IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661, p- ISSN: 2278-8727Volume 16, Issue 3, Ver. II (May-Jun. 2014), PP 25-32
www.iosrjournals.org

Traffic Event Detection using Computer Vision

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Abstract: *To make sure that the vehicles on road follow traffic rules, lane disciplines and traffic signals, it takes a lot of human effort and precious time. An automated system which is coupled with traffic cameras can help in this monitoring process. Haar-like features is one of the best techniques that can be used for detecting the objects within images/video feed from the traffic cameras. This process includes the subtasks of data collection, negative positive separation, creating training samples, creating description files, haar training and a strong action program which can detect vehicles and the traffic events. Hence alerting the monitoring authority to take care of the situation and make sure that the traffic events handled carefully. For experimental purpose one can train their database for few vehicles but a more robust database and a robust detection program can produce a great performance results.*
Keywords: *Road Traffic, haar training, Event detection, Surveillance, Monitoring.*

I. Introduction

The total vehicle population in the world is increasing drastically, and India is also no where behind in this population count. According to U.S. publisher Ward's, as of 2010 there were 1.015 billion motor vehicles are in use in the world. This figure represents the number of cars, light, medium and heavy duty trucks, and buses, but does not include off-road vehicles or heavy construction equipment. The world vehicle population passed the 500 million-unit mark in 1986, from 250 million motor vehicles in 1970. Between 1970 and 1980, the vehicle population doubled roughly every 10 years. Two U.S. researchers estimate that the world's fleet will reach 2 billion motor vehicles by 2020, with cars representing at least 50% of all vehicles. China's and India's automobile fleets are expected to grow at an annual rate of around 7 or 8%, while the slowest growth is expected in the United States, with less than 1% a year, and Western Europe, with 1 to 2%. Global vehicle ownership in 2010 was 148 vehicles in operation per 1000 inhabitants, a ratio of 1:6.75 vehicles to people, slightly down from 150 vehicles per 1000 inhabitants in 2009, a rate of 1:6.63 vehicles to people. In developing countries vehicle ownership rates rarely exceed 200 cars per 1,000 population.

India's vehicle fleet had the second-largest growth rate after China in 2010, with 8.9%. The fleet went from 19.1 million in 2009 to 20.8 million units in 2010. India has a fleet of 1.1 million natural gas vehicles as of December 2011. Transport in the Republic of India is an important part of the nation's economy. Since the economic liberalization of the 1990s, development of infrastructure within the country has progressed at a rapid pace, and today there is a wide variety of modes of transport by land, water and air. In the interim, public transport remains the primary mode of transport for most of the population, and India's public transport systems are among the most heavily used in the world. India's rail network is the 4th longest and the most heavily used system in the world, transporting 8224 million passengers and over 969 million tonns of freight annually, as of 2012.

Motor vehicle penetration is low by international standards, with only 103 million cars on the nation's roads. In addition, only around 10% of Indian households own a motorcycle. Despite this, the number of deaths caused by traffic is amongst the highest in the world and is still increasing. The automobile industry in India is currently rapidly growing with an annual production of over 4.6 million vehicles, and vehicle volume is expected to rise greatly in the future.

No wonder that the country which called as a subcontinent have such a huge numbers and growth rate in vehicle counts. But same growth should be handled carefully else the control of road accidents will be a big task. The frequency of traffic collisions in India is amongst the highest in the world. A National Crime Records Bureau (NCRB) report revealed that every year, more than 135,000 traffic collision-related deaths occur in India. In New Delhi, the capital of India, the frequency of traffic collisions is 40 times higher than the rate in London, the capital of the United Kingdom. Traffic collision-related deaths increased from 13 per hour in 2008 to 14 per hour in 2009. More than 40 per cent of these casualties are associated with motorcycles and trucks. The most accident-prone time on Indian roads is during the peak hour at afternoon and evening. According to road traffic safety experts, the actual number of casualties may be higher than what is documented, as many traffic accidents go unreported. Moreover, victims who die some time after the accident, a span of time which may vary from a few hours to several days, are not counted as car accident victims.

Coming to point of avoiding the road accidents, traffic rules and road surveillance plays a great role here. Our effort here is to provide a computerized and robust system to help the monitoring persons and raise their efficiency. The area we are focusing here is detecting the traffic events which occur due breaking of traffic rules. Here we want to provide a simple approach which will help in detecting the vehicles on road, their presence on road and their moment on the area of focus.

Increase in the number of vehicles on road creating traffic problems and making the process of monitoring, controlling and managing a hard job. An automated traffic event detection system can make the job of monitoring easy and handy. And this also can help in keeping records of such events. Here, main objective of the system is to record, build, train, and test the traffic event detection system and test its working with real-time videos. Haar-like features is one of the best techniques that can be used for detecting the objects within images/video feed from the traffic cameras. This process includes the subtasks of data collection, negative positive separation, creating training samples, creating description files, haar training and a strong action program which can detect vehicles and the traffic events. Hence alerting the monitoring authority to take care of the situation and make sure that the traffic events handled carefully. For experimental purpose one can train their database for few vehicles but a more robust database and a robust detection program can produce a great performance results[1].

As introduced in the previous section, detection of the road traffic events plays a major role in avoiding upcoming traffic accidents. With the help of the computer vision, we can build a intelligent system which can detect the vehicles on road, count them, sense their presence on the restricted area and hence alerting the monitoring authorities, so that they can deal with the traffic event which occurred and needs the attention of the authorities.

This project takes advantages of the traffic cameras which are used in monitoring the vehicles of roads, and add the smart feature of detecting the vehicles and alerting users. With the help of OpenCV, which is an open source library providing advanced libraries related to computer vision. HAAR training is one of the great features of OpenCV, which is used to detect the objects in videos and images. With the help of this, we can train our system to detect the vehicles and then same can be used in our programming with Visual c++ for further processing like counting, marking etc.

II. Literature Survey

Literature survey means understanding the fundamentals and state-of-the art of the area of interest, which includes learning the definitions of the concepts, accessing latest approaches of area, and understanding the methods and theories. Finally getting results in the form of research topics based on the existing research. For the proposed system, a survey of the topics related to traffic events, vehicle detection and haar training are made and understood the methods and approaches.

Proposed traffic event detection system can give revolutionary road traffic surveillance and monitoring results by helping the traffic monitoring and controlling persons. With the successful implementation of the system, traffic police can use the system for monitoring the events like signal jumps, border crossing, traffic jams and many more. This system not only can help to traffic police but also in the situations like the unmanaged train level crossings, border jumping and other such activities.

Considering the technical point of view, use of OpenCV libraries in the field of image processing and video analytics can make the system more feasible and give a great performance boost. With the help of haar training, we can have our own, localized database, which can be used for detecting vehicles of vehicles. Hence by this localized haar cascade, a more accurate detection system can be built which got high potential in the field of localized traffic monitoring systems.

As the motor vehicles started rolling out on road people started depending on them and toady's life fully depend on vehicles. Number of vehicles increased on road, and then the problem of traffic, accidents came. And then the idea of monitoring the traffic and controlling it came to existence. Earlier, human police use to monitor, but as technology grown, systems like electronic vehicle counting, traffic cameras, monitoring rooms, moving cameras came into picture.

But these processes take great human effort, to minimize that, intelligent systems came into the traffic monitoring system. Currently the camera based systems are more dominant in this area. Below list displays some of them. Camera based speed tracking systems. Moment catching systems based on background subtraction systems and the classic operator based control rooms. Below are some of the technically rich and recent existing techniques in the field of traffic event detection.

2.1 Existing System

Below list gives some of the existing systems in the area of traffic monitoring.

1.Motion and haar-like features based vehicle detection[1]

Lienhart et al. have added basic and rotated haar-like features in the face detection scheme based on a boosted cascade of simple feature classifiers. There are two key contributions in the paper. The first is introduction of motion features. With the haar-like and motion features, our sample vehicle detector shows off on average a 5% lower false alarm rate at a given hit rate. Considering the speed performance, motion features are used to given the candidate regions and haar-like features are used to detect the vehicles at the above results. Secondly, the haar-like features are used for the highway except face. In the face detection, Haar-like feature shows detection rate comparable to the best previous system. But little work is done in the traffic domain. And empirical analysis of vehicle detection is provided in the experiment section

2.Design of high-performance pedestrian and vehicle detection circuit using Haar-like features[2]

This paper describes the design of high-performance pedestrian and vehicle detection circuit using Haar-like features for intelligent vehicle application. The proposed circuit uses a sliding window for every image frame in order to extract Haar-like features and to detect pedestrians and vehicles. A total of 200 Haar-like features per sliding window are extracted from Haar-like feature extraction circuit and the extracted features are provided to AdaBoost classifier circuit.

3.Real-time vehicle detection based on Haar features and Pairwise Geometrical Histograms[3]

The Pairwise Geometrical Histograms (PGH) is a generalization of Chain Code Histogram(CCH). It is a powerful shape descriptor that is applied to contours matching which is not affected by rotation. As we know, this method is seldom used for vehicle detection. Feature extraction is a very common and useful method of pattern recognition. In recent years, the Viola and Jones rapid object detection approach became very popular. In this paper, we combine the Haar features and PGH together for vehicle detection. We discuss three methods: the vehicle detection using only Haar features, Haar features combined with hu moments and Haar features combined with PGH. The experimental results show that the last one has the best performance.

2.2 Proposed system

The traffic event detection system is proposed here, which gives promising results by using traffic camera. The proposed system functions helping the users to make sure that the vehicles on road follow traffic rules, lane disciplines and traffic signals. It’s an automated system which is trained by taking the local data, including the traffic patterns, vehicles and roads. Haar-like features is one of the best techniques that can be used for detecting the objects within images/video feed from the traffic cameras. This process includes the subtasks of data collection, negative positive separation, creating training samples, creating description files, haar training and a strong action program which can detect vehicles and the traffic events. Hence alerting the monitoring authority to take care of the situation and make sure that the traffic events handled carefully. For experimental purpose one can train their database for few vehicles but a more robust database and a robust detection program can produce a great performance results.

III. System Design

Systems design is the process of defining the architecture, components, modules, interfaces, and data for a system to satisfy specified requirements. Systems design could be seen as the application of systems theory to product development. Systems design is the process of defining and developing systems to satisfy specified requirements of the user. It is a high-level design that provides an overview of a solution, platform, system, product, service, or process. Such an overview is important in a multi-project development to make sure that each supporting component design will be compatible with its neighboring designs and with the big picture.

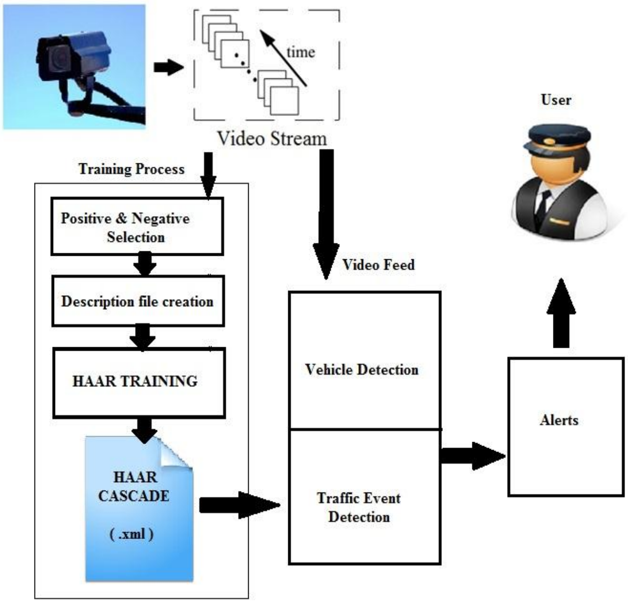

Figure 3.1 System Architecture

As the figure 3.1 shows, proposed architecture consists of the following 3 main parts as, input video feed, training database, vehicle and event detection and finally alerting the users. In next section, each of these modules explained in brief with data flow diagrams.

3.1 Data Flow Diagrams

A Data Flow Diagram (DFD) is a graphical representation of the flow of data through an information system. DFD‘s is very useful in understanding a system and can be efficiently used during analysis. A DFD shows the flow of data through a system. It view a system as a function that transforms the inputs into desired outputs. Any complex system will not perform this transformation in a single step and a data will typically undergo a series of transformations before it becomes the output.

3.1.1 Positive Object Image Creation.

This process consist of viewing each of the images containing the positives, which are the images containing the objects of interest. Figure 3.2 shows the data flow of the image clipping positive object image collection process. In this recursive process, objects are clipped down from images and their (x,y) coordinate are recorded.

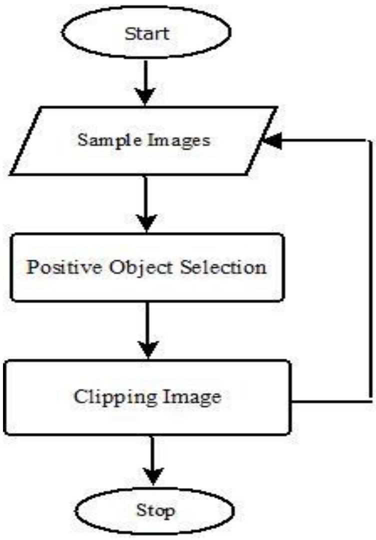

Figure 3.2 Positive object data collection process

3.1.2 Vehicle Detection Process.

In this step, recursively for each frame of the input video, detection program tries to match with the positive samples. Each time a match for a vehicle found then a signal to event detection process will be generated. Figure 3.3 shows the DFD for the vehicle detection process.

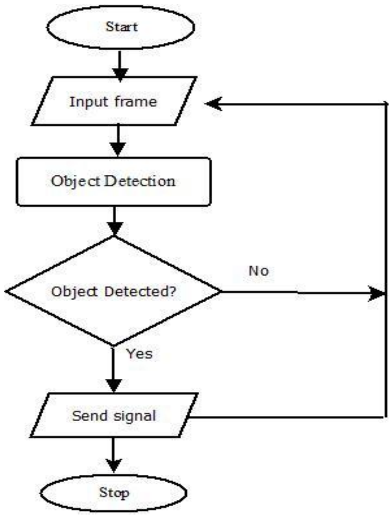

Figure 3.3 Data flow for vehicle detection

3.1.3 Event Detection Process.

In this step, recursively for each Signal generated from the previous step, detection program check the conditions. Each time a condition violated, a signal to event detection process will be generated. Figure 3.4 shows the DFD for the event detection process.

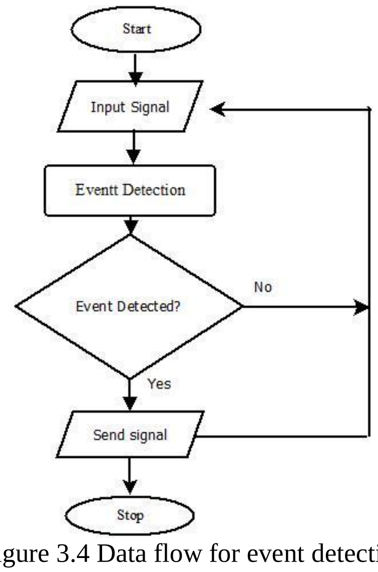

Figure 3.4 Data flow for event detection

IV. Implementation And Testing

As figure 6.1 shows, proposed system consists of following modules. Each module works on its input data and produces the inputs for next module. In first section, the training process works on input samples to produce training data, and in second part, event detection works on the trained data to detect vehicles and events, giving alerts as required. In next section, modular explanation of each module is given.

1. Selection of positive and negative images.
2. Clipping the positive images.
3. Description files creation.
4. HAAR training and .xml file creation.
5. Event detection.
6. Generating alerts.

4.1 Selection of positive and negative images.

Very first step of the proposed project is to selection of positive and negative images. This process is to be done manually. First, one has to collect plenty of images to train the database. Positive images are the images which contain the object of interest. In our case, vehicles are the objects of interest. Figure 4.1 shows the examples for the positive images. One can select these images as the way he likes his detection process catch the positive clips in samples.

Figure 4.1 Examples of positive images.

Negative images are images without the desired object. In our case, roads are negative backgrounds. Mostly any image without the positive object is said as negative here. Figure 4.2 shows the examples for the negative images.

Figure 4.2 Examples for negative images.

4.2 Clipping the positive images.

Clipping process takes the positive images and on manually selection of desired objects, it selects the objects, clips it from full image and records its coordinates in that image. This coordinate selection data consist of information as number of objects present, size of that object and coordinates of the object.

This process also leads to a question that how many images are enough to get a HAAR process done. And the answer is, bigger the database, robust the system. But a ratio is maintained for convenience, ratio like 1000 positives : 2000 negatives is a good ratio.

4.3 Description files creation

This process is to create a text file consisting of the information about objects in the images. For Positives, the file is of following format.

[filename] [# of objects] [[x y width height] [... 2nd object] ...]
[filename] [# of objects] [[x y width height] [... 2nd object] ...]
[filename] [# of objects] [[x y width height] [... 2nd object] ...]
...

For Negatives, the description file consists of following file format.

[filename]
[filename]
[filename]
...

4.4 Training the database

This is the biggest task of the project, and it can take up to 20 hours. OpenCV library provides command line interface for this process. Command to do so is:

cmd> opencv-haartraining -data haar -vec vecfile.vec -bg negative.txt

This process takes all negative, positive images and respective description files as input. Process them and at the end it produces training.xml file, which is used for detection process.

4.5 Event detection

This task does the real-time action of detecting desired objects from live feed or the video. This uses trained database and compare live data. Compare video frame by frame with samples, detects vehicles on matching, highlight detected objects, count detected objects/vehicles and compare with road capacity. Figure 4.3 and 4.4 shows some of such actions. Implement traffic event detection ideas like illegal moment in restricted area, exceeding maximum capacity etc. And at the end, alert users on any events of illegal movements.

Figure 4.3 Vehicle detection from original video frame and marking detected vehicles

In the next figure 4.4, detected objects are marked with rectangles. This process is repeated for each frame and each vehicle detected. As in figure shows, there are two vehicles on the current frame, both detected and marked with rectangles. In figure 4.4, the moment of vehicles in the restricted area is detected and marked with red rectangles. This process triggers the alerting system to check for that whether any traffic event is occurred.

Figure 4.4 Marking restricted area

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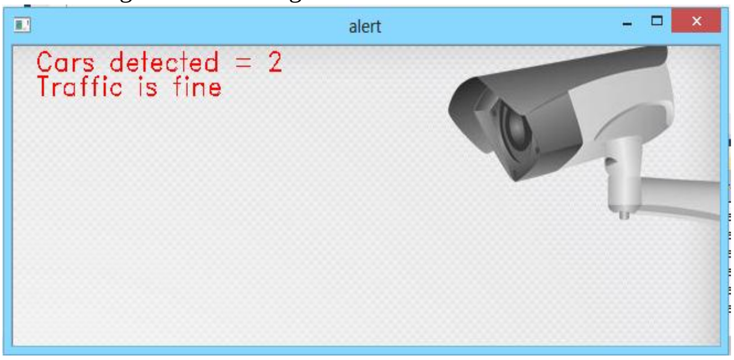
Next step is to alert the users, this process is shown in figure 4.5. for each frame of the video sequence, number of vehicles on the screen are displayed on alert screen, and a alert message depending on the traffic condition is displayed. On detection of vehicles at restricted area, alert screen displays warning messages. This process is a purely programming concept, can be extended to other traffic event detection process.

Figure 4.5 Alerting users on detection of vehicles



V. Conclusion

As shown in above sections, haar training and event detection programming can be implemented to produce a high performance and robust traffic event detection system using the localized traffic image data. And as the haar training creates the cascades depending on number of training samples used, it is suggested to use more data as possible as so that the system becomes robust to avoid any false positive results. As proposed system gives a base for detecting vehicles from traffic cameras, one can further extend the system to detect more events and can contribute to a safe traffic.

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