VOL. 11, NO. 24, DECEMBER 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

CHARACTERIZATION OF NUMBER PLATES THROUGH DIGITAL IMAGES

DBK Kamesh[1], K. Sudhatri[2], S. Ravali[2] and JKR Sastry[2]
[1]St. Martin Engineering College, Dullapally, Hyderabad, India
[2]Kuala Lumpur University, Vaddeswaram, Andhra Pradesh, India
E-Mail: kameshdbk@gmail.com

ABSTRACT

One of the most important aspects of traffic management system is to track the moment of the vehicles on the roadways. Tracking requires identifying a vehicle which is generally recognized through number plates attached to a vehicle while the location of a vehicle can be known through longitude and latitude. Digital cameras can be used to scan the images of the number plates while the vehicle is on the move. From the images one can extract the number plate and characterize the same into data equivalent. In this paper, a method of scanning the images of number plates connected to the vehicle are taken through a digital camera from a fixed position having both rotational axis considering that the vehicles are on the move and are positioned at the signal post in variable angles. The paper also presents a method of extracting the number plate characters form the scanned images.

Keywords: traffic management, image processing, smart cities, intelligent systems.

1. INTRODUCTION

Resolving an image involves capturing, area for storage, manipulation, and display of images. In graphical image resolution, the emphasis is upon the manipulation of the images to be capable of achieving special results through rotating, stretching, hazy, resizing, twirling, and producing the unique image. A basic image resolution system shown in Figure-1 can be portrayed being a cascaded system in which input signal is optical flux from a target and background and the output is a picture presented for individuals' consumption.

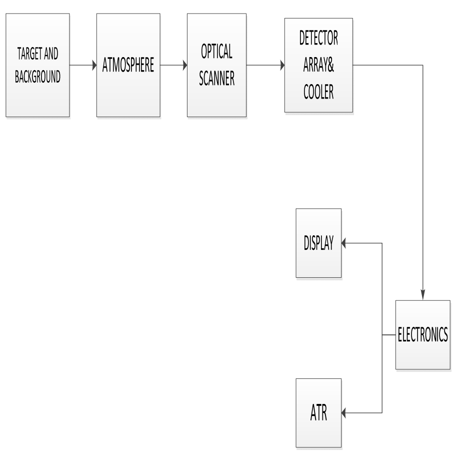

Figure-1. Basic imaging program.

The standard imaging system commences with all the flux leaving the target plus the background. The system can also commence with the illumination of the target with exterior sources. The flux giving the source traverses the atmosphere following the path that includes blur by turbulence and scattering and a reduction in the flux due to atmospheric extinction, just like scattering, and absorption, and others. The flux that makes it towards the access of the optical technologies can then be blurred by optic diffraction and aberrations. The flux is also decreased by optical transmissions. The flux is imaged on to a detector array, both by scanning or staring. Here, the flux is changed from photons to electrons. There is quantum performance that reduces the transmission, and the finite size in the detector imposes a blur on the photo. The electronics further decrease, or in some different cases enhance the indication. The display also gives a signal reduction and a blur, because of limited size of the screen element. Finally the graphic reaches the eye. In some cases the outcome with the electronics is prepared by an automatic target recognizer (ATR), which can be an automated means of discovering and recognizing targets. Even more common procedure is an aided target recognizer (AiTR), which can be more of a cueing process.

The wide development of individually distinct devices such as scanners and digital video cameras lead to image processing a practical reality. Images obtained through readers and a camera involves significant noise or blur leading to reduction received image. Employing image processing is successful for removing these limitations.

Increase in population and growing vehicle ownership especially in the URBAN AREAS leads to increased demand of traveling and the number of vehicles moving on the streets. Today the time required to travel has become one of the major problems due to increased density of URBAN people and the number of vehicles moving on the steer network. Traffic of commuting vehicles on road ways is one of the Major concerns. Traffic control is one of the essential issues that involve people with expertise and experience. The Traffic control and management requires collection of data such as number of cars, speed of movement of the vehicles, traffic flow etc.

Traffic surveillance systems have played a significant role in transportation improvement. Automatic data collection and analysis lead to intelligent optimal control of the traffic Image processing is used for extraction of traffic parameters such as volume, the amount of cars passing, speed, length between vehicles in a row, queue length and traffic.

Imaging cameras having a suitable image control provides the support required to recognize the number plates. Digital cameras can be installed en-route the traffic through which sizable number of car photos are recorded every instant by a camera. Scanning the number plates of the vehicles moving in a great speed involves fixing the number plate in a frame and scanning the image at a rapid speed. The dimensions of the frame should end up in enclosing a number plate without overlapping and edge cutting. Entire number plate must be contained within a frame and should not be cutting anything out of it.

Collected data and the speed of transferring data to central location is one of the most important part of image processing. A simple method could be just scanning the image, processing the image to a small extent and transmitting the image to a large processing location whether the number extraction algorithms can be employed. This kind of a system requires heavy band with for transmission of the images. The speed of imaging has to match the speed of processing the image and transmission of the same. Luckily the current day digital cameras have got the capacity to locally store more number of images. The ability to simultaneously process and transmit more number of images is the challenge to be inbuilt into a small device like digital camera.

The number plate of a motor vehicle is the most appropriate informational source for authentication. Vehicle plate recognition strategy should be a fully automated program that extracts cars plate number using image processing by handling passing vehicles from a single place. This kind of a system does not require any kind of additional gadget to be connected on to the vehicles. Extracting the vehicle numbers involve localizing the region of number plates and characterizing the number involved in the extracted number plate image.
Imaging systems can be effectively used for traffic monitoring and controlling either from local or from remote locations. Many challenges have to be addressed in using the imaging systems for traffic monitoring and controlling.

The positioning of the camera has to be well-defined such that the total 360° view is covered and the image of every vehicle passing through is captured. Capturing exact images of the number plates is difficult as the vehicle move with variable speeds. Alignment of the camera to place the number plate in the camera frame without overlapping is the most complex a system is. Detecting the number plate is much more complex in the presence of photo blocker spray. Cameras should be able to function even in the presence of photo shield cover. Cameras should be able to withstand various environmental conditions like high temperature, rainfall, humidity, etc. The camera must be efficient enough to capture the image in the presence of dense fog or snow-like situations. Photo-blocker sprays and photo shield cover in the presence of flashes make it a little difficult for the installed cameras to detect during night times when the headlights and streetlights are working. A careful interpretation of the number plate has to be done.

2. RELATED WORK

Vibha. L *et al.* [1] suggested a real-time segmentation of moving regions in image sequences as a fundamental step in many vision systems including automated visual surveillance and human-machine interface. In their paper they presented a framework for detecting some important but unknown knowledge like vehicle identification and traffic flow count. The objective is to monitor activities at traffic intersections for detecting congestions, and then predict the traffic flow which assists in regulating traffic.

Osman Ibrahim *et al*., [2] proposed a new Speed Detection Camera System (SDCS) that is applicable as an alternative to radar. It uses several image processing techniques on video stream in online captured from single camera or offline mode, which makes SDCS capable of calculating the speed of moving objects avoiding the traditional radars problems. SDCS offers an inexpensive alternative to traditional radars with the same accuracy or even better. It can be divided into four successive phases.

Naveen Chintala cheruvu *et al*., [3] presented a Video based vehicle detection technology which is an integral part of Intelligent Transportation System (ITS), due to its non-intrusiveness and comprehensive vehicle behavior data collection capabilities. An efficient video based vehicle detection system based on Harris-Stephen corner detector algorithm has been proposed. The algorithm was used to develop stand-alone vehicle detection and tracking system that determines vehicle counts and speeds at arterial roadways and freeways. A system was developed to eliminate the need of complex calibration, robustness to contrasts variations, and better performance with low resolutions videos. The performance of the system proposed is equivalent or better compared to a commercial vehicle detection system. Using this vehicle detection and tracking system, an advance warning intelligent transportation system was designed and implemented to alert commuters in advance, the speed reductions and congestions at work zones and special events. The effectiveness of the advance warning system was evaluated and the impact was discussed in their paper.
Kannan Subramanian *et al.,* [4] presented a paper on number plate detection with application to electronic toll collection system. They described a new approach of tagging number plate for collection of toll within Automated Toll System. In this system they detect the location of number plate of vehicles with the help of template matching and extract number from number plate and process it for collection of toll. The number plate is tagged in the database with the user's personal information, bank account and vehicle details. Toll is automatically deducted from users' bank account or credit card and notification is provided to the user by sending SMS or email. Users have to follow standard rules for number plate design prescribed by the toll. Manual toll facility will be provided for unregistered vehicles and in

ARPN Journal of Engineering and Applied Sciences

case of system failure. This system can be implemented in different places such as Clubs, Restaurants, Companies, Parking areas etc. The algorithm proposed by them uses three steps which include vehicle number plate extraction, character segmentation, and optical character recognition.

Akash Kannegulla *et al*., [5] stated that thermal imaging is a concurrent technology used in many applications like power line maintenance, surveillance and intelligent transportation systems. They focused on traffic control and surveillance using thermal imaging cameras. With the combination of two powerful technologies- thermal imaging and image processing, a very accurate measure of traffic density has been achieved, unhindered by any environmental factors like low visibility due to fog or darkness, or other stray objects like animals or humans. The simulations of the gray scale thermal images captured are performed in Mat lab, using which the exact count of vehicles on the road is obtained. They not only presented a novel method for speeding up traffic flow, but also overcome the limitations of existing techniques like implementation costs and precision in determination of traffic density.

Heba A. Kurdi [6] expressed that traffic congestions occur when travel demands exceeds the capacity. However, it is impractical to build more roads and infrastructure to accommodate these demands. Governments are increasingly recognizing the importance of traffic control tools, such as Closed Circuit Television (CCTV) systems as a feasible solution to mitigate the traffic congestion problem. CCTV systems are deployed across city centers, motorways, trunk roads, car parks etc., to collect diverse data on large regions where manual observation can be difficult, problematic or unfeasible. By processing this data, which contains video images of traffic parameters, useful information can be extracted, including speed, traffic composition, vehicle shapes, vehicle types, vehicle identification numbers and occurrences of traffic violations or road accidents.

S.Lokesh *et al.,* [7] stated that with the increase in population, the usage of vehicles has been increasing and controlling of traffic is one of the challenging works. Frequent traffic jams at major junctions call for an efficient traffic management system in place. The resulting wastage of time and increase in pollution levels can be eliminated on a city-wide scale by these systems. Previously the traffic control techniques used magnetic loop detectors, induction loop detectors buried on the road side which provide limited traffic information and require separate systems for traffic counting and for traffic surveillance. Major proposal is to implement an artificial density traffic control system using image processing and Raspberry pi. The hardware that includes webcam, PC, Raspberry pi and the software that includes OCCIDENTALIS and MATLAB has been used.

Lohit Ujjainiya *et al*., [8] expressed that highway obstacle detection is one of the most challenging task in real time for automated vehicle navigation system. The basic idea is to design an effective system for real time environment, which detects the presence of obstacles in the track of the vehicle. Raspberry Pi Camera module has been employed for object detection and image acquisition. A thorough investigation is performed on a test image in order to validate the best algorithm suitable for edge detection of images. Sufficient analysis is performed to consolidate the results.

V. Parthasarathy *et al.*, [9] presented a prototype for real time image processing for smart automation of traffic signal system for density estimation and emergency vehicle detection such as ambulance. It is implemented by detecting the emergency vehicles and density of the traffic simultaneously there by controlling the traffic signals based on the priority outcome. Density of the traffic is detected by installing IR detectors along the side lanes. The main aim is to control traffic signals with the help of surveillance camera present at junction points.

Amirhassan Najjar *et al*., [10] stated that image processing is a collection of operations and processing done in order to analyse images in different fields. The use of image processing technology for controlling traffic has been presented. Urban traffic surveillance systems have played an important role in improving transportation in the recent years. Automated analysis of traffic and intelligent control and optimization are the new important outcomes of the systems. Traffic controlling through image processing using traffic cameras led to the growth of multi-purpose traffic cameras in several countries across the world. A traffic control cameracan be installed at crossroads within traffic lights. Algorithms for speed detection, license plate recognition have been presented and the performance of the same has been evaluated and presented.

3. ANALYSIS OF EXISTING IMAGING SYSTEMS USED FOR TRAFFIC MONITORING AND CONTROLLING

The current technology associated with traffic control is induction loops, Microwave Radar, Infrared Sensors; video detection etc. Induction loop consists of a loop of wire and an electronic detection unit. The principle is based on metal detection and relying on the fact that a moving metal will induce an electrical current in a nearby conducting wire.

A vehicle detector on the road way closes the loop and the object is detected. A typical induction loop system that can be used for imaging from the perspective of traffic management is shown in the Figure-2.

ARPN Journal of Engineering and Applied Sciences

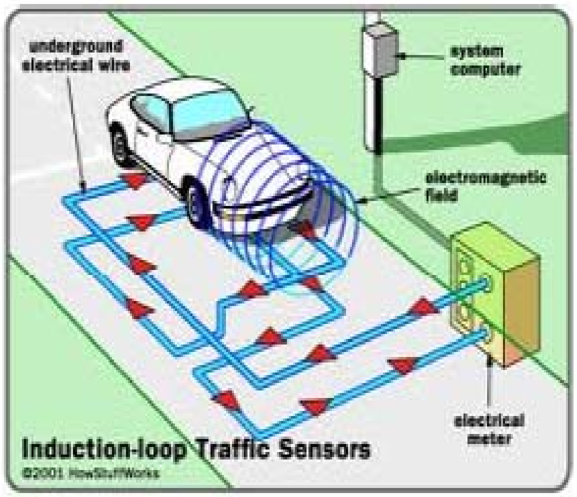

Figure-2. Induction loop.
(Source: Traffic control by digital imaging cameras)

Vehicle Detection loops are being used to find vehicles passing in a specific area such as signal post locations. An insulated, electrically conducting loop is mounted in the pavement. The electronic unit transmits signals frequencies in the range of 10 kHz to 200 kHz according to the model. The inductive-loop system behaves as a tuned electrical circuit in which the loop cable is considered as the inductive element. When a vehicle passes over the loop or is ended over the loop, eddy currents are induced inside the wire loops, which in turn decrease their inductance. The decreased inductance actuates a relay or generates a solid-state optically separated output which sends a pulse to the traffic signal controller signifying the passage or occurrence of a vehicle.

Radar is an object-detection system which uses radio waves to determine the range, direction or speed of objects. It can be used to detect motor vehicles. The radar antenna transmits pulses of radio waves which bounce off any object in their path. The object returns a small part of the wave's energy to the receiver antenna which is usually located at the same site as the transmitter. The basic use of the traffic radars is the measurement of the speed of the vehicle. Traffic radar calculates speed from the reflections it receives. As the car approaches, near the radar one can here high pitch sound of the car horn. The instant the car passes and begins to move away a lower pitch sound is heard. The car makes the same sound when horned by the driver but, for a stationary listener, the speed of the car adds to the pitch of its sound as it approaches and subtracts as it departs. This change from true pitch is called the Doppler shift, and the magnitude of the change depends upon the speed of the car. The Radar compares the shifted frequency of the reflection to the original frequency of the beam it sent out and from the difference it calculates speed. Figure-3 below shows microwave radar detecting the speed of the vehicle.

Figure-3. Microwave radar.

Effective and passive infrared sensors are made for traffic monitoring applications. Active infrared sensors illuminate detection specific zones with low power infrared energy transmitted by laser light diodes operating in the near infrared region of the electromagnetic spectrum. A portion of the transmitted energy is reflected or scattered by the vehicles again towards the sensor. The diodes operated in the near infrared spectrum at 880 nanometers (nm). The signal modulation prevented distraction from other sources of infrared energy, including sun light. Two transmitter-receiver systems are used to test the speed and another transmitter-receiver measured the height of the vehicle. When trucks susceptible to rollover or jack knifing were encountered, flashers were activated to warn individuals to reduce speed.

Passive sensors do not transmit energy; they detect energy emitted from vehicles, road surfaces, and other objects in their field-of-view and also the energy emitted by the atmosphere and reflected by vehicles, road surfaces, or other objects into the sensor aperture.

The energy captured by infrared sensors is focused by an optical system onto an infrared-sensitive material mounted at the focal plane of the optics. This material converts the reflected and emitted energy into electrical signals. Real-time signal processing is used to analyze the signals for the presence of a vehicle. The sensors are mounted overhead to view approaching or departing traffic. They can also be mounted in a side-looking configuration. Infrared sensors are utilized for signal control, volume, and speed.

Video detection is based on real-time image processing providing efficient wide-area detection well suited for registration of incidents on roads and in tunnels. Connected to traffic controllers, the application can also be used for vehicle detection at signalized intersections where it is difficult or expensive to install inductive loops. Video-detection systems are also considered non-intrusive. It uses a vision processor to analyze real-time changes in the image. In this system, cameras called image sensors capture images and provide a video signal to the vision processor. The video signal is analyzed and the results are recorded. Video image detection is one of the leading alternatives to the commonly used loop detectors. It is progressively being used to detect traffic intersections and interchanges. This is because video detection is often cheaper to install and maintain than inductive loop

ARPN Journal of Engineering and Applied Sciences

detectors at multi-lane intersections. Video detection is also more readily adaptable to changing conditions at intersections. This is one of the biggest advantages of video image detection. It provides traffic managers with the means to reduce congestion and improve roadway planning. Additionally, it is used to automatically detect incidents in tunnels and on freeways, thus providing information to improve emergency response times of local authorities.

Traffic management and information systems depend mainly on sensors for estimating the traffic parameters. In addition to vehicle counts, a much larger set of traffic parameters like vehicle classifications, lane changes, etc., can be computed. One such application is closed-circuit television cameras which are becoming increasingly common on freeways andare used for traffic management. These cameras allow operators to monitor traffic conditions visually. As the number of cameras increase, monitoring each of them by operators becomes a difficult task hence videos are recorded and as such, the videos are usually only monitored after an event of interest such as an accident occurred within a particular camera's field of view. With suitable processing and analysis (Figure-4) it is possible to extract a lot of useful information on traffic from the videos, such as the number type and speed of vehicles commuting on the road. To perform the task, segmenting the video into foreground objects of interest (the vehicles) and the background (road, trees) is required. Advantage of segmenting the video into foreground and background reduces the data rate.

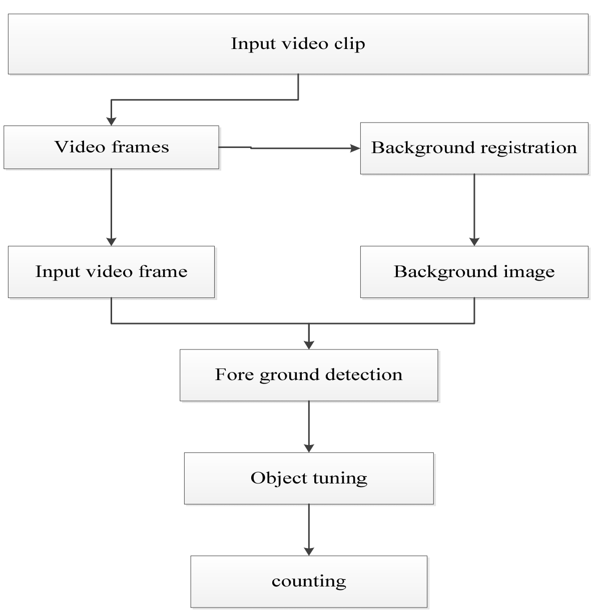

Figure-4. Traffic related information processing through a CCTV.

The tracked binary image mask forms the input image for counting. This image is scanned from top to bottom for detecting the presence of an object. Two variables are maintained which include count that keeps track of the number of vehicles and another count which contains the information about the registered object. When a new object is encountered it is first checked to see whether it is already registered in the buffer, if the object is not registered then it is assumed to be a new object and count is incremented, else it is treated as a part of an already existing object and the presence of the object is neglected. This concept is applied for the entire image and the final count of objects is present in variable count. A fairly good accuracy of count is achieved. Sometimes due to occlusions, two objects are merged together and treated as a single entity. Several types of CCTV cameras are in use such as Gatso. Trivelp, Truvelo D. speed spike. Specs, Traffic master, Traffic master, vector, Speed curb etc. These cameras are capable of sensing information about the commuting vehicle which includes speed, number plate recognition, and the image of the vehicle.

Smart Video Surveillance Software (SVSS) uses a methodology (Figure-5) that requires huge database storage in order to run the system smoothly. It is a collection of data for the surveillance system. SVSS classifies data as bibliographic, full-text, numeric, and image. SVSS has two main types of database which are an event database and a Video Database.

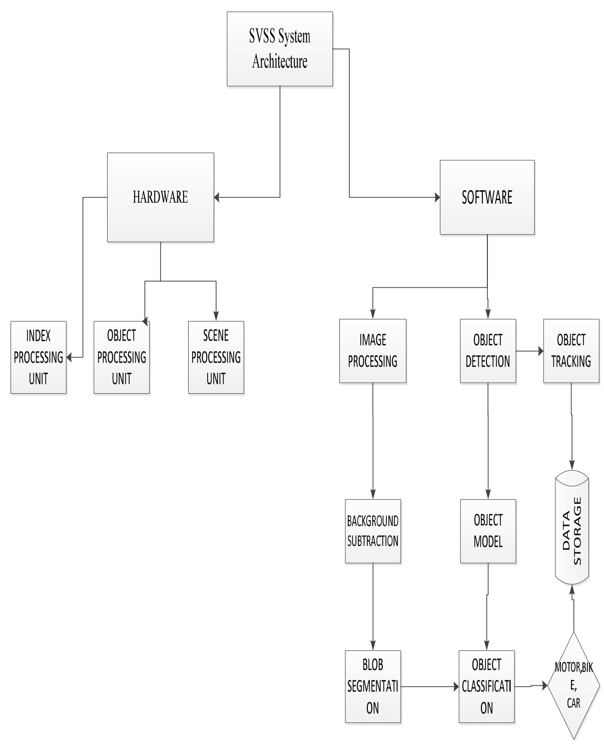

Figure-5. SVSS software architecture.

Speed Detection Camera System using Image Processing Techniques on Video Streams sues four phases for processing. First phase is Object detection phase, which uses a hybrid algorithm that combines an adaptive background subtraction technique with a three-frame differencing algorithm that eliminates the major drawback of using only adaptive background subtraction. The second phase is Object tracking, which consists of three successive operations for object segmentation, Object labelling, and Object counter extraction. Objects tracking operation takes into consideration different possible scenarios of moving objects like Simple tracking, vehicle entering and leaving, object crossing, one object entering and another object leaving etc. In the third phase, speed of the vehicle is calculated using the number of frames consumed by the object to pass-by the scene. The final phase is Capturing Object's Picture phase, which captures the image of objects that violate the speed limits. Several types of cameras are used for achieving different requirements of a traffic management system. The details of the features of the cameras are shown in Table-1.

In the case of Sound Based CCTV Systems, sound is recorded constantly accompanied by the video on a memory unit. When the system hears an unusual sound, for instance a "crash-like" sound, the pre- and post-accident recorded scenes are sent from the memory to the controller automatically. The controller analyses the situation and identifies possible causes. This system was developed by Mitsubishi Electric Company which is titled Traffic Accident Auto Memory System (TAAMS) / Auto Incident Recording System (AIRS). Its first use was in Japan and then it was widely adopted in the USA. However, it seems like the amount of work available in this approach is still lacking when compared to image-based CCTV systems. Image-based CCTV systems have the ability to recognize unusual and abnormal events on roads by analyzing digital images and extracting traffic parameters such as speed and traffic composition. Special software tools are usually used to help in recognizing vehicle shapes, vehicle types, vehicle identification numbers and occurrence of traffic violations or road accidents.

Table-1. Caparison of features of the cameras.

Serial Number	Name of the camera	Features
1	GATSO	Vehicle imaging (400 images / Sec), Ability recognize types of vehicle (VAN/CAR)
2	Truvelo	Measure speed using infrared flash light
3	Specs	Number plate recognition through use of two cameras fitted with infrared illuminators on the gantries
4	Peek	Uses radar technology, uses rare facing, detects speed, image capturing

4. COMPARATIVE ANALYSIS OF IMAGING SYSTEMS

The comparative analysis of imaging systems from the perspective of application requirements is shown in Table 2 and from perspective of technology used is shown in Table-3. From Table-2 and Table-3, it is inferred that the imaging system “Vector” meets about 60% of requirements related to traffic management system. The following are the features of the VECTOR system.

Detailed features of vector system

- Measures the average speed of the vehicle between two or more locations.
- Uses ANPR (Automatic Number Plate Recognition).
- Can be used for:

- Bus lane enforcement
- Level crossings
- Red light enforcement
- Yellow box violations
- Tolling
- Access control
- Congestion charging
- Parking Management
- Can enforce speed limits on dual carriageways and roads with bidirectional travel.
- Can be located at the side of the road or at the central reservations.
- Needs to be located at regular intervals to operate a managed speed control zone.
- Can record date and time which can be used as photographic evidence.
- Don’t use film so there is no limit on number of images that can be captured.
- Can be installed on traffic signals, street lights, gantries and bridges.
- Consists of two cameras, housed within one unit such that two lanes of traffic can be monitored.
- Images can be transmitted by communications media or can be stored in the local high capacity memory.
- Can record Vehicle registration number, time, date and camera location.
- Other features of this camera include GPS clock, compass, accelerometer and two light sensors.
- Can work in all weather and lighting conditions (day and night) and can catch speeding vehicles up to the maximum speed 100km/Minute.

A typical vector camera is shown in the Figure-6.

Figure-6. VECTOR camera.

VOL. 11, NO. 24, DECEMBER 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

5. COMPOSITE SYSTEM

A composite Imaging system, however is required that is capable of recognizing the number plates, traffic density assessment, speed detection, image based accident capturing, vehicle tracking and transmission of data to the control station. 60% of theses requirements can be met by Vector Camera. Different sensor / devices are to be used for including all those features that cannot be met by the VECTOR cameras. The Vector camera and a set of individual sensors / cameras provide an integrated solution. The integration of these devices can be achieved through a separate embedded board. Raspberry pi board has been selected for integrating the camera and other devices. Raspberry pi board has excellent native support for cameras. The integration of VECTOR and other functions through Raspberry board is shown in Table 5. In the integration model vector camera is used for capturing images. These images are sent to the Raspberry pi board which processes these images further using different protocols. The processed images are sent to the control stations using on-board Wi-Fi, Cellular, Micro wave or satellite communication systems. Video can be displayed using the HDMI port. The integration of vector cameras with other devices meant for sensing and communicating is shown in Figure-7.

The 40% of our requirements that are cannot be met by the Vector imaging system include Traffic density assessment, Accident capturing, Vehicle tracking. Density Based Traffic Control System is achieved through implementing process that separate image regions corresponding to objects. By identifying common properties, an image is segmented into various regions. Contours are identified by identifying differences between regions. The simplest property that pixels in a region can share is intensity. So, a natural way to segment such regions is through thresholding, the separation of light and dark regions. Thresholding creates binary images from grey-level ones by turning all pixels below some threshold to zero and all pixels about that threshold to one.

A camera is used to detect and capture images. These images are saved in system memory of Raspberry pi and basic edge detection operations are performed on the test images captured by the camera. Open CV(open source computer vision) serves as the interface on which edge detection algorithms are allowed to run and perform basic image processing functions. The Open CV provides several inbuilt libraries for image processing.

Vector system is located at the side of the road or at the central reservations. Cameras need to be located at regular intervals to operate a managed speed control zone. The vector speed cameras can be installed on traffic signals, street lights, gantries and bridges. These cameras record date and time stamp which can be used as photographic evidence. Vehicle registration number, time, date and camera location are recorded. On linking one vector camera with the other we can almost trace the route taken by a vehicle.

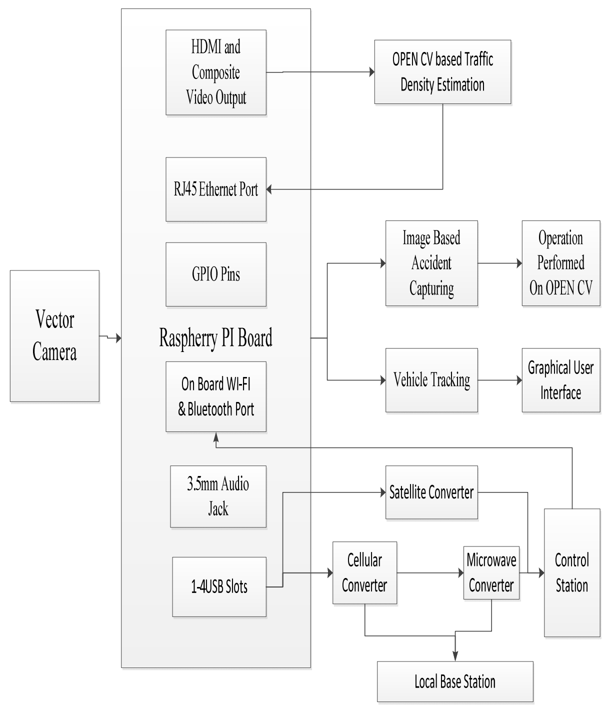

Figure-7. Raspberry pi board based model.

6. CONCLUSIONS

Composite Imaging system enables tracking of the number plates of vehicles, traffic density assessment, speed detection, image based accident capturing and vehicle tracking. Imaging systems must receive inputs from camera through various communication interfaces, protocols and methods. A simple composite system presented in this paper presents every aspect of imaging at economical cost. The composite system is quite suitable for implementing within smart city environment. The additional features are implemented through software requiring least cost and no hardware as such has been used.

Table-2. Comparing imaging systems from the perspective application requirement.

Future	Cameras				
	Gatso	**Truvelo D**	**Speed Curb**	**Vector**	**Speed Spike**
Positioning Camera	Poles	Poles at side	Poles at side	Traffic signals, street lighting columns, gantries, bridges	Traffic street lighting columns
Locating the region of Number Plate	NA	NA	NA	Yes	YES
Image resolution	20MP			1280x1024	1280X1024
Image Size	4:3				
Ability to image the number plate when the vehicle is in movement	Yes	YES	YES	Yes	YES
Ability to image the number plate when the vehicle is in different directions of movement	No	YES	YES	Yes	YES
Ability to communicate using different communication protocols with long range devices	2xGige,wifi 802.11b/g/n	ADSL/ 3G	PSTN,IS DN ADSL	Ethernet, HSPA,GPRS, SMS, WIFI, GPS	GPRS (ADSL)
Rotational capacity of the camera	NA	180 DEG	180 DEG	180 DEG	180 DEG
Ability to transmit the Longitude and Latitude of the camera and the vehicle	No	Yes	Yes	Yes	YES
Ability to store and forward Images	2xusb, 1xeSeta	ADSL/ 3G	DVD	RAM, SD, FLASH	RAM,SD,FLASH

Table-3. Comparing imaging systems from the perspective of technology used.

Parameters	Cameras				
	Gatso	**Truvelo D**	**Speed Curb**	**Vector**	**Speed spike**
Technology Used	Radar	Piezo Sensors	Sensors on Road Surface	Infrared	Infrared illuminators
Facing	Rear	Front	Rear	Side	
Flash	Powerful Flash	Infrared Flash		Infrared Flash	Infrared flash
Film	Reel of Film		No Film	No Film	No film
Communication Interfaces supported	2xGige,wifi 802.11b/g/n	ADSL/3G	PSTN,ISDN ADSL	Ethernet, HSPA,GPRS, SMS, WIFI, GPS	GPRS (ADSL)
Image resolution	5120x3840P			1280x1024	1280x1024
Number of degrees of rotation of the camera	0 deg		180 DEG	180 DEG	180 DEG
Image Compression	JPEG	JPEG	JPEG	JPEG	JPEG
Image formats supported	JPEG, JPEG 2000	JPEG	JPEG	JPEG	JPEG
Automatic positioning of the camera facing the number plate	YES	YES	YES	YES	YES

REFERENCES

[1]. Vibha L, Venkatesha M, Prasanth G Rao, Suhas N, P Deepa Shenoy, Venugopal K R, L M Patnaik. 2008. Moving Vehicle Identification using background registration technique for Traffic Surveillance, IMECS.

[2]. Osman Ibrahim, Hazem El Gendy, and Ahmed M. El Shafee. 2011. Speed Detection Camera System using Image Processing Techniques on Video Streams. International Journal of Computer and Electrical Engineering. 3(6).

[3]. Naveen hintalacheruvu, VenkatesanMuthukumar. 2012. Video Based Vehicle Detection and Its Application in Intelligent Transportation Systems, 2012, Journal of Transportation Technologies. 2(1): 305-314.

[4]. Kannan Subramanian. 2013. Number Plate Detection with Application to Electronic Toll Collection System. International Journal of Innovative Research in Computer and Communication Engineering. 1(1).

[5]. Akash Kannegulla, A. Salivahana Reddy, K V R Sai Sudhir, Sakshi Singh. 2013. Thermal Imaging system for precise traffic control and surveillance. International Journal of Scientific & Engineering Research. 4(11).

[6]. Heba A. Kurdi. 2014. Review of Closed Circuit Television (CCTV) - Techniques for Vehicles Traffic Management. International Journal of Computer Science & Information Technology (IJCSIT). 6(2).

[7]. S. Lokesh, T. Prahlad Reddy. 2014. An Adaptive Traffic Control System Using Raspberry PI. International journal of engineering sciences and research technology.

[8]. LohitUjjainiya and M. KalyanChakravarthi. 2015. Raspberry - pi based cost effective vehicle collision avoidance system using image processing, ARPN Journal of Engineering and Applied Sciences. 10(7).

[9]. V. Parthasarathi, M. Surya, B. Akshay, K. Murali Siva and Shriram, K. Vasudevan. 2015. Smart Control of Traffic Signal System using Image Processing. Indian Journal of Science and Technology. 8(16): 64622.

[10]. AmirhassanNajjar, HamidrezaGhaffary. 2015. Image Processing Application in Traffic Control. International journal of Reviews of Life sciences. 5(3): 351-355.