ISSN 2319-5991 www.ijer
Vol. 3, No. 3, August 2

Review Article

REVIEW ON ROAD SPEED MANAGEMENT IN URBAN AREAS

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Urban transport systems in developing cities face major challenges due to the continuous growth of urban population, congestion, and the fragility of public transportation systems. The speed of vehicles on urban roads has become a matter of concern, as there are lot of accidents leading to fatalities. Speed management should be a central element of any road safety strategy that takes into account the mobility, safety and environmental requirements. The possibility of accident involvement may be positively correlated with speed variation and higher vehicle speeds are generally correlated with increased accident severity. The study overlooks on the need for development of low cost Intelligent Transportation System (ITS) for Indian environment, with the limelight on Tiruchirappalli city, Tamil Nadu, India as the study area. Video Image Processing (VIP) techniques were suggested to estimate the speed of vehicles under Indian traffic conditions, with greater level of accuracy and reliability of traffic data estimation. ITS tool has been proposed to provide a better measure of traffic management to reduce congestion, mortality rates and environmental impacts in Tiruchirappalli city.

Keywords: Traffic Management, Urban Population, Video Image Processing, Intelligent Transport System

INTRODUCTION

Road transport is vital to the economic development and social integration of the country. Easy accessibility, flexibility of operations and reliability has earned road transport an increasingly higher share of both passenger and freight traffic. Transportation in urban areas is highly complex because of the modes involved, the multitude of origins and destinations, the amount and variety of traffic. Urban transportation issues are of foremost importance to support the passengers and freight mobility requirements of large urban agglomerations. Indian cities face a transport crisis characterized by levels of congestion, noise, pollution, traffic fatalities and injuries. High levels of urbanization are compelling governments to seek innovative solutions in the fight against congestion, pollution and accidents.

Urban speed has become a wide spread social problem as, at any time 50% of the drivers are above limits (European Conference of

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Ministers of Transport, October 2004). In a situation where mobility is considered essential, regulation of speed gets lesser importance, as faster movement of vehicles is given more importance. Excessive and inappropriate speed has been recognized as one of the major contributing factors for increasing road accidents. It directly contributes to one third of fatal accidents and is an aggravating factor in the severity of all accidents. It has become the one of the major problem in many countries, especially in developing countries like India.

ACCIDENT STATISTICS

Road accidents are an outcome of the interplay of various factors, some of which are the length of road network, vehicle population, human population and adherence/enforcement of road safety regulations, etc. Developing countries register the maximum number of road accidents in the world. In India, at least 14 people die every hour in road accidents according to the report of National Crime Records Bureau. Between 1970 and 2010, the number of accidents increased by 4.4 times with 9.3 times increase in fatalities and 7.5 times increase in the number of persons (Govt. of India, 2010) injured as presented in Table 1.

Table 1: Growth in Accident Related Parameters: CAGR in Percent

Period	No. of Accidents	No. of Injuries	No. of Fatalities	No. of Registered Vehicle
1970-1980	3.0	4.5	5.2	12.4
1980-1990	6.3	8.4	8.5	15.5
1990-2000	3.3	5.0	3.8	9.8
2000-2010	2.5	2.8	5.5	10.0

Table 2: No. of Accidents and No. of Persons Involved from 2001 to 2010

Year	No. of Accidents		Number of persons		Accident Severity
	Total	Fatal	Killed	Injured	
2001	405,637	71,219	80,888	405,216	19.9
2002	407,497	73,650	84,674	408,711	20.8
2003	406,726	73,389	85,998	435,122	21.1
2004	429,910	79,357	92,618	464,521	21.5
2005	439,255	83,491	94,968	465,282	21.6
2006	460,920	93,917	105,749	496,481	22.9
2007	479,216	101,161	112,444	513,340	23.9
2008	484,704	106,591	119,860	523,193	24.7
2009	486,384	110,993	125,660	515,458	25.8
2010	499,628	119,558	134,513	527,512	26.9

Table 3: Number of Accidents Occurred in Tamil Nadu During Past Five Years

Year	Fatal	Grievous Injury	Minor Injury	Non-Injury
2006	10055	4630	36262	4198
2007	11034	4498	39494	4114
2008	11813	4426	39193	4977
2009	12727	4448	39676	3943
2010	14241	4613	42320	3822

The number of persons killed in road accidents during the year 2010 was 134,513, which means an average of one fatality per 3.7 accidents. The proportion of fatal accidents in total road accidents has consistently increased since 2001 from 17.6% to 23.9% in 2010. The severity of road accidents, measured in terms of persons killed per 100 accidents, has also increased from 19.9 in 2001 to 26.9 in 2010 (Govt. of India, 2010) as shown in Table 2:

Road accidents have been increasing alarmingly and Tamil Nadu, being a major state contributing to total no. of accidents in India. The fatal accidents are increasing at a brisk rate in the state of Tamil Nadu with an increase of 50% during last decade. The accident statistics for the past five years in Tamil Nadu (Govt. of India, 2010) are given below in Table 3.

URBAN MOBILITY AND SPEED

With increasing urbanization, vehicle density on the roads has been increasing exponentially. Most of the vehicles and roads are designed for a particular speed. The improved roadway facilities have encouraged the drivers to drive fast in the urban roads. Excessive speed is a key risk factor for road accidents and greater severity of the injuries in the event of an accident. In such circumstances, it is very difficult to control a speeding vehicle unless some speed management measures are provided.

Higher vehicle speeds also contribute to the increased green house gas emissions, fuel consumptions and noise and has adverse impacts on quality of life in urban areas. Many research works indicate that the coordinated actions taken by responsible authorities can bring about immediate response to the problem of speeding. On Indian roads, it is important that mobility and safety should go hand-in hand for providing greener environment and reducing the number of fatality rate in the country.

IMPACT OF SPEEDING ON ACCIDENTS

Speeding which encompasses excessive speed (driving above the speed limits) or inappropriate speed (driving too fast for the prevailing conditions, but within the limits) is dangerous. Speeding is a complex problem, involving the interaction of many factors including public attitudes, road user behaviour, vehicle performance, roadway design and characteristics, posted speed limits and enforcement strategies.

Vulnerable road users are particularly exposed to vehicle impacts, especially in urban areas at speeds which are above the limits of human tolerance. For instance, pedestrians have 80% chance of survival if hit by a car travelling at a

speed of 30 km/h or below, but less than a 20% chance of surviving an impact of 45 km/h or above [2] as shown in the Figure 1. Speeding concerns all types of motor vehicles and all groups of road users. However, young drivers are the most involved in speeding behavior. Accordingly, an interdisciplinary approach involving engineering, enforcement, and education is needed to reduce speeding-related crashes, fatalities and injuries.

Figure 1: Probability of Fatality for Pedestrians Colliding With Vehicles

EVOLUTION OF INTELLIGENT TRANSPORT SYSTEM

The problems of traffic congestion, accidents and traffic related issues gradually led to the introduction of Intelligent Transport Systems (ITS). It is essentially the application of computer and communications technologies coming in aid of the transport problems. ITS can be defined as the application of computing, information and communication technologies to the real-time management of vehicles and networks involving movement of people and goods. ITS technologies enable gathering of data or intelligence and then providing timely feedback to traffic managers and road-users. ITS results in improved safety to drivers, better traffic efficiency, reduced traffic congestion, improved energy efficiency and environmental quality and enhanced economic productivity. Some examples of ITS include Advanced Traffic Management Systems, Advanced Traveller Information Systems, Advanced Vehicle Control Systems, Electronic Toll Collection Systems, Advanced Public Transportation Systems, etc. The application of ITS in controlling the speed of vehicles runs onto be a challenging task in Indian traffic condition. The relevant researches carried out in the field of speed management are being exemplified below:

Lino Figueiredo et al. (2001) illustrated that as a result of saturation of the transport infrastructure due to the growing number of vehicles, traffic congestion, accidents, transportation delays and vehicle emissions have increased to an alarming extent. Although several solutions like implementation of safety belts, airbags, construction of new and better roads were introduced, it became clear that these were not the right solution as these were very expensive and cause a considerable environmental impact. These difficulties motivated the research community to centre their attention in the area of ITS.

The purpose of ITS was to take advantage of the appropriate technologies to create €more intelligent• roads, vehicles and users. ITS have been around since the 1930s and it has been slowly creeping into our lives. The major developments on ITS was made in Europe, US and Japan, and it had gone through three phases which comprises of Preparation (1930-1980), Feasibility study (1980-1995) and Product development (1995-present) (Judy et al., 2003). Figure 2 gives a framework of ITS architecture that modulates between the vehicles and road users.

Figure 2: Framework of ITS Architecture

ITS APPLICATION IN SPEED MANAGEMENT

ITS involves a large number of research areas and the study focus on the intelligent traffic systems employed especially in the area of speed management and operations. Different systems exist in the area of traffic speed management, ranging from informative to intervening systems. The review of literature gives an outline of exercising ITS in speed management operations and control in urban centres.

Studies have shown that speed recommendations given via in-vehicle systems signalling with light and sound; when the driver exceeds the speed limit were expected to reduce the number of injury accidents by about 10%. A variable speed limit system integrated with a fog warning system reduced the number of injury accidents on a German motorway by 20% (Balz and Zhu, 1994). A Dutch fog warning system including a text warning and dynamic speed limit VMS signs on a motorway reduced the speeds by 8 to 10 km/h, although in extremely dense fog, the system had an adverse effect on speed (Hogema et al., 1996). Variable speed limits applied near school zones in Sweden, resulted in a 20% reduction in the number of accidents (Elvik et al., 1997). Automated speed enforcement systems aim at more efficient speed detection and driver feedback. Varhelyi (1997) had estimated that automatic speed limiting on rural roads reduced the total number of injury accidents by about 10%. The systems have been effective in lowering the percentage of speeding drivers and thus bringing down the average speeds by 10%. The most promising system is Intelligent Speed Adaptation (ISA) or External Vehicle Speed Control (EVSC), estimated to reduce accidents by 35% (Carsten and Fowkes, 1998). The study gives an overview of regulation of speed with appropriate use of technologies and its advancement during the recent years.

Luz Elena et al (2000) illustrated that the surveillance technologies may be used to identify traffic parameters including detection of vehicle presence, vehicle count, speed, headway, occupancy, and weight and link travel time. The data processing device may be a part of the sensor, as with devices that produce serial output data, or may be controllers external to the sensor that have optically-isolated semiconductor or relay outputs. The data-processing device usually consists of computer hardware and firmware that converts the electrical signal into traffic parameters.

Mats Haglund et al (2000) investigated the driver,s attitudes towards speeding and influences from other road users on the drivers speed choice. The recorded vehicle speeds were compared with drivers, responses to questions concerning their speed choice. The study replicates a previous study on 50 km/h roads, where a model including measures of attitudes and perceptions about others behavior, explained about 15% of observed behavior. In this study, a

majority of the drivers observed exceeded the speed limit, and the model ensured about 41% of the variance in the observed speed.

Liang Zou et al (2005) describe a new methodology for performing arterial speed studies using taxis equipped GPS receivers as probe cars. It documents the data collection and data reduction, as well as analyses that illustrate the capabilities of the GPS/GIS methodology. The data collection procedure uses taxis equipped with GPS receivers to automatically collect time, local coordinates, and speed at regular sampling periods. The data reduction procedure filters and aggregates GPS data to compute travel time and speed along highway segments. Finally, the developed methodology is implemented with 100 taxis equipped with GPS receivers of Guangzhou City. The results demonstrate the power of the methodology proposed on travel time.

Mountain et al (2005) evaluated the impact of various types of traffic management schemes on both traffic speeds and accidents. The study analyzed the general trends in accidents and regression-to-mean effects and migration, by separately estimating the accident changes which are attributable to the impact of the schemes on traffic speed and traffic volume. In terms of the percentage accident reduction, engineering schemes incorporating vertical deflections (such as speed humps or cushions) offer the largest benefits at 44%, which is twice that at sites where safety cameras were used to control speeds (22%) and they were the only type of scheme to have a significant impact on fatal and serious accidents.

Rahul (2008) described in his thesis, the applications of ITS in Tiruchirappalli. The study area was separated into different zones and each zone is analyzed with Dynamic Route Guidance technique. The dynamic route choice method takes into consideration the journey time including the delays taken to travel between two zones among the alternative available routes. Dynamic route choice selects the route having the shortest journey time.

Chomtip Pornpanomchai et al. (2009) had developed a vehicle speed detection system using Image processing technique. The system is designed to detect the position of the moving vehicle in the scene by Image segmentation using Region growing method. It uses reference points in every single frame to find the speed of the vehicle. The background adopted for this study was an ideal background with very minimal noise. The noise removal technique used in this system is very basic and may not work effectively on Indian roads.

Adinarayana et al. (2011) proposed a system which used virtual loops for the detection of speed of vehicles. The virtual loop consisted of two imaginary lines and the system detected movement of vehicles across these lines. The virtual distance between the lines was scaled up to real distance on the ground and the time difference between the lines was used to find the speed of the vehicle. The problem with these virtual loops is when two or more vehicles cross the imaginary loop lines at the same time, the system might not be able to identify all of them correctly.

Ankit Pachouri (2013) proposed an integrated video camera system that helps in communicating, processing the information and disseminating to the road user. The study had put forward an effective measure for speed management especially in Indian conditions. It

proposed speed management in highly populous urban areas by two methods, viz., External Vehicle Control and In Vehicle Control.

ITS IN INDIAN CONDITIONS

Traffic management and operations faces a big challenge for mixed traffic conditions prevailing in developing countries like India. The introduction of ITS has made the task more complex with its implementation and suitability. The prime focus of the study relies on use of an effective traffic management measure with aid of ITS in regulating the speed of vehicles within the urban roads in India.

ITS are used extensively in countries like the USA and Singapore, where the traffic is homogeneous and abides by lane discipline. Traffic in India however, is heterogeneous and lacks lane discipline, thus the implementation of ITS poses several challenges.

However the following ITS tools may be implemented in the Indian urban cities to tackle the problem of traffic and accidents:

- Electronic Toll Collector at all Toll Booths.
- Speed Detection using Speed Guns at all intersection.
- Dynamic Route Guidance system may be developed for all urban arterials.
- Tracking of vehicles using GPS.
- Use of Variable Message Signal (VMS) in case of an accident and provide the detour route.
- Installation of Radar Speed Guns along with video cameras.

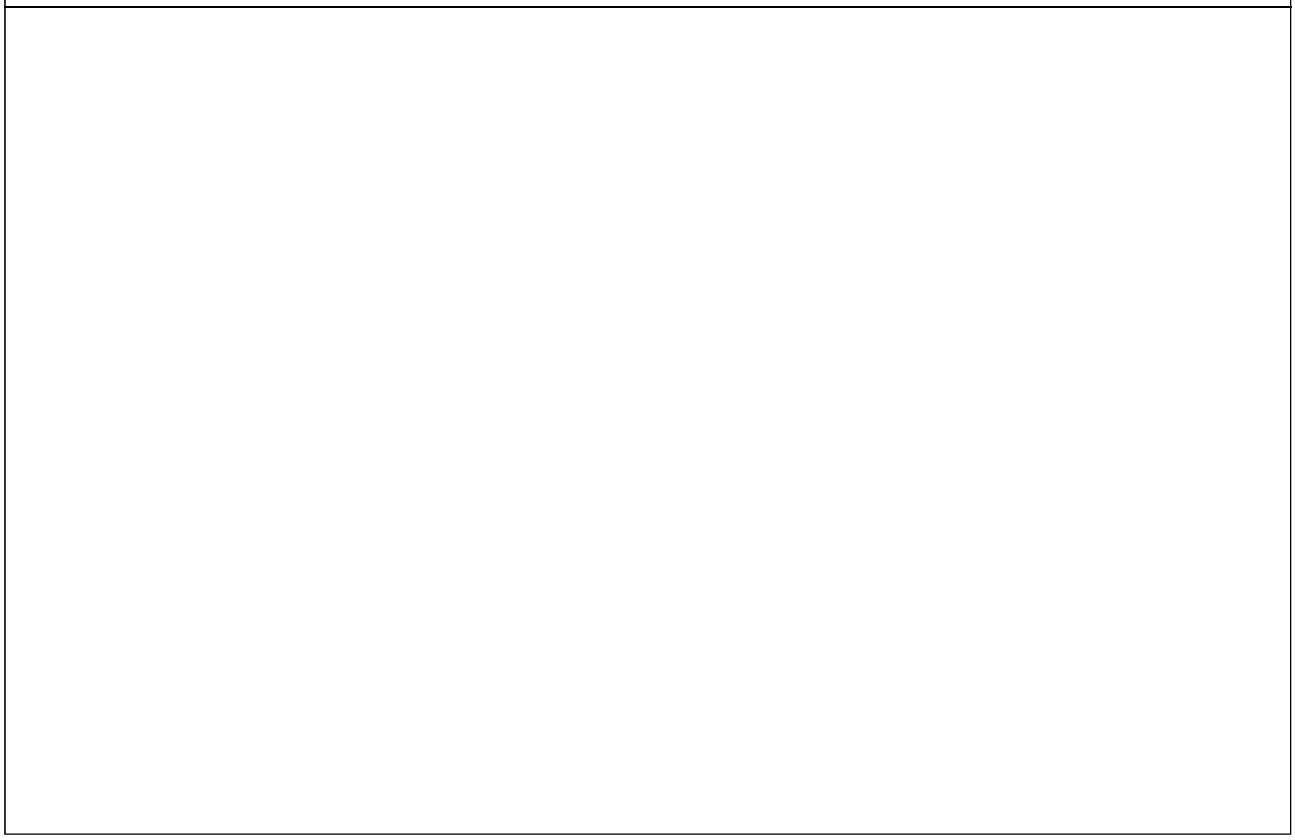
Speed Management can be effectively carried out in Indian urban conditions using the following two techniques:

External Vehicle Control

The primary step in traffic monitoring on urban roads is to detect the presence of vehicles for traffic management and operation. Infrared sensors are made in use for vehicle detection which is laid across the road in the speed zoning locations of the city, especially in Indian conditions. It consists of a transmitter and receiver provided at the either ends of road. IR sensors are connected to the Radar Speed Gun provided at some distance from the sensor. When the vehicle cuts off the IR beams in a definite sequence, it switches the Radar speed gun to measure the speed of the approaching vehicle within the zone. The vehicle speed recorded gets stored into the computer database (Adinarayana et al., 2011).

The information collected is made in view to the road user by means of effective driver feedback techniques like VMS or many other ways in real time itself. Simultaneously traffic camera is provided alongside with speed gun to record the video footages of the vehicle passing through. The speed of the vehicle and video footages are synchronized into a common database based on the clock time storage of both the data (Carsten and Fowkes, 2000). Further processing of the video footages can be done to extract the license number plate of the vehicle in an offline stage. The method of speed management by means of external vehicle control is shown in Figure 3. The system provides an advisory method for traffic speed regulation by informing the road users on site regarding the speed of vehicles through Variable message signs, LCD display units, etc. This can be followed by enforcement of penalties for those vehicles successively violating the speed limits during shorter period of time. The database stored provides the information regarding the speed of vehicle, license number plate, video

Figure 3: External Vehicle Control For Speed Regulation



footages and the time period of speed violations. The license plate number of each vehicle extracted can be linked with the RTO database in order to obtain the vehicular information. Further challan systems are employed for enforcing the penalties on the drivers violating the speed limits for the city. Challans are sent to the driver address as a measure of speed ticketing, but can be made practice in an offline stage. The method proves expensive in implementation terms but provides with an informative as well as an adaptive measure for speed management in the city road network.

In Vehicle Control

In vehicle speed control utilizes an open source mobile application that helps to track the vehicle position, vehicular speed, route path, etc. (Andry and Richard, 2008). The application proves to be informative to the road users; in addition it helps the control centre to keep a check on the vehicles moving within the city limits. The primary objective of ITS Mobile application is to create a fully fledged application which provides information to the road users about Tiruchirappalli city road network. The application must be outsourced or enforced by the government to be exercised by the road users.

ITS mobile application must contain the requirements of GPS integrated mobile, nowadays available in most of the mobile phones. A central control segment, here the government can provide the application having unique ID tagged to every vehicle user registered in Tiruchirappalli city. ID tag embedded with the vehicular information allows the control centre to

track the vehicle within the city limits and also helps to communicate with the road user via message services. The application is developed on an Android platform. It utilizes Google map and GPS services of Android, it is supposed to have an active internet connection available in the phone along with GPS service active. This provides an indirect means of advising the road user to regulate the speed within the urban road network. Along with the above proposed ITS Tools, serious study needs to be carried out in this field, so as to propose some more ITS tools to curb the traffic and accident related problems.

CONCLUSION

An effective speed management system should be very flexible and easy to use such that it could be used in a real time traffic scenario and at the same time it should be efficient and accurate. External vehicle control proves an adaptive system for determining the violation of traffic speed limits within the urban areas. Thereby it involves high implementation cost in bring out traffic speed regulation practices when applied onto ground. The data executions are carried out in an offline mode which delays the process of enforcement and also needs a huge amount of storage area to keep in data records. External vehicle control proves static in action and lack the flexibility for regulating the speed on the whole urban road network. On the other hand, the mobile application requires an initial thrust to enforce the road users to exercise the module unit. It is dynamic in action, and also provides advisory mode of operation in management of traffic operations. It encourages the road users with productive information of real time traffic scenario throughout the city.

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