SURVEY AND COMPARATIVE STUDY OF VARIOUS APPROACHES TO MONITOR THE ROAD TRAFFIC

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Abstract: With rapid increase in population, vehicle ownership grows twice as rapidly as income, which leads to large increase in traffic density. Road traffic monitoring is necessary for road & transportation planning, designing of the road, intelligent route planning, and also for traffic management. Several techniques have been used for road traffic monitoring by researchers. A survey of road traffic monitoring has been made by using traditional techniques and non-traditional techniques. This paper describes these techniques in detail and comparative study has been made.

Index Terms: traffic density, road traffic monitoring, intelligent route planning

I. Introduction

Because of exponential increase in vehicle growth and under-resourced road network, there is an occurrence of large traffic density in the urban area. To monitor the road traffic, various methods have been used by researchers. A general survey has been performed to chronicle past research efforts in developing traffic surveillance technologies. For road traffic monitoring, sensors such as IR sensors, ultrasonic sensors have been used. Also, wireless sensor network, magnetic loop detectors, inductive loop detectors, RFID and GSM technologies, LASER system, RADAR system, vision system have been used. Along with detailed description, comparative study of the existing methods which are used to monitor the road traffic has been made.

II. Traffic Monitoring Technologies

As per the literature survey, traditional methods and non-traditional methods are used for road traffic monitoring. Traditional methods are based on remote observations and non-traditional methods uses data recorders or sensors at various points of road network to monitor the road traffic.

A. Traditional methods

Traditional methods are "Traffic police" and "Automatic traffic light control system" which are commonly used in India at road intersections to monitor the road traffic.

1) Traffic police:

"Traffic police" includes traffic police who controls the flow of traffic. Traffic officer needs to stand at each and every cross-sections of the road. Depending upon the signals given by traffic police, vehicles get moved.

This system can measure traffic density, but this is based on manual counting. Priority for an

emergency vehicle is given by the traffic police by stopping other vehicles. But, this method needs one person for continuous monitoring of the road traffic [1]. This method has been widely accepted at the road intersection to control the traffic also this system helps to give a way to an emergency vehicle.

2) Automatic traffic light control system:

In order to remove the continuous presence of the traffic police, "Automatic traffic light control system" have been suggested, which uses fixed time cycle given for every color of light. Depending upon the color of light which is displayed, vehicle gets stopped or passed.

This system is failed to measure the traffic parameters as, the preset time is used to control the traffic flow. In this method, there is no need of traffic police for traffic monitoring, but this method will not work, if there is cut in electricity. This method is failed to identify an emergency vehicle, which causes delay in emergency vehicle. Also, there is lack of discipline for the traffic in India; therefore, serious accidents may be caused because of disobeyed drivers. This method has been widely accepted in India to control the traffic at traffic signal.

B. Non-traditional methods

During the past 20 years, however the emphasis has shifted from traditional techniques to some advanced techniques. These methods basically consist of a data recorder and a sensor placing on or in the road. Pneumatic tubes, IR sensors, ultrasonic sensors, magnetic loop detectors, inductive loop detectors, RFID and GSM technology, LASER system, microwave RADAR system, vision system are the techniques used for road traffic monitoring.

1) Pneumatic tubes:

Fig 1: Installation of pneumatic tubes (photo credit: www.arlingtonva.us)

As depicted in Fig 1, a rubber tube is placed on the surface of the road. When the vehicle tire passes over the tube, the vehicle is detected by change in the pressure.

This system can measure the speed of the vehicle and can identify the type of the vehicle. The installation cost is very less, but it has limited lane coverage and can be damaged by heavy vehicles [1]. Pneumatic tubes get widely accepted in Britain for vehicle actuation of traffic signals [2].

2) IR sensors:

Passive and active infrared sensors are used for the detection of vehicles. Because of the infrared energy radiated from the detection area, the vehicle is detected.

These sensors are used to detect the vehicle, speed and class of the vehicle. It can be applicable to multiple lanes, but implementation cost of theses sensors is high also its performance is affected by change in the climate conditions. IR sensors have been used to control the traffic at road intersection [3].

3) Ultrasonic sensors:

As depicted in Fig 2, these sensors are used for the detection of the vehicle which emits sound waves (of range 25 kHz to 50 kHz) .By measuring the time for the echo signal to return to the object, the vehicle is detected.

These detectors can detect the presence of the vehicle and also measures vehicle speed. These detectors are inexpensive and require minimum hardware but, affected by bad weather conditions [4]. These sensors widely accepted for vehicle detection along with wireless sensor network [5].

Fig 2: Ultrasonic Sensors (photo credit: www.liveozshop.com)

4) Magnetic loop detectors:

It uses the magnetic field, produced by loop wires which are arranged in square form. When vehicle passes over the loop, the magnetic flux linked with the loop changes**.** This vehicle counting information can be transmitted to the counting device.

Magnetic loop detectors are used to detect the presence of vehicle. These detectors are not affected by variations in the weather conditions, but affected by the heavy vehicles. Also, the implementation and maintenance cost is more [6]. Magnetic loop detectors have not gained wide acceptance for road traffic monitoring because of high maintenance cost [3, 6].

5) Inductive loop detectors:

As depicted in Fig 3, the coil of wire is embedded in the road's surface and a detector. Inductance of the cable loops changes when a vehicle passes over them.

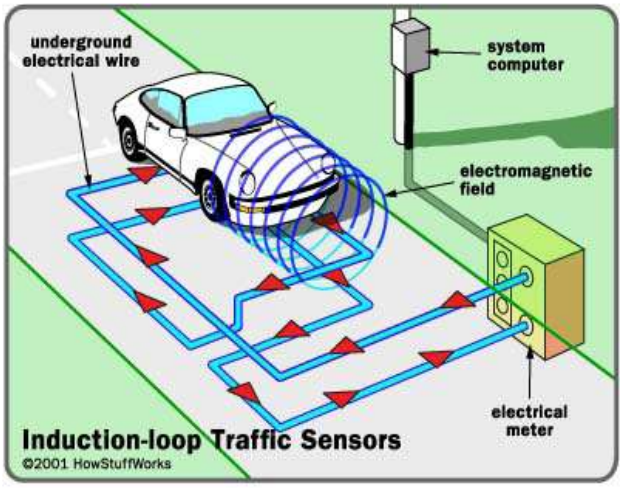

Fig 3: Inductive loop detectors installed on road for vehicles (Photo credit: www.ustraffic.net)

This system can measure speed, occupancy, headway, gap of vehicles. Therefore, it is suitable for individual vehicle detection. It is insensitive to weather and lightening conditions but, installation cost is more. The detection accuracy decreases if; there is detection of large number of vehicles [7].

These loop detectors are accepted for automatic vehicle classification at UK; but these loops are not widely accepted for traffic monitoring [3, 7].

6) RFID and GSM technology:

For monitoring road traffic congestion, active RFID and GSM technology was used [8]. As depicted in Fig 4, it includes various devices like active RFID tag, wireless router, wireless coordinator, GSM modems, and monitoring station software. This system measures speed of the vehicle also length of the vehicle. This system can collect the data very fast but, as this system needs various devices, implementation cost is high also needs set up for monitoring station. RFID has been used for traffic violation detection in high speed roads also it is accepted to estimate the traffic congestion at road intersection; but not implemented to control the traffic [9].

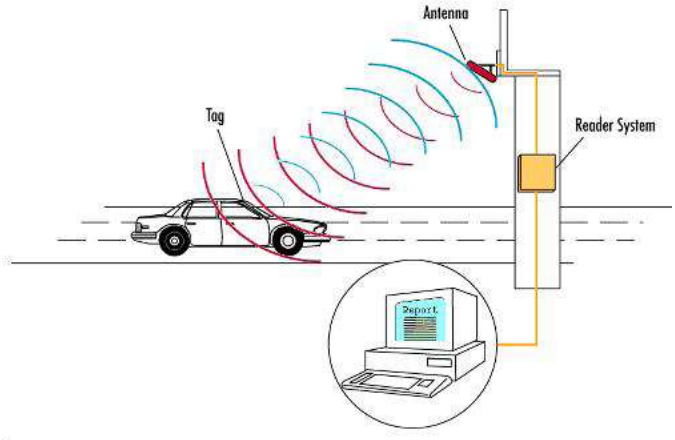

Fig 4: Application of RFID at electronic toll collection system (Photo credit: How Stuff Works)

7) LASER system:

LASER beams are also used for road traffic monitoring. Laser detectors are installed on overhead position. As traffic moves light beams are obstructed. Electronic devices can record these events and detect traffic jam. This system can measure vehicle speed and length. This system not affected by bad weather [10] but LASER detectors need an overhead structure. This LASER system is applicable to only structured traffic; therefore it is accepted to monitor the traffic highways and toll plazas only but not widely accepted because of high cost [10].

8) Microwave RADAR based system:

This system uses Doppler Effect that can detect the moving vehicles and speed of the vehicle.This system can detect the presence of the vehicle and speed of the vehicle. The system is not affected by weather conditions but it cannot detect stopped vehicles [11]. These systems have potential to monitor the traffic and road situations but not yet accepted for operational traffic management [3, 11].

9) Wireless sensor network:

In this technique, the sensor nodes are deployed along the road side. The real time traffic information is collected from these nodes. Vehicle speed, lane occupancy rate, traffic flow can be measured. The cost of the system is low, also the system is scalable. But one of the issues of WSN is energy efficiency problem [12] and sensors needs to be robust in Indian weather conditions.

Wireless Sensor Network accepted for to control the traffic light; but not robust to all weather conditions. Also, it is used in parking area to monitor the vehicles and update availability of parking spaces [13].

10) Vision system:

As, depicted in Fig 5**,** this system uses video cameras which are installed on the fixed polls. From the recorded video, images are extracted and by using image processing, the vehicles are detected and counted. Vehicle speed can be measured and the system can monitor multiple lanes.

Fig 5: Video image processing system (photo credit: autoscope.com)

Vision system can measure the vehicle speed, headway and traffic count. It addition to the traffic monitoring, it can provide the video footage which can be used for security purpose. But, the system cannot work efficiently in different weather conditions and if it is used, at the traffic signal intersection, it cannot detect an emergency vehicle [14]. Vision based approach can be combined with mathematical and statistical experiments for the detection and counting of road traffic flow [15]. Computer vision system has been used for lane detection and departure warning, driver fatigue detection, traffic sign detection and for vehicle

detection at highways but not widely accepted for the traffic at road intersection [16].

III Comparative study

Table 1 show the comparison of different advanced techniques used for road traffic monitoring. Comparison is made on the basis of measurable traffic parameters, cost, lifetime of the technology also sensitivity to the weather conditions. As shown in the Table1, to measure the different traffic parameters, different techniques are used. Installation and maintenance cost is also varying for different technologies. Some techniques are affected by change in the weather conditions like rain, fog, snow etc.

Table 1- Advanced technologies used for road traffic monitoring

Parameters/ Technology	Vehicle detection	Type of vehicle	Speed	Traffic Rate	Cost	Lifetime(years)	Sensitivity to Environmental conditions
Pneumatic tubes	Yes	Yes	Yes	No	low	0.5	low
IR Sensors	Yes	Yes	Yes	No	high	5	high
Ultrasonic sensors	Yes	No	Yes	No	high	5	high
Magnetic loop detectors	Yes	No	No	No	high	7	high
Inductive loop detectors	Yes	Yes	Yes	No	high	5	high
RFID and GSM technology	Yes	No	Yes	No	high	5	high
LASER system	Yes	No	Yes	No	high	7	low
Microwave Radar	Yes	No	Yes	Yes	high	10	low
Wireless sensor network	Yes	No	Yes	Yes	low	8	high
Vision system	Yes	No	Yes	Yes	high	10	sensitive

IV Conclusion

In this paper, different technologies used for road traffic monitoring are discussed. A survey of the road traffic monitoring technologies was presented. Also comparison of the different technologies was given. Literature survey shows that, video image detection system has scope for future research, as it can be used for road traffic monitoring and controlling as well as for emergency vehicle detection, if it is combined with sound based technology. In India, the traffic is unstructured and

highly undisciplined. After surveying various traffic monitoring techniques, we can conclude that, it is necessary to develop one technology that can be suitable for Indian weather conditions as well as for Indian traffic conditions. There are drawbacks of each technology, which can be overcome by adding some features from other technologies.

References

[1] Nikunj P. Bhensadadiya, Dulari Bosamiya," Survey on Various Intelligent Traffic Management Schemes for Emergency Vehicle", IJRITCC, ISSN: 2321-8169, Volume: 1 Issue: 11, 830 – 833

[2] Peter W. Bonsall, Michael G. H. Bell,"Information Technology Applications in Transport", VNU Science Press, 1987

[3] Promila Sinhmar," Intelligent Traffic Light & Density Control using IR Sensors and Microcontroller", IJATER, ISSN: 2250-3536, Volume: 2, Issue: 2

[4] Ashish Jain, Manisha Mittal," Traffic Density Measurement Based On-road Traffic Control using Ultrasonic Sensors and GSM Technology", ACEEE, International Conference on Emerging Trends in Engineering & Technology,2013

[5] Youngtae Jo, "Analysis of Vehicle Detection with WSN-Based Ultrasonic Sensors", Sensors 2014, PP. 14050-14069

[6] Amine Haoui, "Wireless Magnetic Sensors for Traffic Surveillance ", ELSEVIER, Transportation Research Part C, 2007

[7] Somashekar G.C., " High Density Traffic Management using Image Background Subtraction Algorithm, IJCA,Recent Advances in Information Technology, 2014

[8] Koushik Mandal, Arindam Sen, Abhijnan Chakraborty and Siuli Roy, "Road Traffic Congestion Monitoring and Measurement using Active RFID and GSM Technology", IEEE Annual Conference on Intelligent Transportation Systems, 2011.

[9] Fawzi Al-Naima, "Vehicle traffic congestion estimation based on RFID"'International Journal of Engineering and Business Management, Special issue on RFID & WSN, Volume: 4, 2012

[10] Hussain T.M., Saadawi T.N., "Overhead infrared sensor for monitoring vehicular traffic", Vehicular Technology, IEEE transactions, ISSN: 0018-9545, Page 477-483, Volume: 42, Issue: 4, 1993

[11] Parulekar G.D., "Vehicle Detection and Monitor Techniques for Intelligent Transportation – A Survey", IOSR-JMCE, ISSN: 2778-1684,PP. 57-59

[12] Youngtae Jo, Jinsup Choi, "Traffic information acquisition system with ultrasonic sensors in wireless sensor networks", International journal of distributed sensor networks, Volume: 2014, Article ID: 961073

[13]Mohamed Amine Kafi, "A Study of Wireless Sensor Network for urban traffic monitoring: Applications and Architectures", International conference on Ambient Systems, Networks & Technologies, Volume: 19, PP. 617-626, 2013

[14] Vikramaditya Dangi, Amol Parab, Kshitij Pawar and S.S Rathod, Image Processing Based Intelligent Traffic Controller, Undergraduate Academic Research Journal (UARJ), ISSN: 2278 – 1129, Vol-1, Iss-1, 2012.

[15] Shuguo Yang, Xiaoyan Yang, "The Application of the Queuing Theory in the Traffic Flow of Intersection", International Journal of Mathematical, Computational, Natural and Physical Engineering Vol:8, No:6, 2014

[16] Kristian Kovacic, "Computer Vision Systems in Road Vehicles- A Review", Proceedings of the Croatian Computer Vision Workshop, 2013