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CENTRALIZE URBAN TRAFFIC MONITORING SYSTEMS AND ITS BIG DATA HANDLING

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ABSTRACT
With rapid growth of urban population and increasing number of vehicles on roads Traffic Controlling becomes an important problem to resolve. Solution for this not only saves lot of time but also increases economic growth in terms of fast logistics deliveries, business facilities and decreases energy consumption. Traffic monitoring can be made intelligent by use of computer vision techniques to detect vehicles type, colour, number plate, traffic rule violations, events detection and counting of vehicles automatically. Broader aerial view of cities traffic from Satellites or any other source can perform important task in finding congestion and decision taking. Autonomous driving is a future of transportation, so V2V communication and understanding of its protocol should be a part of urban traffic monitoring. In this paper we have proposed an integrated system of all these systems with one central controlling point with parallel processing facility. We used Apache Spark as big data processing software to analyse big data generated from multiple sources. In the end some useful quires to access important information from stored data are provided and the execution time proves fast access of data by using proposed system.
KEYWORDS: Traffic Big Data Analysis; Urban Traffic Monitoring; Congestion Detection; Intelligent Traffic Monitoring

INTRODUCTION

Traffic monitoring should intelligent enough to control congestion son roads. Unfortunately it is becoming worst day by day. Travellers' waste their lot of time on roads. No one likes traffic congestion and don't want to stuck in it. According to Tom traffic index everyone on road has to spend 59%extratimeduetotrafficcongestionandthisfactoris increasing [1].World is progressing very fast, challenges of traffic control systems can be solved by intelligent monitoring. Intelligent monitoring can efficiently utilize roads. These will save time and money. To achieve this goal there should be a system which can operates from one central point and can monitor maximum area of city. It can predict traffic congestion by knowing traffic volume and capacity of that road in real time. That system can provides convenient path for drivers and can intelligently detect events, for example in case of accidents or wrong driving system should detect it automatically and passed that information to traffic police and concerned services.

Currently there are plenty of methods available for traffic controlling. Video based monitoring and detection by using image processing algorithms is very common. Image processing can be applied on real time video, many tasks can be performed e.g. counting of vehicles, number plate detection, colour and type detection, driver's information, congestion detection etc. In modern cities security cameras and CCTV are already installed, which can be used in traffic monitoring as well. In vision based traffic controlling important task is to detect or predict traffic congestion timely, so that system can warns the incoming traffic to take alternates route.

Vision based system can detect and track a vehicle in real time which can be helpful for security purposes, in case of criminal activities. In modern cities video based monitoring to prevent from criminal activities is essential. It can keep a watch on public points like airports, railway stations, bus station sand road network. Law enforcement agencies are installing CCTV cameras network to cover more and more area of modern cities. Traffic monitoring can be very helpful in investigation of criminal activities. Criminal scan be tracked in videos of traffic controlling cameras. Furthermore automatic detection of traffic rules violations increases traffic efficiency and makes traffic more disciplined on roads.

Large amount of details produced everyday by traffic monitoring systems. Modern cities have more than ten thousand of video cameras installed to monitor traffic efficiently. A cityshouldkeep12months of traffic data to make record which would be useful in solving criminal cases and economical investigations. Traffic data is growing 60 percent per year [2]. It is forcing to store data for shorter period or otherwise increases the data storage capacity. There is a need to access that big data efficiently in terms of accuracy and time. Big data processing software can be helpful in this case, because it requires less to rage space and can produces fast results.

Traffic congestion can be controlled efficiently when there is abroad view of traffic. From Satellite video, it can be easily detected where is traffic congestion and what is complexity of that traffic. Satellite view can provides integrated picture of city traffic. In a single view, it can be easily detected where is traffic congestion. Cellular service can be used to acknowledge a vehicle about its traffic behaviour or violation of traffic rules in real time. Similarly, system can guide that vehicle about its convenient path.

Our proposed method is integration of traffic cameras, CCTV, satellite system, road side and vehicle sensors and cellular system to work together and to be controlled by a central point with distributed processing. There is huge amount of data generated by these sources, so need of a big data handling software. Apache Spark is fastest Big Data processing software. It is 100 times faster than Hadoop [3]. Apache Spark is a fault-tolerant platform. It replicates and distributes data across Spark cluster. This system provides parallel processing, which takes less time to access images and videos on a distributed system. Intel Corporation already works with Trust way Ltd and using Hadoop system. In that system Trust way can access 2.4 billion number plates of data in just 10 seconds to analyse collision [2].In our proposed system Apache HB as is used as data base, it solved the theoretical and practical limitations of a relational data bases. Block representation of proposed system is in Figure 1.

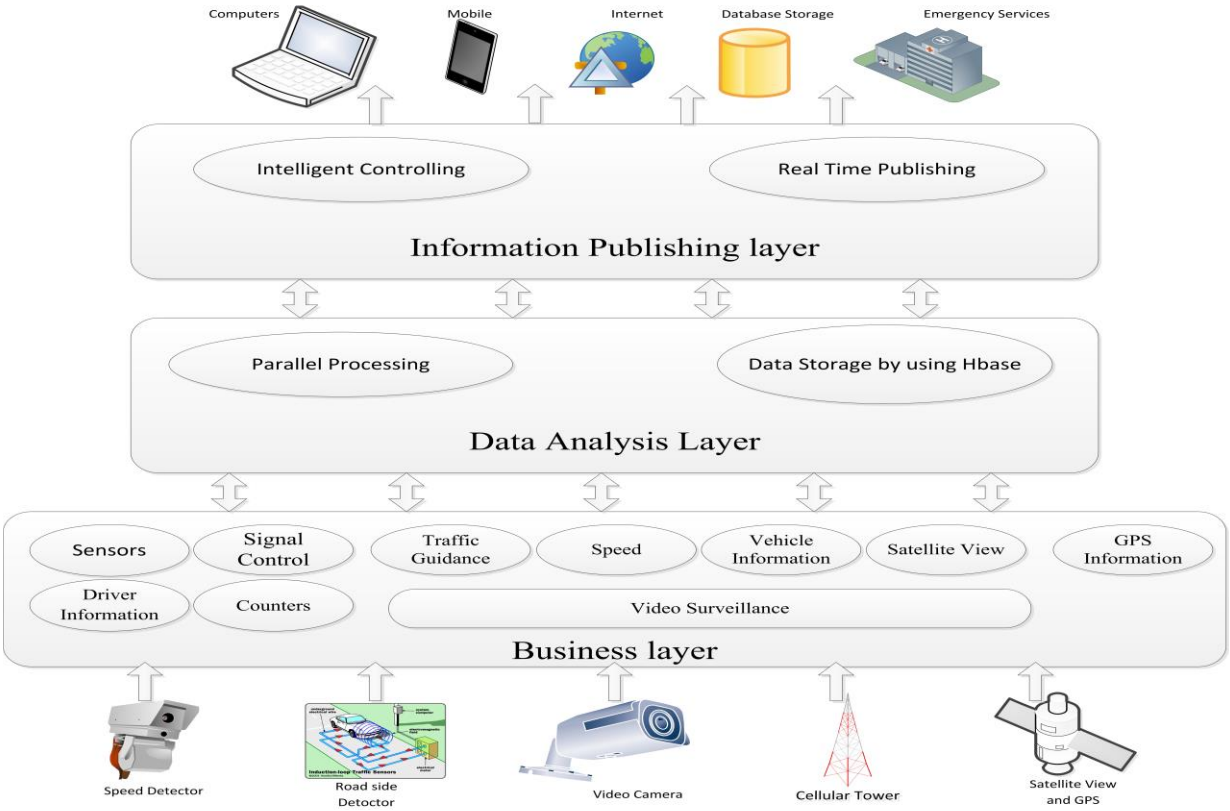


Figure 1: Main Block Diagram of proposed system

There are three layers (1) Business Layer (2) Data Analysis Layer and (3) publishing layer. The basic is business layer, it handles data from all sources and provides this to data analysis layer. Its main task is the storing and handling of data. It collects data from various source units, and converts that data in to business form, which can be easily accessible to other layers. Data source units consist on traffic video surveillance system, signal control system, GPS vehicle tracking system, driver information management system, traffic guidance system, vehicle to vehicle management system, Road side sensors management system. Cloud computing can be implemented on this layer.

Data analysis layer is responsible for better data storage techniques and advance mathematical models to accomplish fast and efficient analysis of data. In our proposed system data analysis layer handle big data generated from multiple traffic controlling units. This layer provide its information on real time and can be publicly accessible at any time, for example degree of road congestion, road saturation, average speed of traffic flow, interrupt rate, occupancy rate. This layer can predict congestion and provides its information to publication layer as congestion warnings on different sites, navigational systems etc. Data analysis layer is built on Apache Spark, Uses common hardware which is easily available in markets. Linux operating system is used to provide fast processing to Apache Spark [4].

Information publishing layer is responsible to publish its data publicly. It is very common now to use navigation system while driving; there are city management sites on which traffic data should be published. Our system can provide its data to these systems as authentic information. With autonomous advancement in transportation industry, our proposed system will act as useful information source for autonomous driving.

RELATED WORK

Currently there are multiple techniques available for traffic controlling such as inductive loop detectors[5], infra-red Detectors [6],radar detectors [7] and vision based systems. Vision based systems are very popular now a days, because of versatility in their work, some high level projects includes PROMETHEUS [8], VSAM [9],ADVISOR [10]are using vision based system.

Google Traffic is a feature on Google Map which tells about traffic condition. There is coloured routes available on this features, red describes traffic congestion blue describes suitable path[11]. This application takes its traffic information from its users. So accuracy is not so efficient and its information are not authentic and mostly delayed. Detail about this can be accessed from here[12]Traffic safety is very important issue, most of accidents are happened on roads inter sections[13]. Inter sections on Highways are more dangerous because of high speed traffic. U. S. Department of Transportation provides statistic sofa decade (1998and2007), in which accidents on inter sections exceeded 90,000[14].European Road Safety reveals statics of causalities in 2002to2013,is more than 100 thousand only at inter sections of roads [15],[16].According to European Union traffic monitoring systems, fatalities at inter sections are slightly equal to 20% of all cases [17]. In 2013 in European Union, more than 5 thousand people were killed on inter sections because of road traffic accidents [18]. Explanation of inter- section traffic problems and their solutions is provided in detail in this paper [19].

One of Popular technology currently uses in traffic controlling is VANET. It is vehicular adhoc network. This network consists on Central management unit (CMU), multiple road side units (RSU)and vehicles as node of that network [20].Further update in this technique is vehicle to vehicle (V2V) communication.V2Vis performing very important role in intelligent transportation system (ITS) [21]. IT provides variety of applications such as prevention of collisions, nearby information service, cooperative traffic monitoring and traffic flows control. VANET is uses wave standard WiMAX IEEE 802. 16 and Wi-FiIEEE 802.11p[20], [21].

Autonomous auto mobile is emerging technology to- wards future transportation. There are vehicles available now which can autonomous lyrunon roads. Google already make his autonomous test drive on roads [22] there is much need in improvement in this technology. There are some draw backs in this implementation. Autonomously vehicles tested so far have on-board sensors, which can only detect adjacent vehicle. And these vehicles not perform well in complex traffic. This problem can be overcome by using vehicle to vehicle communication V2X communication [23] better. In ETSI release 1 [23], there are many driver warning for V2X system with corresponding standards are provided.

PROPOSED SYSTEM

SATELLITE VIEW

Satellites are the active source to take broader View of city, they can be used to detect congestion in cities traffic. There are 3,600 Satellites orbiting around earth from which 1000 are operational [24]. Every satellite have not such facility to view earth efficiently with its cameras or they are made for other tasks to perform. There are several GPS systems working around the world. American GPS system has 32 satellites form which 24 are operational. In this system every satellite completes its orbit in 12 hours.

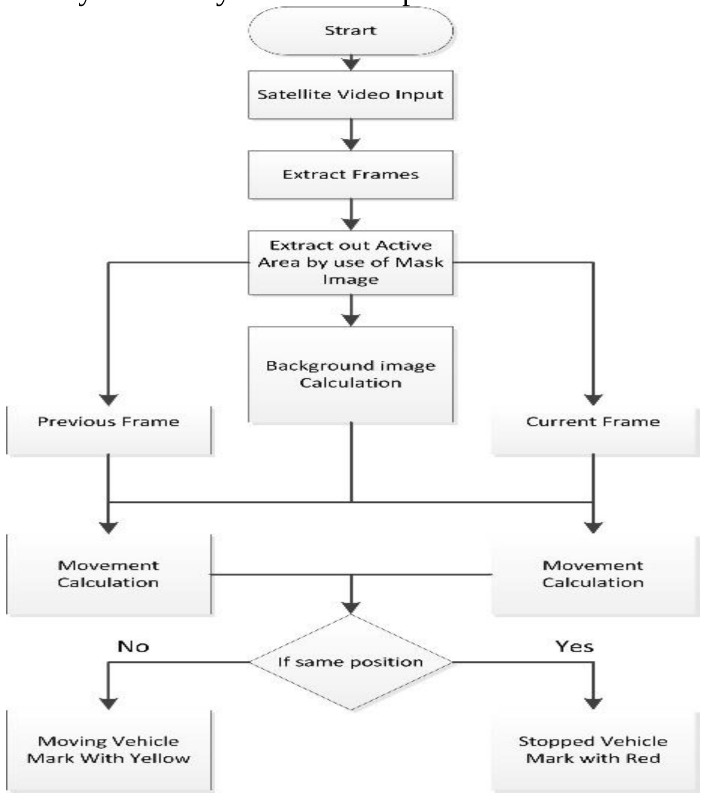


Figure 2: Flow Chart of Satellite System Algorithm

These satellites can provide aerial view of cities, this view further processed to detect congestion on roads. Idea is to take short video from as pecific position of satellite. Image processing algorithm applied on this video which detects congestion on roads. By using24working satellites of American GPS system, we can have a short video of cities from as pecific point at every 30 minutes. This time interval can be decreased by using more satellites. To detect accurately video is divided in multiple views and each view is processed separately. With 2Km square range of area provide better range of view, in which moving vehicles can be detected easily by use of image processing algorithm. In Figure 2 flow chart of satellite system is given.

VIDEO SURVEILLANCE SYSTEM AND EVENTS DETECTION

Accidents are a major cause of traffic jam on roads. It is important to take actions which avoid accidents. It is also important to detect and acknowledge about these accidents quickly, so that to alert up coming traffic to change their routes if possible and also passing information to emergency services timely. Inter sections are very dangerous are as for vehicular drivers. Every year more than 2.5 million accidents happened on highway intersections only, reported by Federal Highway Administration [25].Because of their architectures which introduce several conflicts points. We developed video base event detection system for. For this an active region in video camera is selected, if some traffic stops on that place system captured that image and inform controllers about it. Furthermore wrong vehicle driving and accident happening vents are automatically detected and sends its information to concern departments.

Figure 3: Flow Chart of Traffic Surveillance System Algorithm

In Figure 3 flow Chart of traffic surveillance system described traffic monitoring authorities installed thousands of CCTV cameras to monitor traffic on road side. Multiple authorities have their own CCTV system. In London 33authoritiesincludingTransportforLondon, London Councils, Representatives from London Borough sand the Metropolitan Police are sharing their CCTV cameras [26]. Duplication of a coverage of CCTV cost economic impact on government. Multiple monitoring units installed to monitor this large number of CCTV cameras. In our proposed system intelligent monitoring on these CCTV cameras implemented. This system records all in stances automatically and report to main system about them. Proposed system will count vehicles on specific points, saves vehicle type, colour, number plate, driver information by use of traffic cameras and roads side sensors. System keep this information on regional offices and also update information on main controlling system, where big data handler extract some useful information from it by applying data mining algorithms.

BIGDATAHANDLING

Proposed traffic management system is using big data technology, which can handle vast a mounts of complex and diverse data. There are three things (1) data storage (2) data analysis (3) data management, these 3 things Big Data software handles efficiently. Big Data takes less space for data storage, gives fast data analysis techniques and requires less data management. Apache Spark is a very fast and efficient parallel processing platform currently available to solve Big Data problems. Apache Spark is 100 times faster than apache Hadoop in some cases [3]. Spark is similar to Hadoop stores its data on different nodes. Larger tasks are divided in to smaller tasks, byusing Map Reduce model [3].At the same time, it is stable and fault tolerant too. Hive is used as a data ware house which store data in RDDs. H Base is used as a data base. H Base has an ability too per ate data in column mode. Sqoop is used with Spark to translate data from RDMS. Flume is used for collecting, aggregating and moving data.

BIG DATA CAN IMPROVE THE EFFICIENCY OF TRANSPORTATION INDUSTRY

There are many points selected in cities where special HD Video cameras and others sentialappar at us installed to collect vehicle images, driver information, vehicle color, its type, speed, passing time, lane of road and its direction and so many other required information. These are stored in data base and used in our system to calculate traffic flow, average speed, degree of congestion and travel path information in short time.

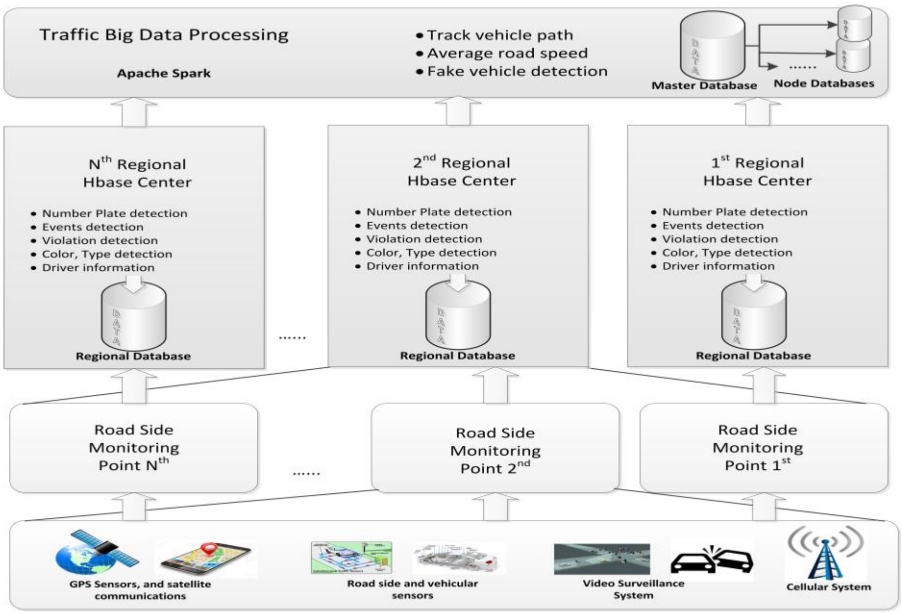


Figure 4: Data Handling Block Diagram

To develop smart cities it is necessary to make roads traffic system intelligent enough so that its traffic jams is negligible and there is efficient utilization of roads. Intelligent traffic system produces large amount of data daily. Only Big Data accessing with parallel processing technique can handles such large data. Following in Figure 5 is a structural diagram which is data flow diagram of our system.

There are multiple sources installed on single monitoring point. These sources provides data to single road side intelligent monitoring points. These road side points further saves their data in H base data base of regional offices. Apache Spark is implemented with one master and several worker nodes on central office, which have access one very single source. In our system Apache spark is used to take quick results of following functions.

TRAFFIC FLOW CALCULATION

Our system calculates the traffic flow of a required point for a specific time interval suchas5minutes, 10minutes,15 minutes, or other time period. This would be helpful to get traffic information at special instance for example on week days or vacation peak times. These data can be publicized which would be very useful for real time traffic information sites. This will helpful for travellers as well as policy makers and business supervisors. Apache Spark Map Reduce parallel processing model is used, data is taken from H Base data base including point ID, direction ID, pass time. The key in map ()function is point ID and direction ID, the value in map ()function is pass time. The output key value pair of Map () function is<key, one>the key include point ID, direction ID and pass time, the value is one. Reduce()function can calculate the sum of one direction of traffic flow, between the start time and end time in a detection point, the output<key–value>pair is<point ID, direction ID, pass time, count>.

AVERAGE SPEED CALCULATION

Average speed calculation is very important indicator in traffic monitoring. Road efficiency is directly proportional to average speed. Average speed can be measured by following formula.

$$V=n\times d/\sum_{1}^{n}(t_{end}-t_{start})$$

Where d is the distance between adjacent measuring point, t_{start} and t_{end} are the entering and leaving time of vehicle from a road segment, n is number of segments, middle section of the road segment does not included. To simplify programming Map Reduce calculates the average speed, first map () function is used to take all information when vehicle passes the point, from H Base includes plate num, point ID, direction ID, pass time. Reduce () function can calculates the time vehicle has spent on the road. At the second round of calculation, in the map()function, the key is point ID and direction ID, the value come from the map () functions output at the first round. Reduce ()function counts sum of the spent time and calculates average speed.

DETECTION OF COMPLETE PATH OF VEHICLE

An important thing for security investigation is to find a whole travel path of a vehicle. This thing requires a lot of manpower and much time some time a week to track specific vehicle path from provided video surveillance systems. By use of proposed system find this travel path is very easy in minimal time as well. In proposed system number plate detectors at different points of system detect and record vehicles automatically in H Base. Querying the travel path by taking number plate and passing time as index keys, start time and end time is entered manually, as a time duration in which tracking is required.

DETECTION OF FAKE VEHICLES

System can detect fake vehicles. Vehicles with fake number plates detected and extracted out easily from registered vehicles. Similarly vehicles which have registered number plate but different type or colour can be detected by comparing with types and colour of registered vehicles. But the fake vehicles which are exactly clone of other vehicle can be detected by using this system. Name this vehicle as clone vehicle. Number plate, colour, and type everything is same as the true vehicle. This clone vehicle harmfulness is obvious. Mainly this king of vehicles used in criminal activities. System can query the information and find out two or more detection point of vehicle, and calculate the time difference between them, if the time difference varies a lot from estimated time it may be is clone vehicle, because a vehicle cannot travel such distance between the two different points within the certain time. In Map Reduce model, reduce ()functions key is plate num, its value is detection point ID+”,”+pass time, then query it with the specified time difference that cannot be possible. Apache spark can efficiently calculate it by using map () and reduce ()functions.

RESULTS

First original image is filtered out from mask image. Mask image shown in Fig 6(b) is an image on which active area is made brighter, so that only that area would be used for further processing. Because satellite is moving during video acquisition, so accurately background estimation is second step. For this several experiments done on different frames and then background is extracted. Then Vehicle detection is detected by subtraction of frame from background frame. All detected vehicle are counted and marked with yellow colour in Fig 6 (c).Vehicles which do not change position in previous frame and incurrent frame are stopped vehicles and mark as red. In our experiment SkySat-1 satellite video is used with specification are in Table1.

In Figure 7 wrong vehicle driving and accident detection events are visible. Red rectangle around vehicle describes wrong way driving and when collision happened and both vehiclesstoppedasinFigure8, this marked as accident happened situation.

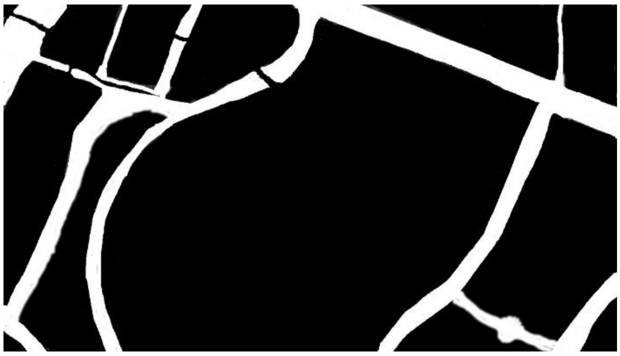
Table 1: SkySat-1VideoSpecification

Specifications	SkySat1Video
Sensor Colour	Panchromatic
GSD (Resolution)	9cm
Frame Rate	30fps
Field of View	2km* 1.1km
File Format	H.264(.mp4)

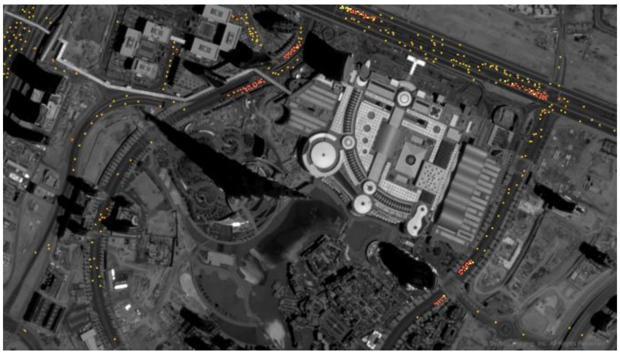
Table 2: Execution time of quires with data size

Test Type	Data Size(MB)	Processing Time(Sec)
Average Speed Calculation	1GB	7.634967
Traffic Flow Calculation	1GB	7.464972
Detection of Complete Path of vehicle	39.5	1.422754
Detection of Fake Vehicles	94.34	3.152573

(a)

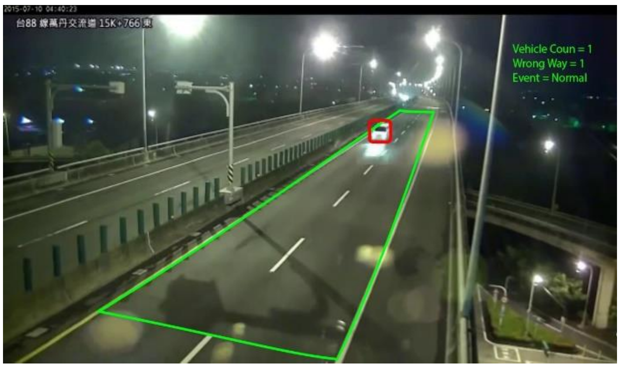


(b)

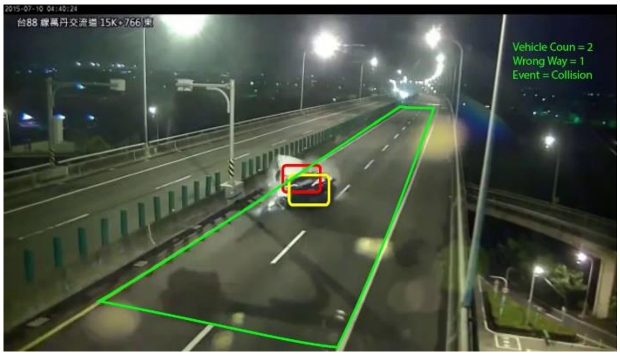


(c)

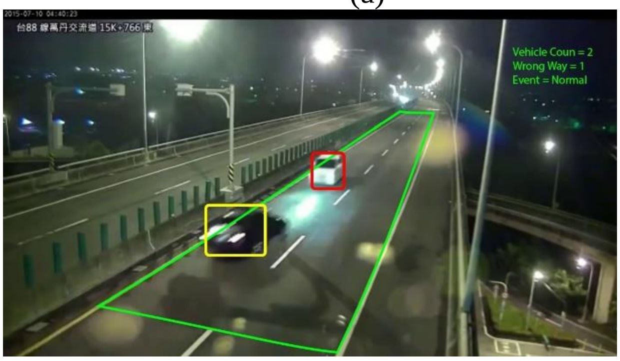
Figure 5: Congestion detection images from satellite. (a)Original Image(b) Mask Image(c) Vehicle count image, red dots are stopped vehicles, Yellow dots are moving vehicles



(a)



(c)



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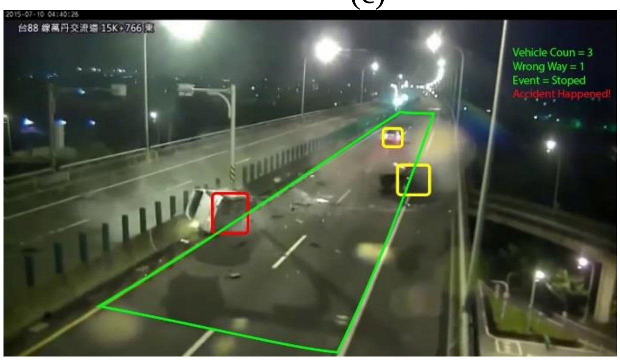

(d)

Figure 6: Event detection implementation on traffic

Video. (a) Wrong Vehicle Detection (b) Wrong Vehicle and Opposite Vehicle, Chances of Accident (c) Collision Detection (d)Accident Detected

WeimplementsApacheSparkclusterhaving1master and4workernodes.Eachmachine is assigned with 1CPU and1GBmemory.Wetaketrafficflow dataofyear2015 from UK Department for Transport [28]. Results of quires execute on time with data size implemented on Spark cluster is providedinTable2.

CONCLUSION

Paper provides integration of different techniques available for traffic monitoring to workforintelligentmonitoring ofurbancitytraffic.Systemcandetectcongestionandits complexity by use of satellites. It can provides intelligent monitoring in traffic cameras, CCTV cameras and sensors installed on roadside.V2Vcommunicationispartofsystem and data generated from these sources is saved in big data HB ase data bases. Results section proves congestion detection and events detection by using image processing techniques and some quires are provided which generates useful information about city traffic in real time, which can be help full in managing traffic efficiently and also in controlling law and order situations.

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