Statistical Survey on Object Detection and tracking Methodologies

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Abstract -Object detection and tracking is the critical task in many computer vision applications such as video surveillance, driver assistance system, person identification, behavior analysis. Object detection and tracking especially for human and vehicle is currently most active research topic. The processing part of video or image includes following stages: background modelling, motion segmentation, classification, tracking, understanding the human behavior, human identification. In this paper, we review current technologies for each stage of the object detection and different algorithms to detect an object. Video surveillance has many other applications like pedestrian detection, abnormal behaviour analysis of the person, person identification, traffic management. There are basically four different techniques for object detection: region based detection, feature based detection, contour based detection and model based detection. Intelligent transport system (ITS) needs very precise approach to implement it. Here in this paper we have explained each technique and also described some authors' implementation result overview.

Index Terms—Background subtraction, Human detection, Object tracking, Object tracking, Video surveillance,

1 INTRODUCTION

INTELLIGENT Transport System (ITS) is one of the current research areas today. Real time visual tracking and detection of object is challenging tasks with many practical applications: Person identification, video surveillance system, traffic management, video compression, target detection and tracking. Visual surveillance system applications are not only to put cameras in the place of human eyes, but also to accomplish the entire surveillance task as automatically as possible. The tracking of moving objects from frame to frame in real time video sequences captured by the moving camera is a highly challenging task. The challenges come from complex object motion, non-rigid object tracking, partial occlusion, illumination change, and real time processing requirement. Object tracking is implemented by target detection also. Target representation refers to how the object to be tracked and modelled, target localization deals with how the search of the corresponding object in the following frame is accomplished.

Video surveillance systems generally track moving objects from one frame to another in an image sequence. The tracking algorithms usually have considerable intersection with motion detection during processing. Tracking over time typically involves matching objects in consecutive frames using features such as points, lines or blobs. There are also other methods to detect objects using shape based model, finding centroid of the target. Object can be classified according to the application in surveillance systems. Object can be human, vehicles, obstacles on the road, pedestrians carrying different objects etcetera. According to the target selection different algorithms can be implemented. There are several different techniques present to detect pedestrian, vehicle or any other objects. So, the techniques to detect the object will vary according to the application and the environment condition.

Enhancing comfort and safety of the driver and the occupants of an automobile has been a major motivator in the innovations associated with Intelligent Vehicles and Intelligent Transportation Systems (ITSs). Infrastructure enhancements to reduce pedestrian-related accidents can be divided into three categories of countermeasures: speed control, pedestrian–vehicle separation, and measures to increase visibility of pedestrians in [1]. These enhancements can be complemented by systems that detect the pedestrians and prevent accidents by warning the driver or triggering autonomous brake. In the cases where an accident cannot be prevented, collision mitigation devices that are incorporated into vehicle design enhancement can be deployed to reduce the impact of the collision on the pedestrian.

Accurate and real time object tracking will significantly improve the performance of object recognition, activity analysis and high-level event understanding. The existing methods can be divided into three major categories: region based models in [3], [4], contour based tracking in [2], and feature -based models in [5], [6] and model-based tracking. To detect any object there is a simple procedure. Only different algorithms are chosen according to the type of object considered. These are the stages to detect any object in video: environment modelling, motion segmentation, filtering, object classification, object detection, and object tracking.

In video surveillance, it is necessary to capture a continuous image and update the background image for

continuous working of the environment modelling. Environmental models can be classified into 2-D models in the image plane and 3-D models in real world coordinates. Due to simplicity 2-D models have more applications but, the environment factors such as lighting variance, shadows bring many difficulties to the acquirement and updating of background images. Many algorithms have been proposed to overcome these problems like temporal average of an image sequence in [7], [8], adaptive gaussian mixture model [9], and parameter estimation based on pixel value in [10], [11], etcetera. In [11], [12] a basic framework for recuperating and updating background images based on a process in which a mixed gaussian model is used for each pixel value is proposed and real time estimation is used to update background images in order to adapt to illumination variance and disturbance in backgrounds.

Detection of moving regions provides attention for tracking and behavior analysis because only these regions need be considered in the later processes. Recently, many segmentation methods use either temporal or spatial information in the image sequence to get more accurate results. Here moving regions are detected in an image by taking the difference between the current image and the reference background image in a pixel-by-pixel manner. In [13], [12], [15], background model is used to reduce the influence of the environment changes. In [16], [17] compute the displacement vector field to initialize a contour based tracking algorithm for the extraction of articulated objects. In [10], method to detect moving targets in real time video streams using temporal differencing technique has been explained.

Different moving regions may correspond to different moving targets in natural scenes. The image sequences captured by surveillance cameras mounted in road traffic scenes probably include humans, vehicles and other moving objects such as flying birds and moving clouds, etcetera. To further track objects and analyze their behaviours, it is essential to correctly classify moving objects. Object classification is used for standard pattern recognition issue. There are two categories of approaches for classifying moving objects. Shape-based classification in [14] uses the area of image blobs as classification metrics to classify all moving object blobs into humans, vehicles. Motion-based classification in [28], residual flow is used to analyze rigidity and periodicity of moving objects.

Surveillance systems generally track moving objects from one frame to another in an image sequence. The tracking algorithms usually have considerable intersection with motion detection during processing. In [18] uses the object tracking using centroid weighted kalman filter to track the object. Here the kalman filter is used to predict target position and combining centroid weighted method to optimize the predictive state value. Then it updates observation data according to the corrected state value. The general block schematic is shown in figure 1.Here generalized object detection outline is been shown. The paper is divided into following steps. Section 2 describes the general object detection algorithms, types of methodologies. Section 3 explains the types of the object tracking methodologies. Section IV describes the hardware and software requirement and issues for detection of the object and comparative study analysis for the software tools. Section 5 describes applications of the object detection and section 6 explains results of few reference papers to get the idea of the object detection techniques.

2 APPROACHES FOR OBJECT DETECTION

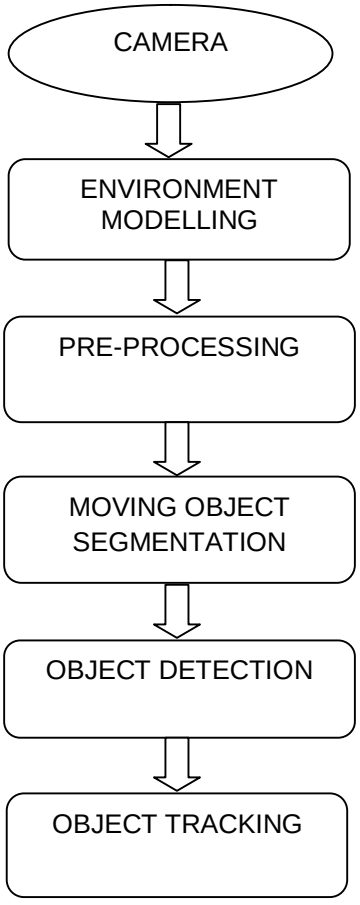

Figure 1 General block schematic of video surveillance system

Object detection is divided into different stages which are shown in figure 1. There are different approaches to get more accurate result in video surveillance. Each stage has diverse algorithms for different environment conditions. As it is related to the security, there are quite a lot of approaches to get precise result in minimum time period. Due to environmental conditions like illumination changes, shadow object detection becomes difficult and significant problem. A

familiar approach for object detection is to use information in a single frame. Now, each stage is described as follows:

2.1 Environment Modeling:-

Object detection is categorized basically as rigid and non-rigid objects in video surveillance systems. According to the type of the object the implementation of algorithms differs. Here in this paper we introduce mainly the survey of algorithms for detection and tracking of humans and vehicles.

Environment modelling is also divided into 2D and 3D models. But here we have considered only 2D models. In environment modelling, there are different approaches for the frame subtraction. Here each frame of video is subtracted and the background value is updated. In [19], a tracking algorithm based on adaptive background subtraction for detecting and tracking moving objects in the video is used.

Detection of moving objects is realized here by subtracting background image from every frame of video to judge which sections of frame are stationary or moving. Due to the changes of the moving of objects and other environment disturbance, the background image always changes. In this paper the background image is constantly updated.

In [20], the technique provides accurately segmented object boundaries. Here the object and background is modelled using Gaussian mixture model (GMM), and a rough contour according to the object edge feature is extracted. After that the states of the object like translation, rotation and scale, are estimate during shape context matching. In [21], background subtraction types: the pixel level, the region level, and the frame level are explained.

2.2 Pre-Processing:-

Pre-processing in video is necessary for real time detection. As in real time detection system, much chances of noise are there, it is necessary to do pre-processing. Real time system requires much precise algorithms for detection because environment effects, lighting condition affect the systems. It is necessary filter the image before implementing the object detection algorithms. Also, due to noise, small gaps occur in the images, so we have to remove it to get exact extracted image for further processing. Kalman filter is very precise method for the filtering purpose. After removing the noise, we can execute the object detection and tracking.

2.3 Moving object segmentation:-

Background or motion segmentation is also an important task in object detection. In video surveillance system, the difficult task is to extract the moving object accurately. After the extraction, the object is detected by applying different algorithms. In [22], frame differencing method is used for detection of the object. This paper uses the MATLAB image acquisition toolbox for detecting the moving object. But the occlusion problem is also present in this method. In [23], adjacent frame difference method is applied to extract the moving object from continuous video frames. After that Canny edge detector is implemented to get the boundaries of the object using MATLAB. With this object reorganization is also implemented.

There are basically three types of video differencing: Background subtraction, temporal differencing and optical flow method. In video surveillance, other different techniques are also applicable. Motion segmentation is difficult task here because cameras are mounted on the crossroads. Occlusion is major problem, as there are different moving object going across the road. Therefore we cannot differentiate the objects.

As there are so many different algorithms for detection of the object accurately like blob based object detection, contour based object detection, shape based object detection, etcetera. Video surveillance is a very vast field to study. As security issues increases, video algorithms and accurate software to get precise result in less time. As the time is most precious thing in video surveillance, we need techniques for the object detection such that it can detect objects in less time period.

2.4 Object detection:-

In video surveillance system, to track and detect the object is a tricky task. It has also applications to recognize an object in video surveillance. There are so many environment factors such as sunlight, traffic lights, weather effects etcetera. As we have seen the background subtraction is the first step of the object detection and tracking. In [18], centroid weighted kalman filter is used for object detection. This algorithm first subtract background image from foreground image and centroid is used to find the exact position of the object. As kalman filter used in [18] is better option for object detection but accuracy is low compared to other algorithms.

In [24], pedestrian is considered as an object. Pedestrian safety is considered as the basic concern.6-D vision algorithm is used for pedestrian detection. In this paper, points are used to get the depth value of the object or pedestrian and then using the spatial position information the pedestrians are detected. Situation analysis and the vehicle control modules are merged to get the collision avoidance warning. By using vehicle control, lateral control for evasion is also implemented. This algorithm is useful because fusion of two algorithms give accurate result with zero false detection.

Object detection comprises of motion detection or segmentation and object classification. These two are

combined to detect true object results. So many algorithms are there for motion segmentation and its classification. As we have explained, motion segmentation is basically background subtraction or frame subtraction. Once the object or the motion is extracted, the classifiers are used to detect a particular object. Object delectation methods are classified basically as: Motion based classification and Shape based classification.

In [25], skin color based object detection is performed. In various lighting conditions, skin color is extracted for better result. Hough Transform is used to detect pedestrian's head. But it cannot be implemented in crowded scenario because probability of occlusion is more in crowded environment. Blob based and contour based techniques are also satisfying. In [26], blob of a human is taken from human cyclic motion analysis. This method uses bayes classifier to get better result for the position of the person. The combination of blob motion and HOG techniques give some good results.

Contour based detection is also one of the good options for accurate result. In [20], firstly shape matching approach is implemented using contour extraction method. Canny edge detector is used to get the edges of the object after that the contour is extracted which is rough plot of the object. The SVM classifier is also good classifier for the object detection.

3 OBJECT TRACKING APPROACHES

Object tracking is the next step to the object detection. A very important question in the field of intelligent transportation system is to prevent pedestrians from being hit by vehicles. So, a vision-based approach that can identify pedestrians resourcefully and automatically is in need.

Video surveillance is having very wide range of applications which includes different techniques to recognize the objects at different environment conditions. Object tracking is useful as a part of safety of the pedestrian or vehicles. Therefore detection of the object is applicable at crossroad, in the crowded environment, at traffic signals, various lighting conditions, and etcetera. Several algorithms are available to get accurate results. In object tracking, objects are tracked in every consecutive frame sequences for different application in video surveillance system. The basic object tracking is divided into three categorize: region-based tracking, contour-based tracking, feature-based tracking, and model-based tracking.

3.1 Region- based tracking:-

To track the object, color and texture features of the object are considered. Here tracking is implemented using motion segmentation with stable background model. Human body or vehicle is considered as blob and background subtraction methods are used to track the objects. Color and gradient information are used to cope up with the shadow and occlusion problem. In [26], blob based tracking is implemented. Here background subtraction method is used to detect an object which is precise technique to extract the object. Foreground blob is extracted to get exact object. After the detection, mean-shift algorithm is implemented using particle filter. The mean shift algorithm is a nonparametric technique to locate density extrema or modes of a given distribution by an iterative procedure. In [26] blob and HOG both algorithms' results are shown to get the better idea of the tracking result. This gives approximately accurate results but there are other techniques which can give more precise results.

In this paper, comparative study of the survey paper techniques are explained. HOG is used because it is having less computational complexity. The results are more satisfactory. In [19], adaptive background subtraction method is implemented for tracking of the object. Here to detect an object background subtraction method is used. Current image is compared with the background image to get the moving position of the object. After this only moving regions are considered for target detection. Labelling of connected components is used to detect connected regions in binary images. It scans an image and groups its pixels into components based on pixel connectivity. Centroid is used to label the object and track them. This paper is based on MATLAB tools which have advanced image processing tools to implement object detection algorithms and less response time with more perfect results.

3.2 Contour based tracking:-

This method uses the border or the edges of the background images. Boundary features provide more precise shape information. This technique is based on the information provided by the object boundaries. There are many algorithms to detect boundary or edges of the objects like canny edge detector, Harris corner detector etcetera. In [20], shape based contour is extracted. First a rough contour is extracted using canny edge detection method by edge pixel values. After that parameters are estimated using shape matching. A shape is represented by a discrete set of points sampled from the contours on the shape. These points can be on internal or external contours. Tracking is finally completed by elastic shape matching for extracting the exact contour. This approach has advantage like rotation, biased occlusion handling, and translation. But in crowded outdoor environment more robust technique is required. Contour based tracking is useful as the shape of the object is detected and whole object is tracked.

3.3 Feature-based tracking:-

Different features are used to detect and track the object in various environment conditions. Feature based tracking is combination of extracting different features, classify them

and match it with the predicted results. Different features like height, width, area, and etcetera are considered. In [27], moving region segmentation is implemented using background subtraction method to subtract background image from current image. Here GMM (Gaussian mixture model) is used for multi color environment. After the filtering process, feature extraction is implemented by finding the centroid of the object. The centroid of the bounding box provides the spatial position, which is the average position of all pixels in the region. In this paper, height, area, width and aspect ratio are used to extract the object. Tracking is implemented by prediction of the search window for the pedestrian and then matching of the detected pedestrians with the current situation. Kalman filter is used for tracking of the object. In this paper time required to detect and track the object is moderately less but this techniques cannot handle occlusion.

Feature based tracking is useful when shape based techniques are not reliable. Different environment and weather condition affect the algorithms. When we are measuring the features of the object in the current situation, we get more accurate result. Shapes are changing according to the position of object at different levels. But it has disadvantage for 3-D model which does not give satisfactory results.

3.4 Model-based tracking:-

2-D and 3-D models are basic models which are considered for object detection and the tracking. Generally, model-based human body tracking involves issues like construction of human body models; representation of prior knowledge of motion models and motion constraints; prediction and search strategies. Physical model is also considered as reference. In vehicle detection, shape of the vehicles is predetermined. So, on that basis template of the predicted result is matched with the current results. As in model-based approach, we can define the shape of the detected object. Therefore tracking of the object becomes easier. Same thing can be applied to the human body also. As the shape of the human body is fixed like head, arms and legs, we can train the classifier according to the shape and implement the tracking algorithm more precisely. Only difficulty in model-based approach is in 3-D model where construction of human shape is very complicated.

4 HARDWARE AND SOFTWARE

Object detection and tracking is a key research topic in video surveillance system and image processing field. Everyday new techniques, algorithms are being developed to get more precise results in less time period. Video surveillance is a vast field for research as it deals with security issues such as traffic area, pedestrian's safety, vehicle's safety, vehicle and person identification etcetera. So the selection of the hardware and the software tool for the detection and the tracking purpose is more vital.

4.1 Camera classifications:-

There are various types of cameras have been used in video monitoring systems. Bullet, dome, covert, outdoor, varifocal and night vision are some of the basic types of surveillance cameras. Different cameras with different techniques are CCTV camera, CMOS (Complementary Metal Oxide Semiconductor) camera, IR cameras and CCD (Charged Coupled Devices) camera. Closed-circuit television (CCTV) cameras can produce images or recordings for surveillance purposes, and can be either video cameras, or digital stills cameras. There are basically two types of image sensors are used today: CMOS and CCD in video surveillance systems. The image sensor converts light into a digital signal. So both image sensors have its advantages and disadvantages also. CCD and CMOS sensors can both produce high quality images when they are properly designed. CCD chips have traditionally been the standard for scientific imaging, photography and industrial imaging due to their higher image quality and low noise. CMOS has traditionally been used in less expensive devices such as cheap cameras and cell phones where cost, space and power consumption must be kept at a minimum.

Today, there is much less differentiation between the application of CCD and CMOS sensors. CMOS manufacturers have made great improvements in the image quality that can be obtained, while CCD manufacturers have improved the power consumption and package size. So less expensive cameras and cell phones utilize CCD technology and we can find CMOS sensors being used in professional and industrial devices.

Now a days as the security issue increases, the need of more accurate result from video monitoring system increases. Monocular cameras exist in most of the video surveillance systems but stereo or multi camera system is required to get better results. Many researchers have proposed techniques for the object detection by stereo vision applications. In [29], the author has proposed the stereo vision techniques for multi object detection in video surveillance system. In this paper, set of features are extracted and it is projected on the 2D ground plane for the image construction. Kernel based clustering method is used to group the projected points. This method gives better result for 2D vision only because image construction in 3D is very complicated.

4.2 Different software tools:-

Video surveillance system requires more precise software tools with less response and processing time. There are many software tools to detect the object, recognize the object, and

track the object etcetera. One of the best options for video and image processing is MATLAB. MATLAB is a high-level language and interactive environment for numerical computation, visualization, and programming. Using MATLAB, we can analyze data, develop algorithms, and create models and applications. The language, tools, and built-in math functions enable you to explore multiple approaches and reach a solution faster than with spreadsheets or traditional programming languages, such as C/C++ or Java. MATLAB has many processing toolbox to implement variety of the applications. MATLAB offers parallel computing which is the required for video and image processing applications.

MATLAB offers Math toolbox, control system design toolbox and analysis which are used for fuzzy logic control system, signal processing and communication toolbox, test and measurement toolbox, computational finance toolbox for various applications. MATLAB also offers the simulink tool for the modeling purpose. It provides fixed-Point modeling, event-Based modeling, physical modeling, control system design and analysis, signal processing and communications, code generation in the simulink. So by these toolboxes we get more accurate results with less computational complexity. MATLAB offers less complexity to implement image processing applications. But it has only one disadvantage that it's processing time for an image or video is more compared to the other software tools.

Another better option for image and video processing is OpenCV. OpenCV (Open Source Computer Vision) is a library of programming functions for real time computer vision. It has C++, C, Python and Java interfaces running on Windows, Linux, Android and Mac platforms. OpenCV is useful in image processing applications like image segmentation, transforms, feature extraction, machine learning: detection and reorganization, tracking of object, camera calibration for 2D and 3D images etcetera. The advantage of the OpenCV is that we can use it on any platform and the complexity to implement different algorithm is very less here. Different algorithm functions are considered in the OpenCV libraries. So we can easily use that function to implement and use the algorithm. The most important advantage of the OpenCV is that it requires very less processing time unlike others software tools. One can implement video and image processing method more easily and precisely than other tools.

5 APPLICATIONS

Intelligent transport system is beneficial for many major recent issues. The security and health issues are the most important research topics in image processing field. Now a day road accidents are the world's largest health issue because maximum victims are dead in road accidents. Another issue is the security of the person at traffic or on the crossroad. So techniques of the object detection like human and vehicle, human identification, human behaviour analysis, object classification etcetera is more necessary.

Video surveillance system is a key research area today. Everyday new algorithms are being implemented to get more precise and fast results. We can use these techniques for the following applications in video surveillance system or for the personal security issues.

- We can detect human as well as vehicle in traffic signal to limit the accidents on the road by using object detection algorithms.
- Object detection with automatic braking system in vehicle can limit the pedestrian deaths in the world.
- Human identification can help to identify a particular person for security purpose.
- Behaviour analysis can also help in security issues in video monitoring systems.
- Object detection and classification can also help in traffic management.

6 OBSERVER'S RESULTS

In this section, we review the results of some author's who has implemented few object detection and tracking algorithms. Here we have review some reference paper and its results have been shown in this paper to get better idea of the application. In [27], the tracking and detection algorithm is divided into following stages: moving segmentation, filtering, feature extraction and pedestrian tracking.

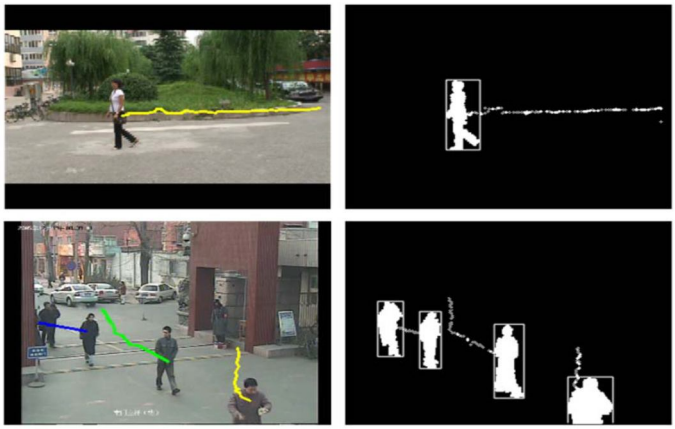

Figure 2 Result of tracking algorithm implemented in [27]

Tacking of pedestrian in [27] is processed as follows: prediction of the search area and matching with the predicted results. The result of [27] is shown in figure 2. In [27], approximately 95% pedestrians are detected correctly. And with the matching algorithm, matching with the predicted image is approximately 92%. We should also notice that in this paper, processing time is comparatively less because of the use of precise algorithm implemented using OpenCV library.

In [22], frame subtraction method is used to detect an object in video. Here the object detection is implemented using MATLAB software. In [22], boundary detection method is used to place a bounding box around the object in the video. This paper used MATLAB image acquisition toolbox to get more accurate results. In [22], the results show that the algorithms can detect moving rigid as well as non rigid objects precisely. Figure 3 shows the results of the [22].

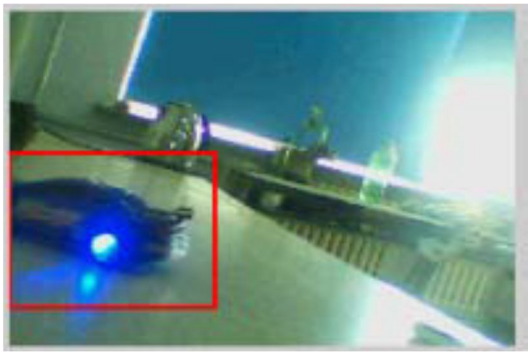

Figure 3 object detection result of [22]

7 CONCLUSION

Object detection and tracking in video surveillance system is a very challenging task. We have presented here the video surveillance system framework with the different methodologies. We have presented here the overview of the video monitoring system with reference to the different author's viewpoint.

In this paper we give brief idea on how to process the image, extract the features, motion detection, classification of the object and tracking. Based on different methods, different techniques have been discussed. For object detection, environment modeling methods which are used to remove noise have been explained. Background subtraction stage is discussed with the edge detection and frame separation methods. Optical flow is also used but frame separation and GMM based methods are more precise. Moving object segmentation is used for object detection only. By this we can detect and classify the object using different classifier. HOG descriptor, HAAR classifier, bayes classifiers etcetera are classifier for object detection.

In this paper, tracking algorithms implemented using four main methodologies are explained briefly. Tracking is based on ROI, feature which are extracted, predefined model based, contour based. Different techniques have been explained with the brief overview. Here we have explained hardware and software issue which is not considered in other techniques. Camera classification and different categories of camera is explained here. Furthermore, two software MATLAB and OpenCV library which are widely used today for image and video processing is discussed here with its advantages and disadvantages. Also some author's results are shown for reference to get the idea of object detection and tracking.

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