Intelligent Traffic and Transport Management Systems: Categorization, Problems and Future Objectives

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Abstract In recent years, large number of vehicles are running on the roads, but available traffic infrastructure is not able to beat it. Therefore, nowadays, traffic congestion is major concern, and it gives rise to happen more accidents. This problem creates adverse effects on society, including economic development, traffic accidents, rise in greenhouse productions, time loss and health issues. In this situation, it requires a modern and robust traffic management system to reduce traffic congestion and its adverse effects. There is a need of traffic management systems which consist of a set of modern applications which consist of application and management tools to expand the efficiency overall traffic. Also, such system should provide the safety to the transportation systems. This system works by gathering information from various types of sources, and then it analyzes the collected such information and identifies the problems that could degrade the traffic efficiency and then runs services to manage them. By considering all these aspects, this paper presents a classification system to analyze challenges and develop a future outlooks to generate a traffic management system.

1   Introduction

In a developing infrastructure, roads are a piece of core unit in it, and it supports people and logistics movements, formation in the foundation of social and economic development and interconnecting cities, ports, projects and airports. There are various issues arising in this procedure, i.e., maintenance, development of roads, congestion and traffic and increasing population. For this, we propose a new system of roads
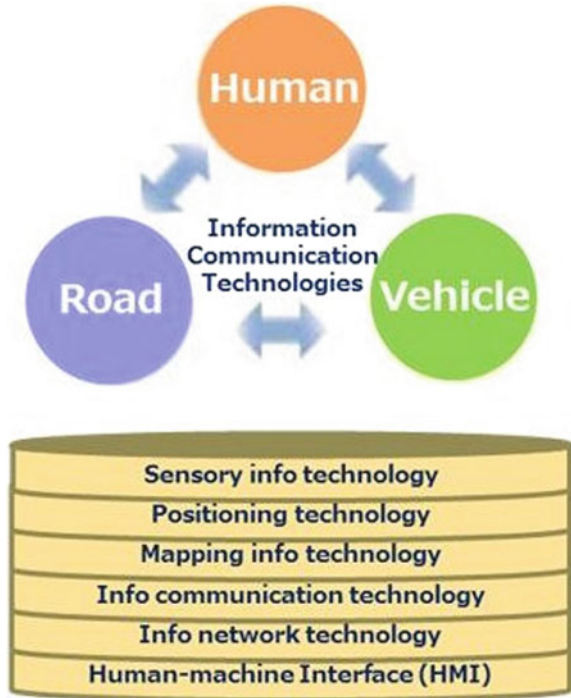
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Fig. 1 Basic components
used in ITS

which is a combination of information, communication and control techniques to integrate drivers, vehicles and roads properly. This system is called as intelligent transport system (ITS) which only aims to traffic-related issues along with many other ones (Fig. 1).

For which, we have set its applications focus on three issues of problems: Society, the road administrator and drivers. At societal level, it helps in decreasing accidents, environmental effects and reducing traffic. Similarly, at the level of road administrator, management of roads and traffic can be handled by identifying the hazardous locations and frequently congested areas using probe information collected by vehicles. And at last in case of drivers, we can get advantage in economic front such as reduced tolls, route detection and payments of tolls and parking. ITS provides just not only a convenient road traffic application along with the provision of the usage of variety of information and communication technologies that results to the generation of new employment and business opportunities along with economic development.

1.1 Problems Faced in Traffic Management System

Basic Problems Faced in Traditional Traffic management System:

Urbanization: Increase in population living in metropolitan and nearby cities for having better earning opportunities.

Increasing transportation demands: Along with increasing population, demands for better and cheap transportation also increase, due to which there is an increase of motor vehicles on roads.

Increasing pollution: Along with increasing vehicles, emission of pollutant gases like CO_2 and other gases occur as the usage of fuels increases in sufficient amount.

Increasing traffic issues: Road safety and congestion.

1.2 Categorization of Intelligent Traffic and Transport Management System

Categorization of ITTMS is done on basis of infrastructure-based and infrastructure-less approaches. All the research work done in this field so far is basically categorized in infrastructure-based and infrastructure-less approaches. Parameters focused for dividing various approaches are design, goals, identification strategy, re-routing strategy and network challenges (Fig. 2).
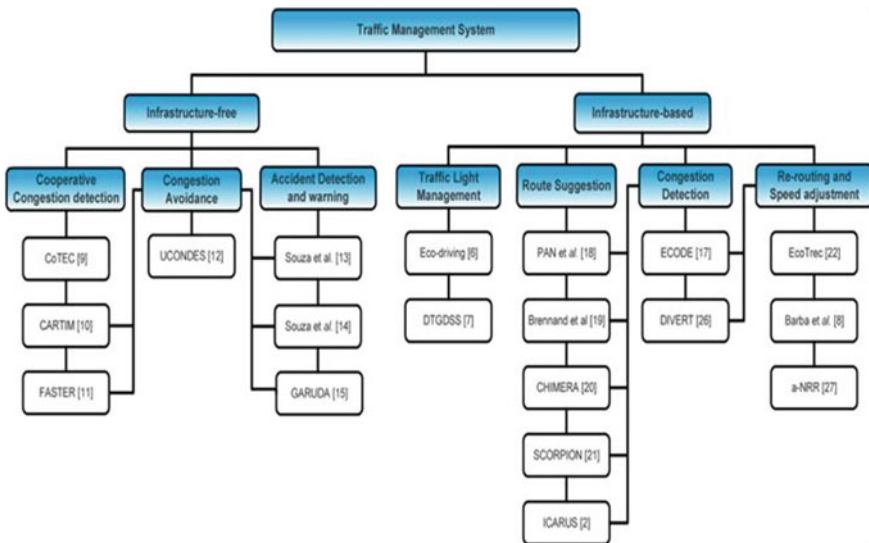

Fig. 2 ITTMS classification

2   Comparison of Various Infrastructure-Based and Infrastructure-less ITTMS Approaches on Design and Goal Strategy

See Tables 1 and 2.

3   Proposed Methodology

The challenge is to build a low-cost information platform for monitoring traffic flows and to bring that information from different parts of a city together so that it can be analyzed to enable better traffic management routines for mega-cities in low income countries. Present traffic flow monitoring techniques used in developed countries such as SCOOT cannot cope with the volume of traffic, which would go quickly wear out the SCOOT loops. In addition, newer systems such as ETSI-G5 technology for connected vehicles are very expensive. These systems work by having On Board Units (OBUs) and Roadside Units (RSUs), which are placed along the road infrastructure. Currently, an OBU and an RSU each cost over $1000 USD. So the solution being proposed is to use Bluetooth Low Power (BLE) devices. These devices communicate using Bluetooth technology and have a common coverage range of 70–100 m.

Since mobile phones also have Bluetooth interfaces, a lot of apps have been written to take data from the BLE device and use the mobile phone to communicate with a central server or navigational entity. Though what we are proposing does not remove such capability, the system we want to build is not be dependent on users having mobile phones. Instead, the BLE device will beacon every few seconds, and those beacons with their UUIDs will be picked up be WiFi/BLE gateways. The gateway devices cost £54 each, and this project will buy 50 of such gateways. These gateways will then use right wireless routers wireless routers, which will be connected to the University of Ghana's communications network. This is an Ethernet network running at 1 Gbps. The data will be routed to a central server where it will be stored and processed and used to display traffic flows in real time.

The WiFi/BLE gateways will be placed on two very busy roads that border the University of Ghana. The first is called National Highway—4 or N4, which runs from north to south along the east side of the campus. In fact, it forms a direct boundary with the campus for 3.5 km. The second road is called the Haatso-Atomic road and runs from east to west on the north side of the campus and forms a natural campus boundary for 1.5 km. So in this proposal, we would like to monitor traffic from both roads making this a total of 5 km of road infrastructure that will be monitored. The data gathered will be analyzed to show the traffic flow along these roads. The results will be displayed using a virtual network computing (VNC) server; hence, the results will be available to all commuters in real time. Information will also be

Table 1 .

Solutions of various ITTMS approaches		Design		Goals						
		V2V	V2I	Congestion De-	Accident detection	Traffic classification	Traffic	Data dissemination	Congestion avoid-	Speed adjustment
Infrastructure-less approaches	CoTEC [1]	Yes	No	Yes	No	Yes	No	No	No	No
	CARTIM [2]	Yes	No	Yes	No	Yes	Yes	No	Yes	No
	FASTER [3]	Yes	No	Yes	No	Yes	No	No	Yes	No
	UCONDES [4]	Yes	No	Yes	No	No	No	Yes	Yes	No
	De Souza et al. [5]	Yes	No	Yes	Yes	No	No	Yes	Yes	No
	De Souza and Villas [6]	Yes	No	Yes	Yes	No	No	Yes	Yes	No
	GARUDA [7]	Yes	No	No	Yes	No	Yes	Yes	Yes	No
	Eco-driving [8]	No	Yes	No	No	No	Yes	No	Yes	Yes
	DTGDSS [9]	No	Yes	No	No	No	Yes	No	Yes	No
Infrastructure-based	DSP [10]	No	Yes	Yes	No	No	Yes	No	No	No
	Brenand [1]	No	Yes	Yes	No	No	Yes	Yes	No	No
	CHIMERA [11]	No	Yes	Yes	No	No	Yes	Yes	Yes	No
	SCORPION [12]	No	Yes	Yes	No	No	Yes	No	Yes	No
	ICARUS [13]	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No
	ECODE [14]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No
	DIVERT [15]	Yes	Yes	Yes	No	No	No	Yes	Yes	No
	EcoTrec [16]	Yes	Yes	No	Yes	No	No	No	Yes	No
	Barba et al. [17]	Yes	Yes	No	Yes	No	Yes	No	No	Yes

Table 1 (continued)

Solutions of various ITTMS approaches		Design		Goals							
		V2V	V2I	Congestion De-	Accident detection	Traffic classification	Traffic	Data dissemination	Congestion avoid-	Speed adjustment
	a-NRR [18]	No	Yes	No	No	No	No	No	No	No

Table 2 .

Solutions of various ITTMS approaches		Identification strategy				Network challenges			Re-routing strategy		
		Fuzzy log	Neural network	Classifier	EA	Broadcast storm	Network particle	IEEE 802.11 P	Shortest path	Traffic balance	Rerouting
Infrastructure-less approaches	CoTEC [1]	Yes	No	No	No	No	No	No	No	No	No
	CARTIM [2]	Yes	No	No	No	Yes	No	No	Yes	Yes	No
	FASTER [3]	No	No	No	Yes	Yes	No	Yes	Yes	Yes	No
	UCONDES [4]	No	Yes	No	No	Yes	Yes	No	Yes	Yes	No
	De Souza et al. [5]	No	No	No	No	No	No	No	Yes	No	No
	De Souza and Villas [6]	No	No	No	No	No	No	No	No	Yes	No
	GASUDA [7]	No	No	No	No	No	No	No	Yes	No	No
	Eco-driving [8]	No	No	No	Yes	Yes	Yes	No	Yes	Yes	No
	DTGDSS [9]	No	No	No	Yes	Yes	No	No	Yes	Yes	No
Infrastructure-based approaches	DSP [10]	No	No	No	Yes	No	No	Yes	No	No	No
	Brennand et al. [19]	No	No	No	Yes	No	No	No	Yes	No	No
	CHIMERA [11]	No	No	Yes	No	Yes	Yes	No	Yes	Yes	No
	SCORPION [12]	No	No	Yes	No	No	No	No	No	No	Yes
	ICARUS [13]	No	No	Yes	No	Yes	No	No	Yes	Yes	No
	ECODE [14]	No	No	No	No	Yes	No	No	Yes	Yes	No
	DIVERT [15]	No	No	No	No	No	No	Yes	No	No	No

(continued)

Table 2 (continued)

Solutions of various ITTMS approaches	Identification strategy					Network challenges				Re-routing strategy		
	Fuzzy log	Neural network	Classifier	EA		Broadcast storm	Network particle	IEEE 802.11 P		Shortest path	Traffic balance	Rerouting
EcoTiec [16]	No	No	No	No		No	Yes	No		No	No	No
Barba et al. [17]	No	No	No	No		No	No	No		Yes	Yes	No
a-NRR [18]	No	No	YES	No		No	No	No		No	No	No

communicated using mobile phones as well as road signage such as overhead road gantries.

Proposed methodology has been organized into:

(a) **Research Design**: The study is both exploratory and descriptive in nature. Exploratory research design has identified the related variables of the study and defined the research problem. The conceptual framework incorporating the relevant variables is also proposed through exploratory research. Thereafter, descriptive research design has been used to empirically test the proposed conceptual framework of the study and subjecting the data to statistical analysis.

(b) **Objectives of the Study**:
- Proper monitoring of traffic flow on roads using a low-cost solution will help in providing information and raising warning messages on timely basis to all the road users.
- Identifying the pits, cracks on the roads, crocodile-shape roads, distraction caused due to any unwanted objects and unwanted breakers in order to prevent damage in the vehicles and road accidents. Main objective is to minimize the casualties/fatalities that happen on the road.
- Objective is to provide the safety on Indian Roads by associating the risk associated with roads and to specify the ranking of roads on the basis of quality of roads.
- By analyzing and retrieving the data from the vehicles regarding obstruction on the road in turn will be provided to the government in order to remove that obstruction. Objective is to provide congestion free and cost-effective driving experience to all road users.

(c) **Sampling Design**:

The sample for the study the city of Noida has been selected. We plan to collect the data regarding the roads condition and traffic conditions of the road near the Amity campus. To study will be performed on the road conditions using the sample size of 500 vehicles with BLE devices for communication and sensors like accelerometers embedded with them.

(d) **Data Collection Instruments**:

The basic data collection instruments are the sensor that is embedded on the vehicle.
1. Accelerometer
2. Gyro meter
3. Cameras
4. GPS
5. Smart phones with WiFi connectivity
6. Bluetooth
7. APP on smart phone for emergency messages.

(e) **Data Collection Method**:

The study is based on survey method of collecting initial information during the research process. Primary data is collected by researcher himself using survey
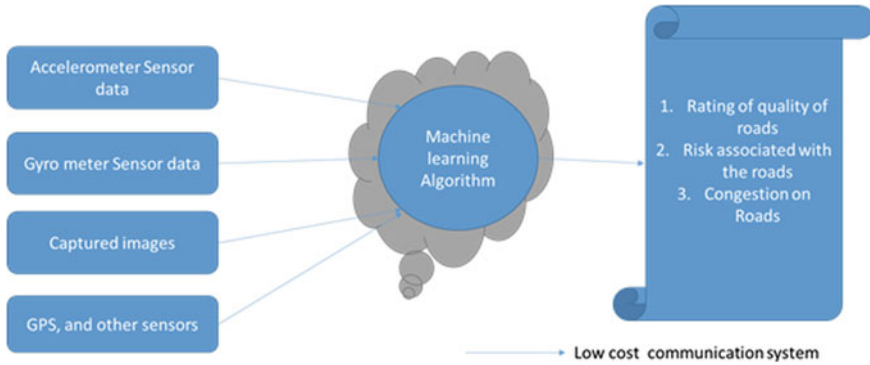
Fig. 3 Proposed model

method. It is a reliable way to collect the data because researcher knows where it came from and how it was collected and analyzed.

(f) **Statistical Techniques**:

The various data cleaning and analysis operations will be performed based on the data collected form the sensors and perform the analysis using statically operations used in the machine learning algorithm. The summarized tentative plan for the same has been described in the figure below.

(g) **Variables of the Study**:

Demographic variables such as gender, age, education, occupation, driving experience, driving training and type of vehicles are independent variables of the study, and factors such as risk perception and perception of driving tasks have been treated as exogenous variable and road safety attitude comprising five factors of traffic rules, personal responsibility, road safety and distraction on roads are treated as endogenous variable in the study (Fig. 3).

4   Challenges in ITTMS

In this section, various challenges faced in ITTMS are:

- Homogenous and heterogeneous data collection and integration of data.
- Managing large amount of data received from sensor is a tedious task.
- Monitoring and surveillance of traffic condition.
- Functionality similar to Google Maps for providing alternate route guidance.
- SCOOT technology can only be used where the traffic flow is very less such as Yamuna Express Way or Agra-Luck now Expressway.
- In addition to SCOOT, new technology was developed that is ETSI-G5 which is very expensive as it uses On Board Units and Road Side Units which are placed along with the road infrastructure.

- Neither SCOOT nor ETSI-G5 talks about the safety of roads. Only monitoring or surveillance of vehicles is done using these technologies. This seems to be providing a costly incomplete solution in terms of all types of traffic flow.
- Quality of the roads and accidents due to animals is not being considered in the literature as the factor for road accidents or damages in the vehicles.
- Study of traffic congestion at traffic lights was not discussed in the literature.

5 Conclusion and Future Scope

This paper basically focuses on the various challenges faced in the traffic management system. An improvement in ITTMS is expected from the researchers and industrialists by identifying the various challenges and research gaps. Various researchers have already proposed different research schemes in order to strengthen the traffic flow and congestion of traffic. Basic analysis of all the researchers who have done their research in the field of TMS is done, and some gaps are identified as future work for other researchers. Proper monitoring of traffic flow on roads using a low-cost solution will help in providing information and raising warning messages on timely basis to all the road users. Identifying the pits, cracks on the roads, crocodile shaped-roads, distraction caused due to any unwanted objects and unwanted breakers in order to prevent damage in the vehicles and road accidents. Main objective is to minimize the casualties/fatalities that happen on the road. Objective is to provide the safety on Indian Roads by associating the risk associated with roads and to specify the ranking of roads on the basis of quality of roads. By analyzing and retrieving the data from the vehicles regarding obstruction on the road in turn will be provided to the government in order to remove that obstruction. Objective is to provide congestion free and cost-effective driving experience to all road users.

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