.05 to 0.08 second for iGMM [30], when it has experimented on a Pentium M, 1.73 GHz.

Shridevi S. Vasekar et al. [12] [19] presented a new method for tracking an object, which uses Kalman filter and background subtraction [22] for tracking. The complete system is executed using MATLAB R 2013a software. The method effectively handles occlusion and complex shapes object, for that system is tested using three standard datasets. M. Sivarathinabala et al. [14] presented a tracking system that has been implemented by using blob analysis and particle filters to detect limited occlusion. The proposed approach has been tested by using the CAVIAR dataset and user-generated datasets. This method is capable to track the objects which are crossing to each other. The future work of this system can be extended along with full occlusion detection and multiple objects tracking capability.

Chaoqun Wang et al. [16] presented a new dual-network object tracking (DOT) method which is a combination of appearance and motion features for tracking. Also, a fusion approach is developed to efficiently exploit both information features. The DOT model is tested on OTB-2013 and it is capable to execute 32 fps video. Rudrika Kalsotra et al. [17] presented a morphological based system for detecting the moving object. The background subtraction technique is exploited with motion estimation and the change video frame is segmented by comparing the pixel's intensity values with threshold values. This method detects moving objects accurately and capable of handling background changes, illumination changes, noise, and limited occlusion. Moreover, the proposed method is not capable of efficient working for real-time situations. In order to operate for the video scenes captured from the moving camera, further research is to be carried out.

Tao JIA et al. [20] proposed moving object detection by the combination of symmetric difference and single-mode background model, the background model is updated by using blob analysis and improved flexibility to illumination variation classification approach. It is capable of applications like the detection of moving objects. Linkai Chen et al. [25] proposed a background subtraction method for object detection and tracking [25]. Figure 1 demonstrates the basic method for detecting and tracking objects in the background. Background subtraction is a generally used method for detecting objects in videos from stationary cameras. The simple subtraction method of the background identifies the moving objects from the difference between the current frame and a frame of reference, which is termed the background model or background image. A method of background subtraction is capable of handling changes in illumination and the background of the clutter.

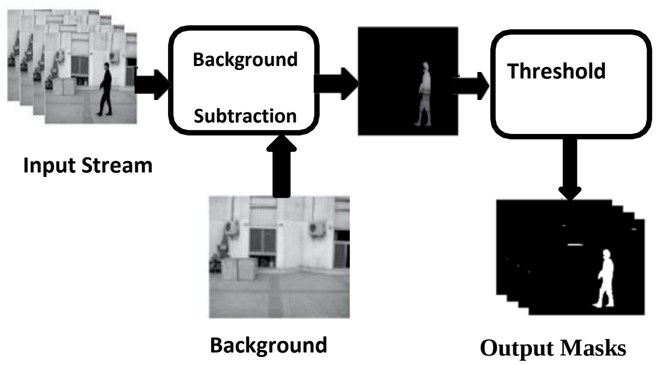


Fig. 1: Basic background subtraction

. Jianqin Yin Yanbin Han et al. [26] proposed a motion estimation of an object with camouflage (disguise) color detection approach on optical flow. Due to camouflage (disguise), an object may have color or gray which is the same as the background Moreover, it is difficult to detect these targets for the conventional detection method because the motion characteristics of the object and background characteristics are different. The first optical flow is computed to signify the movement outline, and then the image results grouped. Kalman filtering is used to increase the accuracy of object detection. In terms of accuracy, processing time, and memory requirements, Hammad Naeem et al. [28] evaluated five methods for real-time object recognition and tracking. The achievement of a video tracking algorithm is determined by its response to input video having a high frame- rate. A more complex algorithm to obtain accurate results as the frame rate (fps) increases. The ' Kanade-Lucas ' algorithm is suggested for real-time implementation applications based on the experimental results. The 'Kanade-Lucas' algorithm is fastest, requires less memory and gives higher accuracy with minimum complexities. It is capable to achieve higher accuracy in situations where the images have very high distortion.

Sepehr Aslani et al. [29] proposed system exploits different methods to detect, filtering, segmentation and tracking objects. It also uses Horn-Schunk algorithms in this system. It is the most appropriate method for estimating optical movement and detecting moving objects through the frequency of frame shifts. The morphological procedure extracts the object's important characteristics from binary images and then performs blob analysis to identify the object in the next step. Low processing time is a significant advantage in blob analysis.

Huy-Hung Nguyen et al. [32] presented a new method that can enhance the optical flow estimation. It is implemented by identifying the imperative direction of every moving object. The simulation result shows improved results when combined with the proposed approach with background subtraction and optical flow estimation technique. There is scope for enhancement, however, as there are still deficiencies in the detection of occlusion and shadow of objects. Deval Jansari et al. [33] suggested using two different methods to detect objects. Background subtraction method which relatively requires less time for processing but it needs all the frames in advance, it is the main limitation to implement it for real-time application. The optical flow-based approach, however, needs only two frames at a time to detect objects at the time expense. A proposed tracking system is a robust method for tracking multiple objects by using color-based probability matching in video sequences considering several problems such as multiple objects of similar color, occlusion, etc.

Kiran Kale1et al. [34] proposed presented tracking system combines the optical flow and motion vector estimation for moving object detection and tracking. This proposed algorithm is capable of detecting and tracking multiple moving objects in the video. The combination of optical flow and motion vector estimation gives accurate and robust results over different types of real time. Sang A block-updating approach-background subtraction for moving object detection was proposed by Haifeng et al. [37]. This method gives the former two frames of start frames, initial models history, then eliminates current frames and reference frames. Then it divides difference image into multiple sub-blocks and calculates the sum and it compares the threshold value of all pixels of each block. This achieves the binary image using threshold segmentation. This method is very useful for the external environment, according to the experimental results, and can accurately detect moving objects

3 PROPOSED METHODOLOGY

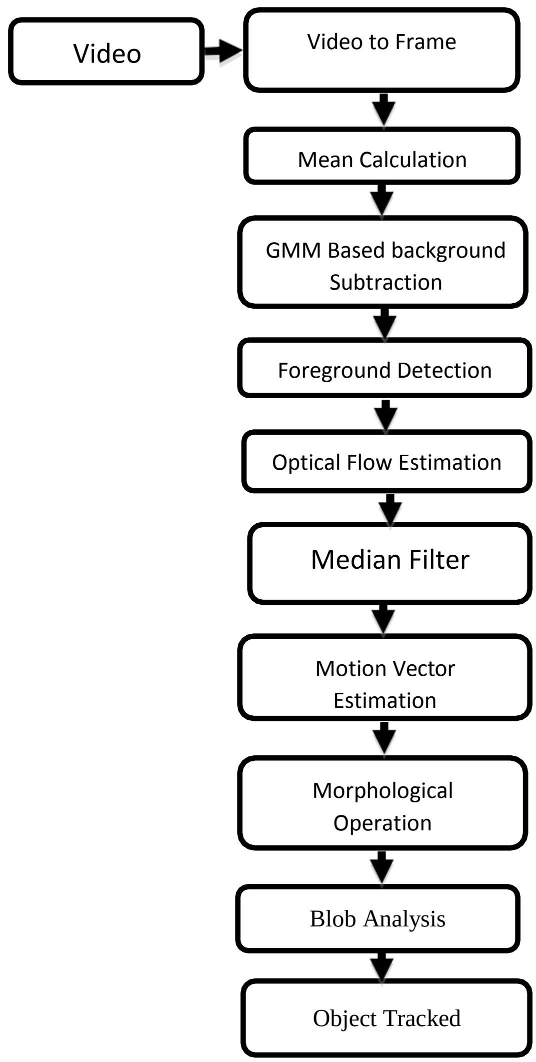


Fig. 2: Flow chart for the proposed system

Figure 2 provides a flowchart motion-based method to identify and track moving objects in a video using a stationary camera. Detection of moving objects and tracking using motion-based are important components of many detection and tracking techniques, including, video surveillance, traffic monitoring, and security in military and public places. The proposed tracking system for objects can be split into two steps:

1. Detection of objects moving in each frame

2. Correlating the detections in the next successive frames that match the similar object.

For the detection of moving objects Gaussian mixture model-based background subtraction algorithm is used. After this morphological operation is used on the foreground object image to remove noise. In the end, blob analysis is performed to detect clusters of linked pixels, which are expected to correspond to moving objects. The motion of every object is calculated by a median filter. The median filter is used to find/predict the object location in every frame, and decide the probability of every detection being assigned to each track. In any given frame, certain detections may be allocated to tracks, whereas other detections and tracks may not be assigned. The allocated tracks are updated using the corresponding detections.

Algorithm for proposed system:

Algorithm Steps:

The algorithm has the following stages,

1. Apply a video file as an input from which an object is to be detected and tracked.
2. Convert video into frames
3. Convert color frames into grayscale frames.
4. Calculate the optical flow between the current frame and the next frame.
5. Calculate motion vector velocity, i.e. motion vector approximation, and take a mean.
6. Using the median filter to get a threshold image of moving objects.
7. Blob image threshold analysis for object detection and tracking
8. Drawing box in the image around the object.
9. Box displays tracked items moving.

4 Experımentatıon

The entire proposed system is implemented using MATLAB software and tests were conducted on an Intel (TM) i5 3337U CPU 1.8 GHz processor having 4GB of RAM. The algorithm was tested on real-time videos of different resolution videos such as 640x480, 720x576, HD, 1280x720 and Full HD 1920x1080. For the above video, the performance of the proposed system is evaluated in terms of execution time per frame. The execution time required per frame the resolution 640x480, 720x576, HD, 1280x720 and Full HD 1920x1080 are 131.98 millisecond, 209.26 milliseconds, 353.96 milliseconds, and 815.18 milliseconds respectively.

Table I: Real-time videos used for experimentation

	Resolution			
	640x480	*720x576*	*1280x720*	*1920x1080*
Frame width	640	720	1280	1920

Frame height	480	576	720	1080
Frame rate	25 fps	25 fps	25 fps	25 fps
Duration	10 second	10 second	10 second	10 second
Frames	255	255	255	255

5 Result And Dıscussıon

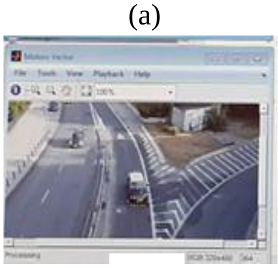
The proposed tracking system for objects is implemented using MATLAB based on context subtraction and optical movement estimation algorithm. Four videos of different resolutions are used for performance evaluation of proposed system. Experimental results are evaluated for different resolution videos in terms of execution time per frame, as shown in the figure. Figure 3, fig. 4, Fig. 5 and Fig. 6 shows the execution time required per frame for the resolution 640 x480, 720x576, HD, 1280x720 and Full HD 1920x1080 respectively. Figure 7 and Table II shows the average time required per frame and fps for videos of different resolution.

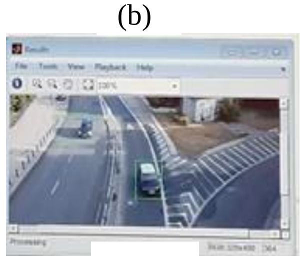

(a)


(b)


(a)


(b)


(c)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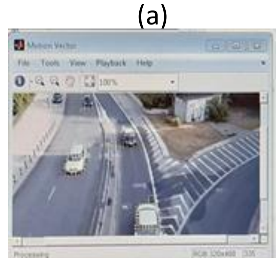
(c)


(d)

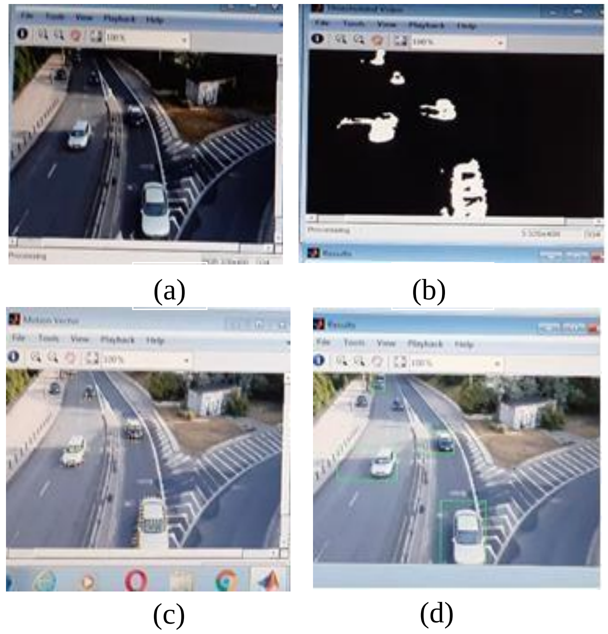

Fig. 3: Different Images for the frames a) Original Image b) Threshold Image c) Image with motion vector d) Image with the object detected

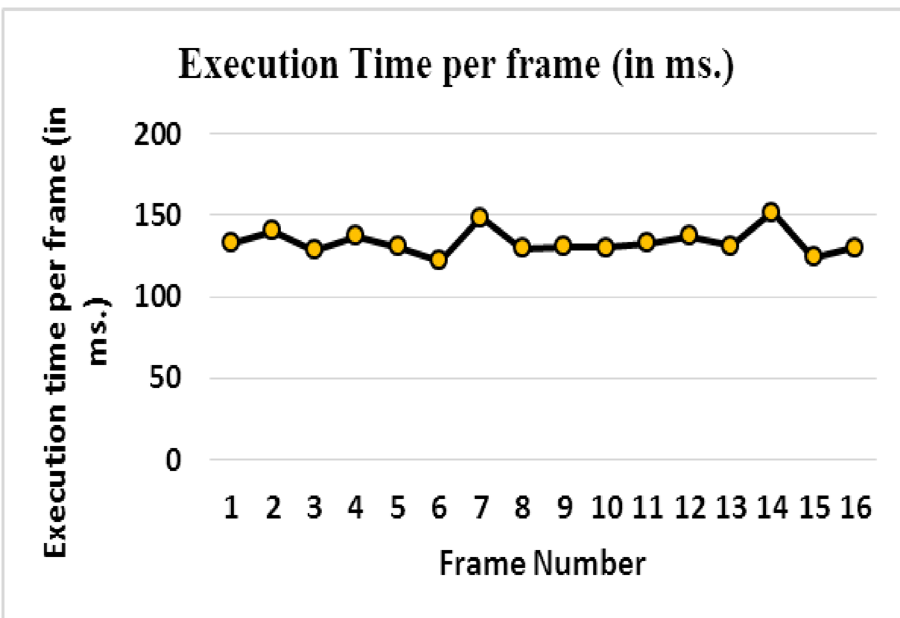

Fig. : 4 Plot of execution time per frame (in ms.) vs. frame number for 640x480 resolution video

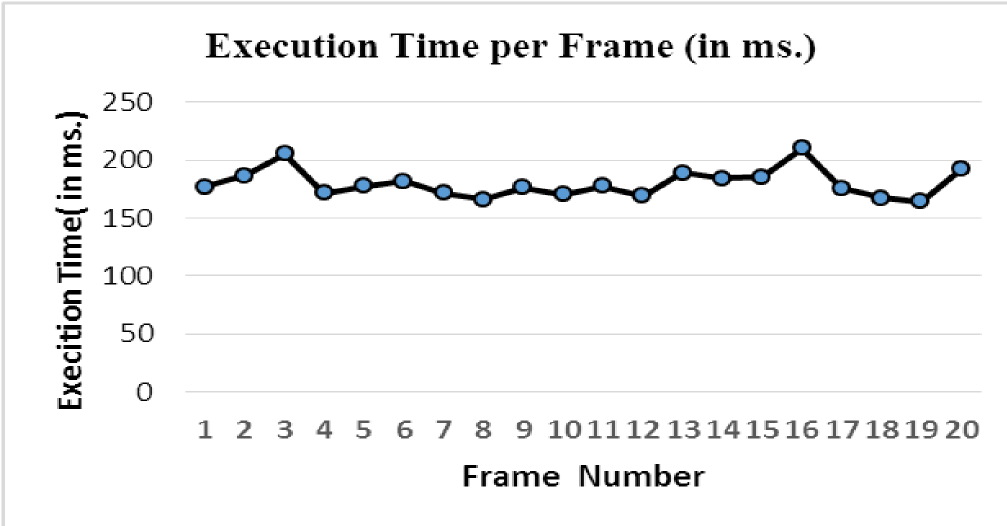

Fig. 5: Plot of execution time per frame (in ms.) vs. frame number for 720x576 resolution video

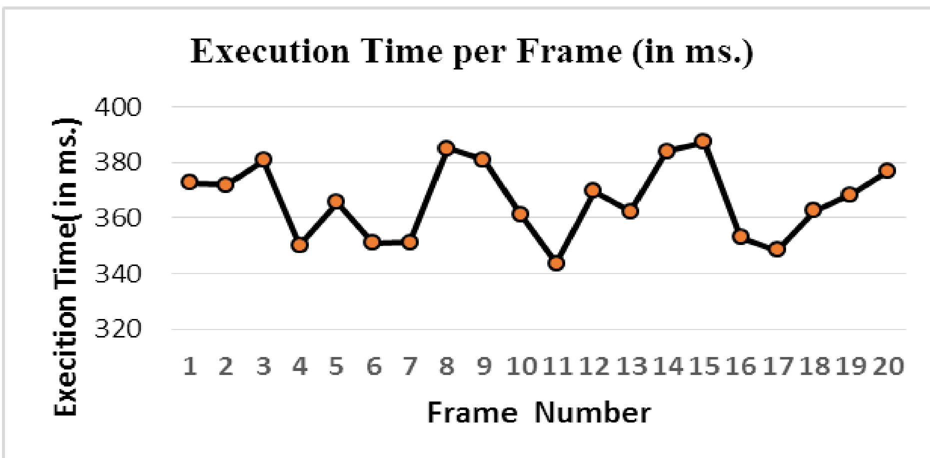

Fig. 6: Plot of execution time per frame (in ms.) vs. frame number for 128x720 video resolutions

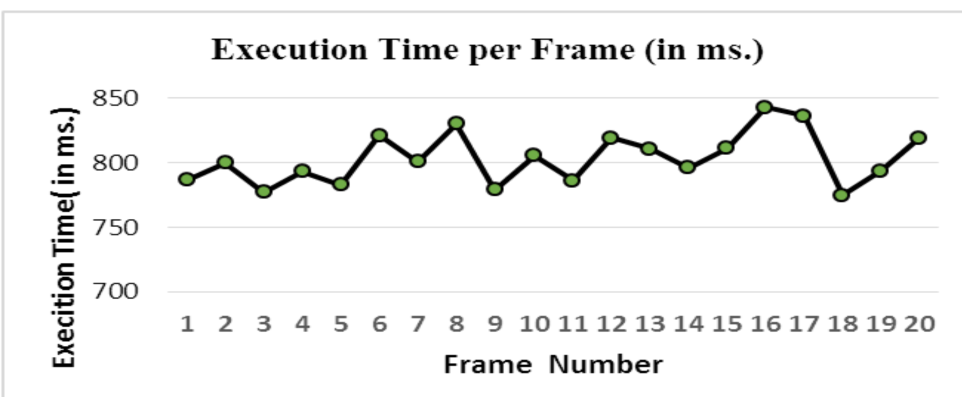

Fig. 7: Plot of execution time per frame (in ms.) vs. frame number for 19820x1080 video resolution

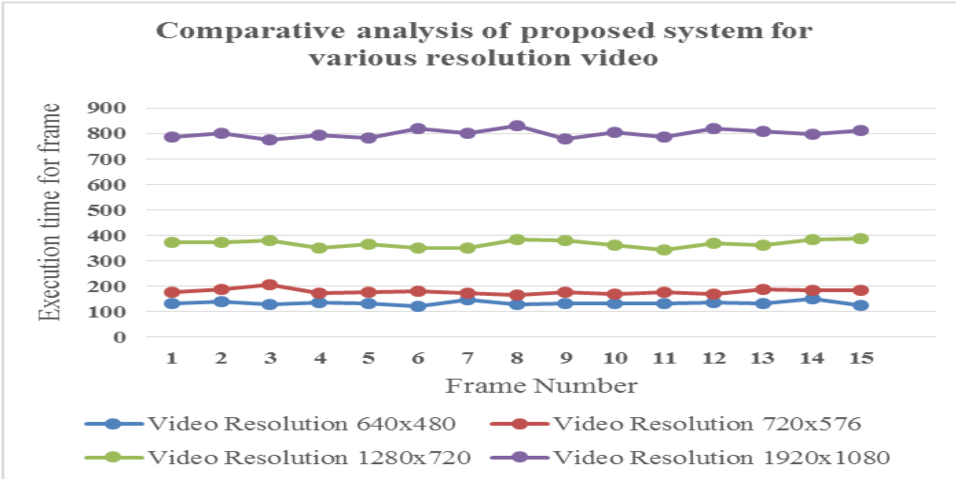

Fig. 8: Comparative analysis of proposed system for various resolution video

Table II: Average execution time per frame for various resolution video for the proposed system

	Resolution			
	640x 480	*720x 576*	*1280x 720*	*1920x 1080*
Avg. Execution Time per frame (in ms.)	131.9 8	209.2 6	353.9 6	815.18
FPS	7.57	4.77	2.82	1.22

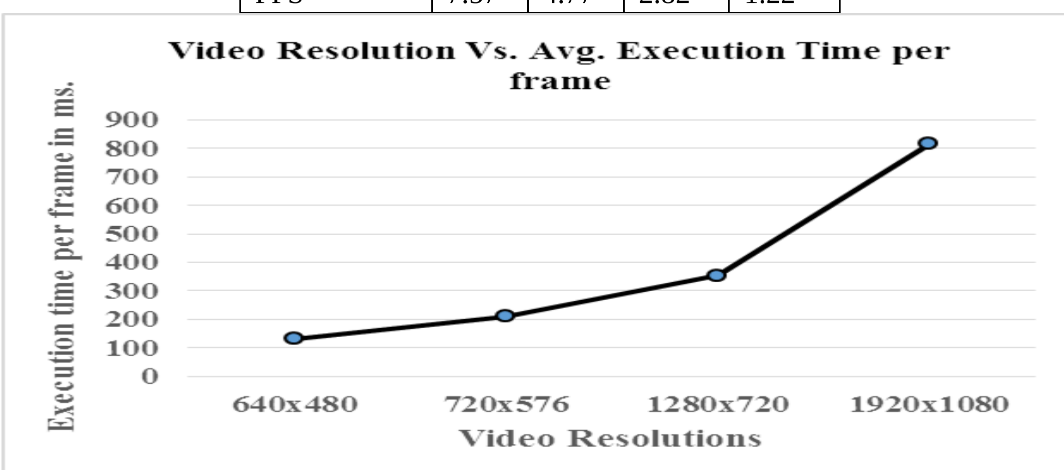

Fig. 9: Plot of video resolution vs. execution time per frame in millisecond for the proposed system

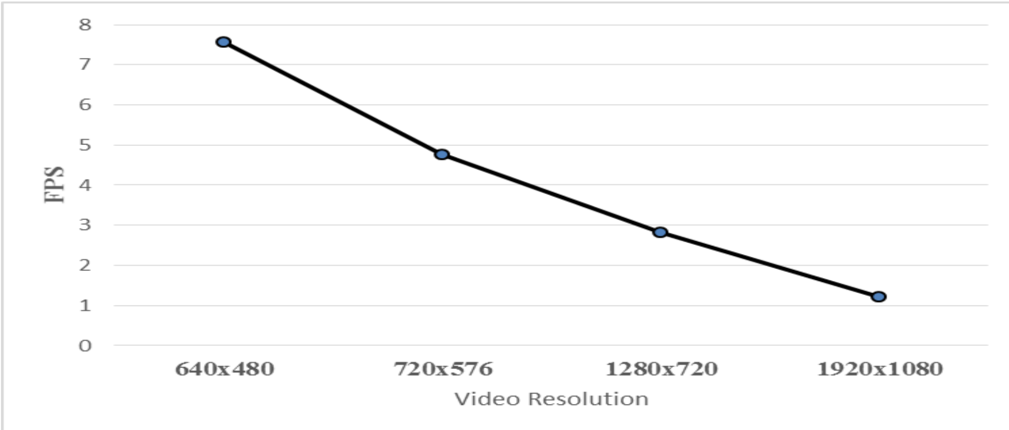

Fig. 10: Plot of video resolution vs. FPS for the proposed system

6 Conclusion

Now day's high-resolution imaging sensors/cameras are being used in areas of video surveillance like security at public places, vehicle traffic monitoring systems, military applications, and satellite imaging systems. Evaluating the object tracking system performance for the simple tracking system in high-resolution video is important. The proposed methodology employs a Gaussian mixture model (GMM) for background subtraction, foreground detection, and an optical flow algorithm to identify and track objects. Initially the foreground objects i.e. the region or object of interest from background image which is obtained by GMM. Only successive frames are required to detect an object in motion. The proposed system is evaluated in terms of execution time required for one frame. In this paper, a performance evaluation of the proposed system was carried out on various resolution videos. The technique proposed is evaluated using i5 core processor, 1.80 GHz processor and 4 GB RAM. The execution time required per frame the resolution 640x480, 720x576, HD, 1280x720 and Full HD 1920x1080 are 131.98 millisecond, 209.26 milliseconds, 353.96 milliseconds, and 815.18 milliseconds respectively. As the resolution of video increases, it requires more average execution per frame. It is also difficult to detect small objects from the frame by using proposed method. Thus, real-time processing for object recognition and tracking is not achieved by this methodology. The future work is to develop the new technique which can run on high-resolution video for detection and tracking in real-time applications as well as enhance the accuracy.

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Authors Profile

Mr.Shakil A. Shaikh is pursuing his Ph. D and working as Associate Professor in Electronics Engineering at Pravara Rural Engineering College Loni, Ahmednagar, Maharashtra, India. He has more than 27 Years of teaching experience. His area of interest is Signal and Image processing He is a Life Member of ISTE.

Dr. A K Kureshi had completed his Ph. D in 2010 in the area of Low Power Techniques and Architecture of FPGAs. He is working as a Director at Maulana Mukhtar Ahmad Nadvi Technical Campus, Malegaon, Maharashtra, India. He has more than 22 years of teaching experience. His area of interest is in the field of Carbon Nano Tubes as Interconnects and logics and in Multi-layer Graphene domain. He is a Member of IEEE and Life Member of ISTE, IEI and IETE

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