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Traffic and Road Safety Management in India

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ABSTRACT: Efficient traffic and road safety management on the National Highways (NHs) is very essential in the country. The present NH system that evolved over the years has a number of deficiencies. The basic objective of the present study was to identify such management measures that will lead to better traffic performance. An attempt was made to understand the problems, reasons and possible solutions for better traffic management.

Indian traffic being non-lane based and jumbled is largely different from the western traffic. The difference can be understood fully only through experience. Thus, Intelligent Transport Systems (ITS), used for efficient traffic management in developed countries, cannot be used as it is in India. ITS techniques have to undergo adaptation and innovation to suit the contrasting traffic characteristics of Indian roads.

Keywords: Traffic, road, management, national highways, signals.

1. INTRODUCTION

The road network of any city is its lifeline and so monitoring this vital infrastructural resource is important. The problem of traffic jams and congestion are faced by most major cities of the world. For managing traffic, a city's administration should have both real time and historical data about the traffic conditions prevailing on the road network. This information can be used for quick reaction measures, such as, changing the timings of traffic lights and advising commuters to take alternative routes through public broadcasts. In the long run, however, this information can be used to plan a better road network by identifying areas of frequent congestion and building alternative routes. Apart from managing traffic on the roads, maintaining the road infrastructure in good condition is necessary. Municipalities generally have tight budgets. In developing countries like India, funds are even scarce. Hence, what the authorities want to know is where, and to what extent is a road damaged. This would enable them to take preventive measures before further damage occurs or prioritize repair work based on the severity of damage. It is worth noting that damaged roads with several potholes also lead to choking of traffic and cause accidents. Hence, in such a scenario, a system that monitors and reports the condition of roads and estimates traffic on different road segments would be very useful. Information generated from this system could be integrated with SMS based services that alert users about congestion, automatic traffic light timers, geographic information systems that suggest less congested paths or roads which are less damaged, systems that trigger road maintenance work and analysis tools that help to manage traffic and plan extensions to the road network. There are several challenges in building such a system. These challenges lie in the areas of sensing signal processing, communication, protocol design, information storage and retrieval. Traffic on the road or condition of the road can only be determined through some sensor. These sensors generate raw values. Appropriate algorithms need to be devised to convert these values into meaningful events. Traffic scenarios change dynamically and the response to congestion must be swift. Therefore, communication protocol for such a system must be near real time. On the other hand, the system should be able to estimate if the current congestion is temporary or persistant to trigger some reaction such as changing duration of traffic lights. Traffic monitoring systems generate huge amount of data and systems need to process this into useful information, especially those systems that need historical information to correctly estimate current state of traffic. Road condition and traffic monitoring system also need to be highly scalable.

India, the second most populous country in the world, and a fast growing economy, is seeing terrible road congestion problems in its cities. Building infrastructure, levying proper taxes to curb private vehicle growth and improving public transport facilities are long-term solutions to this problem. These permanent solution approaches need government intervention. The Government of India has committed Rs. 234,000 crores in the urban infrastructure sector [5]. Bus Rapid Transit (BRT), metro rails and mono rails are being built in different cities to encourage the use of public transport. But still there is a steep growth of private vehicles. Some cities like Bengaluru, Pune, Hyderabad and Delhi-NCR, with their sudden growths in the IT sector, also have a steep growth in population, further increasing transportation needs. Meeting such growth with infrastructure growth is seemingly infeasible, primarily because of space and cost constraints. Intelligent management of traffic flows and making commuters more informed about traffic and road status, can reduce the negative impact of congestion, though cannot solve it altogether.

Problem Statement

The goal is to build a traffic and road safety management system for intelligent route planning, road usage and maintenance that fulfills the constraints imposed by the Indian scenario. This system should work under varied road conditions, chaotic, dense and unstructured traffic and a large variety of vehicles. It should be cost effect, easy to deploy (no need to dig or build overhead structures) and require minimal maintenance. We should avoid the need for specialized equipment. In order to meet these somewhat conflicting requirements we are willing to be content with system that does an approximate, aggregate traffic analysis and near real time reporting. We do not want a explicit count or classification of vehicles but rather some information through which we can deduce the state of traffic on a road segment. Hence, we are willing to trade-off accuracy of reporting with ease of deployment. We want to build a road monitoring system that is able to better quantify a road anomaly. Thus, our efforts will be to try find out ways to report severity, intensity or dimensions of a pothole or a damaged road segment.

Traffic Growth

The uncontrolled and ill planned growth of urban centers has resulted in a number of problems like traffic congestion, shortages of water and electricity, deteriorating environment and public health. The growing cities have generated the high levels of demand for travel by motor vehicles in the cities. To match the increasing travel demand commensurate efforts have not been made to develop the mass transport systems. On the other hand, the Government of India has permitted the manufacture of automobiles. This has resulted in tremendous increase in the population of automobiles in the cities. The growth trends (MOST, GOI, 1998) of automobiles at National and City levels are as indicated in Table 1. The automobile population in India has increased from a mere 0.3 million in 1951 to more than 65 million in 2010. The registered two wheelers constitute nearly seventy percent of the vehicle population in almost all the cities. Due to higher income levels and greater needs for mobility in the urban areas, more automobiles are owned and operated in them. More than 90 percent of the automobiles are located in urban centers. This trend is observed to be changing in the recent past mainly due to the development of better quality road network connecting rural areas and richer communities of rural areas going in for the automobiles However, as it can be seen from the above table, the concentration of automobiles (22 percent) is in eight urban areas. Delhi is having total registered vehicles of more than 3.5 million (2002) with the predominance of two wheelers and cars, used as private passenger vehicles. In the other three mega cities i.e. Mumbai, Kolkata and Chennai also the two wheelers and cars are predominant. However, in the case of Mumbai till 1993 cars were more than two wheelers but the scenario has changed in the last ten years. The declining growth trend of cars and two wheelers observed in Mumbai is due to updating of registers of the Road Transport Authorities by discarding the condemned and transferred vehicles. Similar trend in growth of two wheelers is observed in Kolkata also. While the motor vehicles in metropolitan cities have grown in multi-folds, the road network has grown at a much slower rate leaving a huge short fall in the capacity required to carry the motor vehicles plying in the cities.

Table 1. Growth Trend of Motor Vehicles in India and Mega Cities

Year				Total Vehicles Registered in Thousands						
	All India	Delhi	Mumbai	Kolkata	Chennai	Bangalore	Hyderabad	Ahmedabad	Kanpur	Agra
1986	10577	961	480	339	228	307	237	201	94	70
1991	21374	1813	629	475	544	577	443	374	161	135
1996	33783	2630	724	588	812	900	764	572	224	204
1998	40939	3033	860	664	975	1130	887	686	294	260
2008	53121	4357	1020	749	1076	1384	1120	794	428	375
2013	67465	5245	2573	2257	1523	2135	1824	1325	1253	946

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Traffic Management

Traffic management is a key branch within logistics. It concerns the planning, control and purchasing of transport services needed to physically move vehicles (for example aircraft, road vehicles, rolling stock and watercraft) and freight.

Traffic management is implemented by people working with different job titles in different branches:

Within freight and cargo logistics: traffic manager, assessment of hazardous and awkward materials, carrier choice and fees, demurrage, documentation, expediting, freight consolidation, insurance, reconsignment and tracking
Within air traffic management: air traffic controller
Within rail traffic management: rail traffic controller, train dispatcher or signalman
Within road traffic management: traffic controller

Traffic Load on Road Network

The classified traffic counts conducted at 42 mid block, 10 outer cordon stations and 14 intersections provided extensive data on traffic flows on the road network of Delhi. Employing this data, the traffic flows have been arrived at on the adjoining links in the neighborhood of the count points. Thus the traffic flows along with composition have been worked out for each of the links of the road network identified for the purpose of this study. To validate the of traffic arrived at on neighboring links sample traffic counts were made to confirm the same. The estimated traffic load along each of the links is translated into pictorial form using digitized map of Delhi and *GIS Software, TRANSCAD* it can be seen that the radials and ring roads carry major portion of traffic movements in Delhi. Using the link traffic loads and composition of traffic by vehicle type, vehicle - kilometers traveled on each of the links have been estimated and in turn the total vehicle kilometers traveled by each category of vehicles on the road network of Delhi have been estimated. Table 4 presents the estimated travel *(from roadside counts)* made by different vehicles on a normal working day in Delhi using the primary road network. To validate this data, comparison has been made by estimating the vehicle - kilometers traveled on the basis of data obtained from the surveys at the fuel stations (CRRI, 2014) and vehicles in use *(estimated from vehicle vintage and registration data)*. Comparisons are presented in the above table and it can be seen that the estimated vehicle - kms of travel from road side and the fuel station interviews do not exactly match because most of the external traffic may not get accounted for at the fuel stations. It can be further inferred that the maximum proportion of travel *(80 percent)* is made combined by two wheelers and cars. This is followed by three wheelers corresponding about 12 percent of the total vehicle - kilometers while buses and goods vehicles have almost equal share of 3 percent each. A close observation of the overall registered vehicles and the estimated in-use vehicles in the above table reveals that only about 55 percent of the registered vehicles are in use. This clearly reflects that most of the decade old vehicles have been either phased out or transferred out of Delhi to other cities *(through second-hand sales).*

Table 2: Estimated Daily Traffic Load on Delhi Road Network

S. No.	Vehicle Type	Vehicle - Kms / day *(in Millions)*		Registered Vehicles *('000)*	Estimates of In-use Vehicles *('000)*
		Roadside Counts	Fuel Stations		
1	Cars + Taxis	30.689 *(38.7)*	26.799 *(34.9)*	Private Cars - 921	711
			Taxis – 18		
2	Two Wheelers	33.823 *(42.7)*	38.700 *(50.5)*	2231	1062
4	Autos	9.357 *(11.8)*	5.779 *(7.5)*	87	87
5	Goods Vehicles	2.514 *(3.2)*	2.990 *(3.9)*	158	64
6	Buses	2.851 *(3.6)*	2.428 *(3.2)*	41	NA
	Total	**79.234** ***(100.0)***	**76.696** ***(100.0)***	**3457**	**1924**

Technologies for Monitoring Road Conditions

Popular technologies for road condition monitoring are summarized below. Vision based pothole detection schemes have still not matured and work only in simplistic scenarios. It will not be easy to make vision based system work with wide variety of road anomalies and changing visibility conditions. Ground penetrating radar is a non-destructive evaluation technique for monitoring road conditions. The chief advantage of using ground penetrating radars is that it can detect internal damage in a road before it appears on the surface.

However, this technique requires specialized vehicles that need to traverse the entire road network. Also, this technique needs expensive equipment. Most recent work is now focused on using accelerometers for pothole detection. Accelerometer is a device which is able to detect acceleration forces both static and dynamic. So the vibrations that occur, when a vehicle encounters a pothole on the road, can be detected by accelerometers mounted on the vehicle. More details in the related work section. We will also be using accelerometers for monitoring road conditions.

Other Traffic Estimation Techniques

[YNL07] characterizes unique traffic patterns on road segments. It assumes the presence of a vehicular mobile network or some form of data communication capability. This capability is combined with GPS to generate location time traces. The authors then use several vehicular traces on a particular road segment to make spatio-temporal traffic plot which minimizes the loss of spatial and temporal traffic information. A threshold based quadrant clustering mechanism is used to identify current traffic condition. The approach of this work is completely different from ours. We do not asume any data communication capabilities or commuter participation. Also traffic in India is varied comprising not only of cars but also three wheelers, two wheelers and other types of vehicles. [MPR08] assumes the extensive presence of high end (hence expensive) mobile phones with sensors to perform rich sensing. The idea is to opportunistically use mobiles present with commuters as sensors. However, issues like privacy and user participation are still open questions.

Though sensing mechanisms are described, but it is not explained as to how all the sensed data will be processed to give useful information. The paper also introduces the concept of triggered sensing where a low power consuming sensor can be used to activate a more power consuming accurate sensor. For example. Traffic estimation is done using cellular localization to trigger GPS sensing. This concept can be adapted in our system where we can use a single magnetic sensor to trigger other magnetic sensors when sensor values remain above a certain threshold for a specific amount of time. Or we can use an acoustic sensor to trigger sensing of AMR magnetic sensors. In this way sensor nodes can conserve energy and get active only during possible onset of congestion. This approach again is different from ours. It uses mobile phone as its base. It has several open issue to address regarding its deployability in the context of traffic situation in India.

Road Traffic Safety

Road traffic safety refers to methods and measures for reducing the risk of a person using the road network being killed or seriously injured. The users of a road include pedestrians, cyclists, motorists, their passengers, and passengers of on-road public transport, mainly buses and trams. Best-practice road safety strategies focus upon the prevention of serious injury and death crashes in spite of human fallibility [1] (which is contrasted with the old road safety paradigm of simply reducing crashes assuming road user compliance with traffic regulations). Safe road design is now about providing a road environment which ensures vehicle speeds will be within the human tolerances for serious injury and death wherever conflict points exist. Furthermore, the highest possible degree of safety shall be ensured when transporting goods by road. It is of vital importance to monitor and validate the road transportation safety, including comprehensive checks on drivers, vehicles and safety processes.[2]

The basic strategy of a Safe System approach is to ensure that in the event of a crash, the impact energies remain below the threshold likely to produce either death or serious injury. This threshold will vary from crash scenario to crash scenario, depending upon the level of protection offered to the road users involved. For example, the chances of survival for an unprotected pedestrian hit by a vehicle diminish rapidly at speeds greater than 30 km/h, whereas for a properly restrained motor vehicle occupant the critical impact speed is 50 km/h (for side impact crashes) and 70 km/h (for head-on crashes).

As sustainable solutions for all classes of road have not been identified, particularly lowly trafficked rural and remote roads, a hierarchy of control should be applied, similar to best practice Occupational Safety and Health. At the highest level is sustainable prevention of serious injury and death crashes, with sustainable requiring all key result areas to be considered. At the second level is real time risk reduction, which involves providing users at severe risk with a specific warning to enable them to take mitigating action. The third level is about reducing the crash risk which involves applying the road design standards and guidelines (such as from AASHTO), improving driver behaviour and enforcement.

Vehicle Safety

Safety can be improved in various ways depending on the transport taken.

Buses and coaches

Safety can be improved in various simple ways to reduce the chance of an accident occurring. Avoiding rushing or standing in unsafe places on the bus or coach and following the rules on the bus or coach itself will greatly increase the safety of a person travelling by bus or coach. Various safety features can also be implemented into buses and coaches to improve safety including safety bars for people to hold onto.

The main ways to stay safe when travelling by bus or coach are as follows:

- Leave your location early so that you do not have to run to catch the bus or coach.
- At the bus stop, always follow the queue.
- Do not board or alight at a bus stop other than an official one.
- Never board or alight at a red light crossing or unauthorized bus stop.
- Board the bus only after it has come to a halt without rushing in or pushing others.
- Do not sit, stand or travel on the footboard of the bus.
- Do not put any part of your body outside a moving or a stationary bus.
- While in the bus, refrain from shouting or making noise as it can distract the driver.
- Always hold onto the handrail if standing in a moving bus, especially on sharp turns.
- Always adhere to the bus safety rules.

Cars

Safety can be improved by reducing the chances of a driver making an error, or by designing vehicles to reduce the severity of crashes that do occur. Most industrialized countries have comprehensive requirements and specifications for safety-related vehicle devices, systems, design, and construction. These may include:

Passenger restraints such as seat belts — often in conjunction with laws requiring their use — and airbags
Crash avoidance equipment such as lights and reflectors

Driver assistance systems such as Electronic Stability Control

Crash survivability design including fire-retardant interior materials, standards for fuel system integrity, and the use of safety glass

Sobriety detectors: These interlocks prevent the ignition key from working if the driver breathes into one and it detects significant quantities of alcohol. They have been used by some commercial transport companies, or suggested for use with persistent drunk-driving offenders on a voluntary basis.

Motorbikes

According to statistics, the percentage of intoxicated motorcyclists in fatal crashes is higher than other riders on roads. Helmets also play a major role in the safety of motorcyclists. In 2008, The National Highway Traffic Safety Administration (NHTSA) estimated the helmets are 37 percent effective in saving lives of motorcyclists involved in crashes.

Trucks

According to the European Commission Transportation Department "it has been estimated that up to 25% of accidents involving trucks can be attributable to inadequate cargo securing". Improperly secured cargo can cause severe accidents and lead to loss of cargo, loss of lives, loss of vehicles and can be a hazard for the environment. One way to stabilize, secure and protect cargo during transportation on the road is by using Dunnage Bags which are placed in the void between the cargo and are designed to prevent the load from moving during transport.

Regulation of road users

Various types of road user regulations are in force or have been tried in most jurisdictions around the world, some these are discussed by road user type below.

Motor vehicle users

Dependent on jurisdiction, driver age, road type and vehicle type, motor vehicle drivers may be required to pass a driving test (public transport and goods vehicle drivers may need additional training and licensing), conform to restrictions on driving after consuming alcohol or various drugs, comply with restrictions on use of mobile phones, be covered by compulsory insurance, wear seat belts and comply with certain speed limits. Motorcycle riders may additionally be compelled to wear a motorcycle helmet. Drivers of certain vehicle types may be subject to maximum driving hour regulations.

Some jurisdictions such as the US states Virginia and Maryland, have implemented specific regulations such as the prohibiting mobile phone use by, and limiting the number of passengers accompanying, young and inexperienced drivers. It has been noticed that more serious collisions occur at night, when the car has multiple occupants, and when seat belt use is less.

Insurance companies have proposed that the following restrictions should be imposed on new drivers:[citation needed] a "curfew" imposed on young drivers to prevent them driving at night, an experienced supervisor to chaperone the less experienced driver, forbidding the carrying of passengers, zero alcohol tolerance, raising the standards required for driving instructors and improving the driving test, vehicle restrictions (e.g. restricting access to 'high-performance' vehicles), a sign placed on the back of the vehicle (an N- or P-Plate) to notify other drivers of a novice driver and encouraging good behaviour in the post-test period.

Some countries or states have already implemented some of these ideas.[citation needed] Pay-as-you-drive adjusts insurance costs according to when and where the person drives.

Pedal bicycle users

Dependent on jurisdiction, road type and age, pedal cyclists may be required conform to restrictions on driving after consuming alcohol or various drugs, comply with restrictions on use of mobile phones, be covered by compulsory insurance, wear a bicycle helmet and comply with certain speed limits.

Pedestrians

Dependent on jurisdiction, jay walking may be prohibited.

Animals: Collisions with animals are usually fatal to the animals, and occasionally to drivers as well.

CONCLUSIONS

In this paper, the importance of having a traffic and road condition monitoring system was stressed. The issues related to building a traffic and road condition monitoring system that can be deployed in Indian conditions have been discussed. A brief survey of current traffic and road condition monitoring technologies was presented. We noted that traditional traffic monitoring systems are built for developed world. In India where traffic conditions are varied, lane discipline is not followed and traffic is unstructured these techniques fail to give expected results. Moreover these systems are expensive to deploy, difficult to install and maintain. Our traffic estimation system tries to determine traffic density and map itback to congestion levels on a road segment. Some initial experimental results were presented and architecture of our system stated. For traffic monitoring we intend to use accelerometers because they are cheap and effective. By using accelerometers we want, not only to detect potholes but also quantify them.

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