An Overview of Technique Used in Traffic Monitoring System

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Abstract In the recent past, the term traffic congestion has emerged as one of the most brutal challenges to face for the engineers, governments, planners and policy makers in almost every country. With ongoing advancements in social and economic structures, fabricated by vehicles-oriented urban development, they have established congestion as an inevitable reality of urban life. Predominantly there are various factors which play a humongous role towards aggravating this problem some of them are listed as: (Speed, Travel time, Delay, Volume) etc. Subsequently, every research demands exhaustive data collection and based upon that, reaching upon suitable methods to overcome the widely spread problem. Speed has emerged as the most important traffic measurement to identify congestion. This phenomenon has been widely classified into two types (i) Recurring and (ii) Nonrecurring. According to the United States Department of Transportation Federal Highway Administration-alone, nonrecurring congestion is responsible for more than 50% of the total traffic congestion, whereas, recurring congestion contributes for about 40%. Extensive collection of data is aimed to be done at several locations in order to measure the maximum number of traffic characteristics. The main emphasis of this paper is aimed towards understanding the techniques used in recurring urban congestion, its types and methods to curtail it with least available manpower. Literature reviews regarding this problem reveals some interesting insights.

Keywords Congestion · Speed · Travel time · Recurring · Non-recurring

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1 Introduction

In the transportation realm, congestion is a phenomenon resulting in speeds that are slower and sometimes much slower—than the conventional/normal or required free flow speed. The after effects of the congestion are quite often serious and involves issues including unexpected travel times for the drivers, pedestrians, passengers etc., increased fuel consumption, emission of harmful and toxic greenhouse gases and higher susceptibility to accidents are some its brutal effects. According to the 2011 census, India's urban population has substantially grown from 290 million in 2001, to 377 million in 2011, and this figure is equivalent of about 30% of India's overall population. Speedy urbanization along with many advantages has also come with several problems, including increased congestion. With about 1.21 billion in population in 2011, India emerged as the second largest country after China in terms of the density of population [1]. Although the present share of the urban population in India is relatively small, in the year 2020, urban population of India was estimated/accounted for about 34.9% of total population. Urban population of India progressively increased from 20% in 1971 to 34.9% in 2020. Now even though the percentage density of urban population in India is much more trivial in nature yet, the major contribution of the traffic congestion hails from the urbanized areas only. The causes are in abundance including:

- Large number of vehicles on the roadways due to scant in major transit options or due to some other unusual reasons.
- Asynchronous switching of traffic signals many times on a road intersection, when apparently the computers are suffering from breakdown.
- Overdeveloped areas wherein the major transition system itself is already overflowing and the provided road system results in inadequacy and so on and so forth.

According to a report published by The Financial Express (April 26th 2018) —"The traffic in Delhi costs $9.6 billion, which is about 12% of the GDP, while the peak-hour congestion is 129%. In Mumbai, the following cost is $4.48 billion and the rate of congestion is 135%, in Bangalore, the estimated cost is $5.92 billion and congestion is 162%. The highest level of peak-hour congestion is in Kolkata accounting for 171%, even as the cost is lowest at $1.97 billion." To add more to this grave situation, it was found out that traffic congestion in above mentioned four major cities costed the nation a massive sum of Rs 1.5 lacs crore, which itself was greater than the entire Railway transport budget of that year in many folds. Hence the nation's traffic management system seems to be highly adulterated and the ongoing scenarios of traffic congestion appear to be perpetual. However, TMS schemes have been formulated in many nations alongside India but the implementation of the policies and methods show vivid divergence from nation to nation [2]. TMS aims at making the commuters much more informed about traffic and road status hereby, reducing the negative impact of congestion, even though it can't be permanently solved but it can be permanently handled. Effective data acquisition

alone will not be sufficed to deal with this heterogeneity of vehicles on roadways, it requires comprehensive R&D efforts. Applications which are required in order to assess and manage the existing and forthcoming scenarios need transportation engineering background. Hence, the TMS terminologies must be comprehensible to all the domains working on it. In order to comprehensively utilize the potential of TMS following objectives must be fulfilled:

- Prioritize traffic scenarios according to real-time changes in traffic conditions.
- Accident Prevention and Safety.
- Management of Emergency vehicles.
- Route Optimization and Divergence information.
- Minimum involvement of manpower.
- Environmental Sustainability.

The typical Smart TMS not only helps in monitoring the vehicular traffic but is also a major source of imparting variety of related jobs to it. One can visualize this system as a costlier one; as it involves abundant amount of resources, but it has a much wider scope and even though it requires a good initial investment yet, it contributes towards the Sustainable Development of our existing fragile system. Developed countries like America, U.K. and Japan, have already implemented the TMS on their roads and still many researches are being conducted on to make the traffic systems more advanced and reliable for other developing countries as well.

2 Literature Review

Bertini and El-Geneidy [3]. In the given study, the researchers conclude that a complete ITS system requires collaboration in time, funding, and institutional arrangements. ITS components that are integrated can result in synergistic effects when considered as an entire system. It is shown that in some cases it is possible to build upon national level statistics describing ITS benefits by using data collected from the systems themselves [3]. In addition, there is no guarantee that travel time reduction due to the installation of ramp metering in one city will result in similar benefits in another city particularly if the nature of system integration and institutional cooperation is widely different.

Allström et al. [4]. In this study, the researchers have found that the large amount of data from these sensors does not by itself improve information to the road users (e.g. travel time information) or provide means for traffic control to the road authorities [4]. It is through the use of filtering techniques and models that this data enables new possibilities for online estimation and prediction of the traffic state, and for wide-area control in urban areas.

Aycard et al. [5]. In this study, A complete solution for the safety problem including the tasks of perception and risk assessment using on-board lidar and stereo-vision sensors will be presented. An approach for the safety of vehicles at the

intersection developed on the Volkswagen demonstrator is introduced. A complete solution to this safety problem including the tasks of environment perception and risk as-assessment are presented along with interesting results which could open potential applications for the automotive industry [5].

Cafiso et al. [6]. In present learning a case study was done with in field experiment, to show practical applicability of the system in bus-pedestrian conflicts, but potential use can be extended to different traffic conflicts in the field of vision of the system (e.g., rear end collision) and road users (e.g., vehicle, motorcycle, bikes) [6]. Indeed, the system is able to identify any spatial information of objects in the video frame with the added value, when compared to traditional radar equipment, to turn out in real-time a depth-map where spatial data are provided together with shape and color attributes of the object.

Al-Sakran [7]. The proposed traffic system based on the IoT consists of a large number of RFIDs and sensors that transmit data wirelessly. This calls for improved security to protect such massive amounts of data and privacy of users. IoT requires modification of network connectivity models and readiness for massive increase in amount of real-time information. To achieve that, interaction communication models must be redesigned to include machine to machine and people to machine communications.

3 Methodologies: (Proposed Prototype of TMS)

As mentioned above the paper deals with the congestion by adopting various measurability standards and comparing the data obtained so as to have a bird's eye view on the conditions and henceforth, proposing the most suitable method. In order to rationalize the proposed system, a comprehensive traffic solution is needed to be performed. The paper extensively imparts insights to the two working principles of TMS, namely, V2V (vehicle to vehicle) and V2I (vehicle to infrastructure) technologies.

V2V. Vehicle-to-vehicle (V2V) communication's competency is to cordlessly interchange particulars regarding the speed and coordinates of neighboring vehicles which shows great impact in helping to avoid several crashes/accidents to clear traffic congestion, and to contribute towards improving the environment. However, it must be kept in scrutiny that the greatest advantages can only be achieved when all the vehicles can interact with each other. Vehicles that could potentially use V2V communication technology on a wider scale range from two wheelers to 8 wheelers. Pedestrians may also avail advantage from V2V communication technology so that they can enhance their visibility to motorists and the others.

V2I. Vehicle-to-Infrastructure (V2I) communication is defined as a cordless barter of data existing between the automobiles and the route infrastructures (Command and Control Centre, traffic lights, lane markings etc.) [8]. With large data being

clutched and exchanged, copious and well-timed information can be optimized so as to enable a wide range of safety, accuracy, transportability, flexibility and environmental prosperity.

3.1 Sensors

The role of sensors is to prioritize the traffic intensity based on real-time data and real time scenarios. A sensor is a device which converts a physical phenomenon into a quantifiable analog voltage (or seldom a digital signal) which is fatherly converted into a human-readable display or is transmitted for reading and further processing. It is classified on the basis of power or energy supply requirement as:

Infrared Sensor

The TMS is comprised of Command & Control Centre which is responsible for monitoring and predicting several aspects and their related effect on the pre-existing traffic state. If management, for an instance is equipped with an infrared sensor, it is then embedded into various traffic gauging and maintenance tools at a road intersection for ex. traffic lights, CCTV, electric poles, crossways, electric meters etc. The principle on which it works is- "Active infrared sensors emit and detect infrared radiations, shown in Fig. 1. These sensors have two parts: a light emitting diode (LED) and a receiver. Whenever an object comes close to the sensor, the infrared light emitted from the LED reflects off of the object and thus, it is detected by the receiver" [9].

Acoustic Detectors

Like the infrared sensors the main purpose of these detectors is to accumulate the real time data and based on it gauge the ongoing situations. The major principle on which these detectors work is-"Acoustic wave sensor works on an oscillating electric field which in turn generate a mechanical wave, further propagating through the substrate and converting into an electrical field for measurement" [10]. The algorithms thus, established are used for the investigation and categorization of

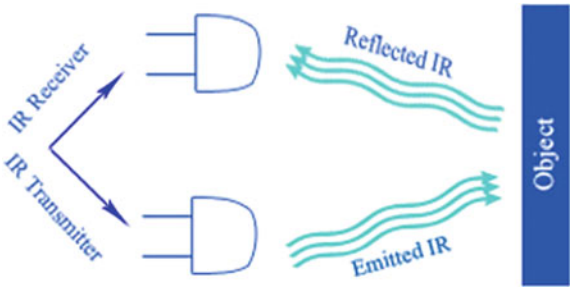

Fig. 1 Working of an infrared sensor

different acoustic signals, and also play a key role in detecting different types of impetuous sounds, which proportionately results in increasing traffic immunity.

Piezoelectric Sensors

These are one of the most widely used sensors which are required for the agglomeration of traffic-oriented data. The most common example of piezoelectric sensor is accelerometer. The main purpose of the sensor is to adjudge the object's position and coordinates in space and monitors its movement. They currently are being used in variety of sectors such as medical, aerospace, and nuclear instrumentation and consumer electronics. Similar to the acoustic detectors they also are squeezed by the pneumatic pressure of the vehicles and in turn generate an electric potential which is converted into a digital signal and get transmitted to the infrastructure.

Inductive Loop Detectors

These are one of the most frequently used detectors and are suitable and favorable to work in V2V and V2I information communication technologies. Their working principle is based on an inductive looping system that behaves as a tuned in EC (electrical circuit) in which, it comprises a loop wire and a fabricated lead-in cable and thus, these serve as the constituent inductive elements. When a vehicle is passed over the given loop or is halted within the loop, then instantaneously it induces eddy currents in the given wire loops, and causes reduction in their inductance. This decrease results in change in the magnetic field which causes a pulse and is installed as a vehicle registration in database [11].

Thus, sensors in future can play a pivotal role for TMS. Their incorporation enables the advancement of a diverse variety of implementations for the traffic safety, congestion control and many more. Sensors render the required mechanism for data accumulation pertaining to the vehicular circumstances (like-route conditions, congestion conditions and vehicular conditions) which can be unified with the existing transportation systems so that it can lessen many of the problems that our transportation systems are facing from a long time.

3.2 Global Positioning System (GPS)

In last few years, TMS are potentially acquiring propensity towards ever more automatic, creditable, interrelated, disseminated operations. The latest development of dynamic transmission gadgets and conveying automation has stimulated an expanding curiosity in the Geographic Information System & Global Positioning System-built position-informed structures and assistance [12]. Everyone is well acquainted as up to what extent GPS has been unified in their daily lives, particularly in the mobile phones. The mentioned system is advanced as a fully automatic, ceaseless and a concurrent invigilate structure that engages GPS detectors as

well as coaxial cable sequent port inter-transmission methods which further are utilized to exchange information between receivers and a data processing unit.

The infrastructure of TMS is dormant of various devices located in a given juxtaposition of a road intersection and based upon their workings the data is conjunct and transmitted to the Command & Control Centre where-about it is further handled and monitored. GPS can serve as a guiding tool. Hereby, GPS works on Route Optimization and Divergence information. At this juncture, transportation/hauling system has a very crucial role in practically everyone's life however, when the time comes to lay hold of the public transportation, specifically the bus transport and its related networks, time and perseverance are of prime importance. To put it into another way, large number of people which currently are using the facility of bus transport have encountered loss in their time because of long duration waiting at the bus stops, due to which the spirit to prefer public transportation in time of urgency exponentially deteriorates, and also it escalates the congestion. In order to curb down this problem, the Malaysia Public Bus Monitoring System came forward to track the current locations of the buses and other public transports in the form of coordinates of latitude and longitude via GPS and GSM [13]. It thus, focuses on reducing waiting time of the bus users and to make the current bus service system robust, flexible and dynamic.

3.3 Radio Frequency Identification (RFID)

It is a system, which works on the emission and reception of radio waves so as to transmit the data of the vehicles passing through it from one place to another. In this study, a RFID Identification System is planted for checking the details of the vehicles at the traffic monitoring centers which are located at various locations. The main concern of implanting RFID in the study is to provide flexibility to the emergency vehicles. Emergency situations are always unpredictable and demand immediate attention and thus it becomes utterly necessary to provide anytime access to the emergency vehicles like Ambulance, Fire extinguishing vehicles [14]. Here RFID can extend a big role in allowing uniform access to such kind of vehicles. The vehicles are equipped with RFID tags analogous to a QR code. If the intersection on which they are transiting is overcrowded with congestion, then the drivers of the vehicles need to activate the tags which emit radio frequencies in a given proximity and these frequencies are detected by the receivers which alert the traffic administrators regarding their arrival and thus, they can take necessary actions to maintain the homogeneity in flow of these vehicles. RFID system works on a variety of frequencies such as, Ultra-high frequency, Low frequency and High frequency [15]. The working of various frequencies shown in Table 1 for various countries is as follows.

Low frequency tags are cheaper in nature and feed on less power when compared to different varieties of RFID tags. High and ultra-high frequency tags can

Table 1 Working frequencies of RFIDs

S. no.	Various range of frequencies	Countries
1	125 to 134 kHz	U.S.A, Japan, Canada
2	13.5 MHz	U.S.A, Japan, Europe
3	433 kHz to 434 MHz	Japan, Europe
4	864 kHz to 869 MHz	India
5	865 to 868 kHz & 920 to 970 MHz	South Korea
6	900 kHz to 930 MHz	U.S.A
7	2400 kHz to 2500 & 572 to 587 MHz	U.S.A, Canada, Europe

transfer data faster, are expensive and provide better ranges as compared to low frequency labels. Generally, two types of RFID tags are used, namely:

Passive Tags: Such tags receive power through the reading transmitting aerial antenna, which generates an electromagnetic wave to produce a current in the antenna situated within the RFID tags. Structural passive RFID tags and active RFID are shown in Fig. 2 and 3 [16].

Active Tags: In such RFID tag a battery is provided, which acts as its power source.

RFID possesses the following components namely (a) a scanning antenna, (b) transponder and (c) receiver. RFID reader is a combination of a scanning antenna and a transceiver.

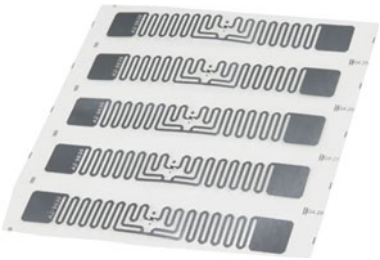

Fig. 2 Structural passive RFID tag

Fig. 3 Structural active RFID

3.4 Smart Traffic Lights

Smart traffic light or intelligent traffic light is a contingency traffic curbing system for a road convergence particularly defined for the event of collision/crashing and accident, with congestion recovery, live lock interception, and dispute resolution. These ingenious traffic lights reduce slacks such as congestion or automobiles standing by at vacant convergences. A grid of these lights can recognize paradigms in traffic states and then refurbish their signals in actual duration. These ingenious traffic lights utilize data procured from devices like sensors, cameras, GPS, vehicles, cell phones and other devices to detect patterns of traffic and the density of vehicles, pedestrians and bicyclists close to an intersection.

"A Modified Approach: Smart Traffic Congestion Control System" incorporates RFID technology to recognize the frequency of traffic jams. The entire light cycle is dynamic and is synchronized, based on density of traffic so as to reduce congestion with prior help of numerous sensors. On every vehicle a passive RFID tag is instated, and the detectors are responsible for recording total number of automobiles passing through the upcoming sensors located in given vicinity [16].

Smart Traffic Lights for Stolen Vehicles

For "Intelligent Traffic Control System and its Implementation for Congestion Control and Stolen Vehicle Detection," extensively, the emphasis is laid on the collaborative working of smart traffic lights and RFID tags in order to trace vehicles which are stolen. The working of the system is as follows-"If the given vehicle crosses a convergence, it is detected/ identified and a text message is thus, sent to the police Centre". As mentioned earlier emergency vehicles are differentiated based on the frequency of their RFID tags, and the idea of providing a green light is used for better precision [17].

Smart Traffic Lights for Pedestrians

Study on "Smart Pedestrian Crossing Management at Traffic Light Junctions through a Fuzzy-Based Approach," utilizes a bleary-based approach by introducing in three mode functions i.e. (low, medium and high). The number of pedestrians on the road serves as input and the stages of the traffic lights as output [18]. Working of smart traffic light for pedestrian is shown in Fig. 4.

Fig. 4 Infrastructural working of smart traffic light

4 Conclusions

- Traffic Monitoring System can be created by utilizing different parts of Internet of Things. Traffic enhancement is accomplished by utilizing those devices which work on the basis of some scientific principle. Two basic highlights for this system have been mentioned namely V2V and V2I for proficient functioning of the system.
- The transmission of information from one technique to another facilitates least density, more accuracy and more flexibility on the road. Various services like collision prevention, path optimization, procurement of real time data, systematic monitoring and so on, overshadow the very few shortcomings that this initiative initially has.
- This paper tries to present a viable answer for quicker development of traffic reducing stream especially in enormous urban communities which are invariably expanding step by step.
- However, this proposed structure which is based on IOT devices carries with it a permanent threat of data breaching of the commuters. Equipped with devices, that carries data without a physical medium. This by default arises the need for enhanced security measures to secure this colossal amount of data of the users.
- The decentralized methodologies make the flow of information streamlined and thus, this framework works flawlessly regardless of whether a neighborhood's road intersection is heavily congested or not.

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