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INTELLIGENT TRANSPORT SYSTEM

Asif Husain[1], Jabbar Ahmad[2], Abdul Mujeeb[3], Rafia Nihal[4]

[1]Professor, [4]Student Deptt. of Civil Engineering, J.M.I., New Delhi, (India)

[2]Assistant Professor, [3]Associate Professor,Deptt.of Civil Engineering,

IIMT,College of Engineering, Greater Noida (U.P.), (India)

ABSTRACT

This paper is devoted to a literature review of intelligent transportation systems. Traffic control has been an issue since humans put the first wheels on the first cart. The modern world demands mobility. Cars represent the main method of mobility, but today's congested highways and city streets don't move fast, and sometimes they don't move at all. Intelligent traffic systems (ITS), sometimes called intelligent transportation systems, apply communications and information technology to provide solutions to this congestion as well as other traffic control issues. Intelligent Transportation Systems (ITS) represent a major transition in transportation on many dimensions. ITS is an international program intended to improve the effectiveness and efficiency of surface transportation systems through advanced technologies in information systems, communications, and sensors. ITS (Intelligent Transport Systems) is a system which is designed to promote advanced technology, to ensure that the Electronic Toll Collection System (ETC) is effective and to support safe driving. With this system, people, roads, and vehicles use the latest information communication technology.

I. INTRODUCTION

Problems like high traffic congestion; low transportation efficiency, low safety and endangered environment can be solved through innovative and sophisticated ways of handling latest techniques that have emerged in recent years in integrating information technology, electronics and telecommunication with roads and traffic management. Intelligent transportation systems, or ITS, encompass a broad range of wireless and wire line communications-based information, control and electronics technologies.

When integrated into the transportation system infrastructure, and in vehicles themselves, these technologies help monitor and manage traffic flow, reduce congestion, provide alternate routes to travelers, enhance productivity, and save lives, time and money. Intelligent transportation systems provide the tools for analyze, and archive data about the performance of the system during the hours of peak use. Having this data enhances traffic operators' ability to respond to incidents, adverse weather or other capacity constricting events.

Intelligent transportation systems (**ITS**) are advanced applications which, without embodying intelligence as such, aim to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks.

Although ITS may refer to all modes of transport, EU Directive 2010/40/EU (7 July 2010) defines ITS as systems in which information and communication technologies are applied in the field of road transport, including infrastructure, vehicles and users, and in traffic management and mobility management, as well as for interfaces with other modes of transport.

II. INTELLIGENT TRANSPORTATION TECHNOLOGIES

2.1 Wireless Communications

Various forms of wireless communications technologies have been proposed for intelligent transportation systems.

Radio modem communication on UHF and VHFfrequencies are widely used for short and long range communication within ITS.

Short-range communications of 350m can be accomplished using IEEE 802.11 protocols, specifically WAVE or the Dedicated Short Range Communications standard being promoted by the Intelligent Transportation Society of America and the United States Department of Transportation. Theoretically, the range of these protocols can be extended using Mobile ad hoc networks or Mesh networking.

Longer range communications have been proposed using infrastructure networks such as WiMAX (IEEE 802.16), Global System for Mobile Communications (GSM), or 3G. Long-range communications using these methods are well established, but, unlike the short-range protocols, these methods require extensive and very expensive infrastructure deployment. There is lack of consensus as to what business model should support this infrastructure.

Auto Insurance companies have utilized ad hoc solutions to support eCall and behavioral tracking functionalities in the form of Telematics 2.0.

2.2 Computational Technologies

Recent advances in vehicle electronics have led to a move towards fewer, more capable computer processors on a vehicle. A typical vehicle in the early 2000s would have between 20 and 20 and 100 individual networked microcontroller/Programmable logic controller modules with non-real-time operating systems. The current trend is toward fewer, more costly microprocessor modules with hardware memory management and Real-Time Operating Systems. The new embedded system platforms allow for more sophisticated software applications to be implemented, including model-based process control, artificial intelligence, and ubiquitous computing. Perhaps the most important of these for Intelligent Transportation Systems is artificial intelligence.

2.3 Floating Car Data/Floating Cellular Data

Fig.: RFID E-ZPass reader attached to the pole and its antenna (right) used in traffic monitoring in New York City by using vehicle re-identification method

"Floating car" or "probe" data collection is a set of relatively low-cost methods for obtaining travel time and speed data for vehicles travelling along streets, highways, motorways (freeways), and other transport routes. Broadly speaking, three methods have been used to obtain the raw data:

- **Triangulation method:** In developed countries a high proportion of cars contain one or more mobile phones. The phones periodically transmit their presence information to the mobile phone network, even when no voice connection is established. In the mid-2000s, attempts were made to use mobile phones as anonymous traffic probes. As a car moves, so does the signal of any mobile phones that are inside the vehicle. By measuring and analyzing network data using triangulation, pattern matching or cell-sector statistics (in an anonymous format), the data was converted into traffic flow information. With more congestion, there are more cars, more phones, and thus, more probes. In metropolitan areas, the distance between antennas is shorter and in theory accuracy increases. An advantage of this method is that no infrastructure needs to be built along the road; only the mobile phone network is leveraged. But in practice the triangulation method can be complicated, especially in areas where the same mobile phone towers serve two or more parallel routes (such as a motorway (freeway) with a frontage road, a motorway (freeway) and a commuter rail line, two or more parallel streets, or a street that is also a bus line). By the early 2010s, the popularity of the triangulation method was declining.
- **Vehicle re-identification:** Vehicle re-identification methods require sets of detectors mounted along the road. In this technique, a unique serial number for a device in the vehicle is detected at one location and then detected again (re-identified) further down the road. Travel times and speed are calculated by comparing the time at which a specific device is detected by pairs of sensors. This can be done using the MAC (Machine Access Control) addresses from Bluetooth devices, or using the RFID serial numbers from Electronic Toll Collection (ETC) transponders (also called "toll tags").
- **GPS based methods:** An increasing number of vehicles are equipped with in-vehicle satnav/GPS (satellite navigation) systems that have two-way communication with a traffic data provider. Position readings from

these vehicles are used to compute vehicle speeds. Modern methods may not use dedicated hardware but instead Smartphone based solutions using so called Telematics 2.0 approaches.

Floating car data technology provides advantages over other methods of traffic measurement

- Less expensive than sensors or cameras
- More coverage (potentially including all locations and streets)
- Faster to set up and less maintenance
- Works in all weather conditions, including heavy rain

2.4 Sensing Technologies

Technological advances in telecommunications and information technology, coupled with ultramodern/state-of-the-art microchip, RFID (Radio Frequency Identification), and inexpensive intelligent beacon sensing technologies, have enhanced the technical capabilities that will facilitate motorist safety benefits for intelligent transportation systems globally. Sensing systems for ITS are vehicle- and infrastructure-based networked systems, i.e., intelligent vehicle technologies. Infrastructure sensors are indestructible (such as in-road reflectors) devices that are installed or embedded in the road or surrounding the road (e.g., on buildings, posts, and signs), as required, and may be manually disseminated during preventive road construction maintenance or by sensor injection machinery for rapid deployment. Vehicle-sensing systems include deployment of infrastructure-to-vehicle and vehicle-to-infrastructure electronic beacons for identification communications and may also employ video automatic number plate recognition or vehicle magnetic signature detection technologies at desired intervals to increase sustained monitoring of vehicles operating in critical zones.

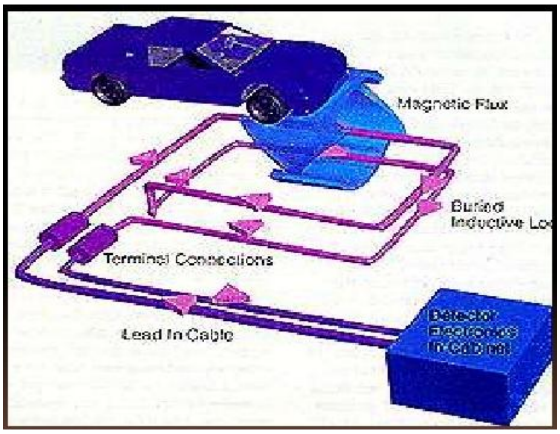


Fig.: Car passing over inductive loop buried in pavement

2.5 Inductive Loop Detection

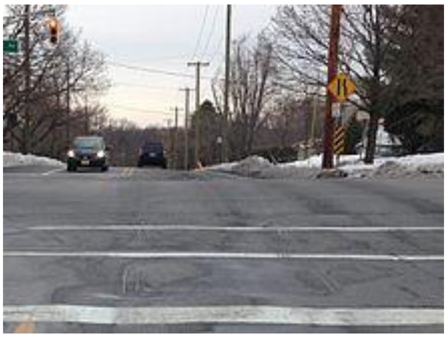
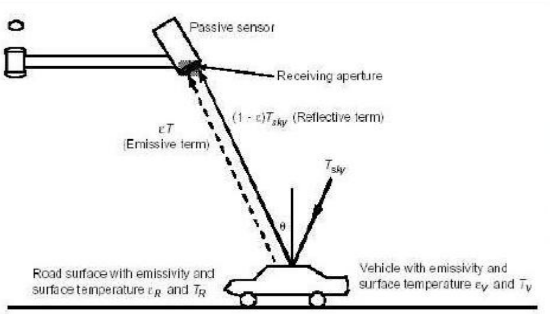


Fig.: Saw cut loop detectors for vehicle detection buried in the pavement at this intersection as seen by the rectangular shapes of loop detector sealant at the bottom part of this picture.

Inductive loops can be placed in a roadbed to detect vehicles as they pass through the loop's magnetic field. The simplest detectors simply count the number of vehicles during a unit of time (typically 60 seconds in the United States) that pass over the loop, while more sophisticated sensors estimate the speed, length, and class of vehicles and the distance between them. Loops can be placed in a single lane or across multiple lanes, and they work with very slow or stopped vehicles as well as vehicles moving at high-speed.

2.6 Video Vehicle Detection

Traffic-flow measurement and automatic incident detection using video cameras is another form of vehicle detection. Since video detection systems such as those used in automatic number plate recognition do not involve installing any components directly into the road surface or roadbed, this type of system is known as a "non-intrusive" method of traffic detection. Video from cameras is fed into processors that analyze the changing characteristics of the video image as vehicles pass. The cameras are typically mounted on poles or structures above or adjacent to the roadway. Most video detection systems require some initial configuration to "teach" the processor the baseline background image. This usually involves inputting known measurements such as the distance between lane lines or the height of the camera above the roadway. A single video detection processor can detect traffic simultaneously from one to eight cameras, depending on the brand and model. The typical output from a video detection system is lane-by-lane vehicle speeds, counts, and lane occupancy readings. Some systems provide additional outputs including gap, headway, stopped-vehicle detection, and wrong-way vehicle alarms.



III. INTELLIGENT TRANSPORTATION APPLICATIONS

3.1 Electronic Toll Collection

Today, most toll roads are equipped with an electronic toll-collection system like E-ZPass that detects and processes tolls electronically. E-Zpass uses a vehicle-mounted transponder that is activated by an antenna on a toll lane. Your account information is stored in the transponder. The antenna identifies your transponder and reads your account information. The amount of the toll is deducted and you're allowed through.

Fig.: Electronic Toll Collection System

3.2 Emergency Vehicle Notification Systems

The in-vehicle eCall is an emergency call generated either manually by the vehicle occupants or automatically via activation of in-vehicle sensors after an accident. When activated, the in-vehicle eCall device will establish an emergency call carrying both voice and data directly to the nearest emergency point (normally the nearest E1-1-2Public-safety answering point, PSAP). The voice call enables the vehicle occupant to communicate with the trained eCall operator. At the same time, a minimum set of data will be sent to the eCall operator receiving the voice call.

The minimum set of data contains information about the incident, including time, precise location, the direction the vehicle was traveling, and vehicle identification. The pan-European eCall aims to be operative for all new type-approved vehicles as a standard option. Depending on the manufacturer of the eCall system, it could be mobile phone based (Bluetooth connection to an in-vehicle interface), an integrated eCall device, or a functionality of a broader system like navigation, Telematics device, or tolling device. eCall is expected to be offered, at earliest, by the end of 2010, pending standardization by the European Telecommunications Standards Institute and commitment from large EU member states such as France and the United Kingdom.

Fig.: Congestion pricing gantry at North Bridge Road, Singapore.

The EC funded project SafeTRIP is developing an open ITS system that will improve road safety and provide a resilient communication through the use of S-band satellite communication. Such platform will allow for greater coverage of the Emergency Call Service within the EU.

3.3 Automatic Road Enforcement

Fig. Automatic speed enforcement gantry or "*Lombada Eletrônica*" with ground sensors at Brasilia, D.F.

A traffic enforcement camera system, consisting of a camera and a vehicle-monitoring device, is used to detect and identify vehicles disobeying a speed limit or some other road legal requirement and automatically ticket offenders based on the license plate number. Traffic tickets are sent by mail. Applications include:

- Speed cameras that identify vehicles traveling over the legal speed limit. Many such devices use radar to detect a vehicle's speed or electromagnetic loops buried in each lane of the road.
- Red light cameras that detect vehicles that cross a stop line or designated stopping place while a red traffic light is showing.
- Bus lane cameras that identify vehicles traveling in lanes reserved for buses. In some jurisdictions, bus lanes can also be used by taxis or vehicles engaged in car pooling.
- Level crossing cameras that identify vehicles crossing railways at grade illegally.
- Double white line cameras that identify vehicles crossing these lines.
- High-occupancy vehicle lane cameras that identify vehicles violating HOV requirements.
- Turn cameras at intersections where specific turns are prohibited on red. This type of camera is mostly used in cities or heavy populated areas.

3.4 Cordon Zones with Congestion Pricing

With the intelligent transportation system, cordon zones can also be enforced where mass transportation systems are available and their use encouraged. Cordon systems make it possible to collect taxes from those entering city areas with high traffic while encouraging the use of mass transit.

Global developments in congestion charging in over 30 years

1970s: Singapore cordon charge, full electronic road pricing (ERP) in 1996.

1986: Bergen, Norway, toll ring.

1990-2003: Oslo, Trondheim and other Norwegian cities adopt toll rings.

1995-96: Southern California high occupancy toll lanes.

2000: Congestion pricing of NY bridges.

2002-2004: Swiss, Austrian truck tolls.

2004: London cordon charge.

2005: Germany tolls autobahn trucks.

2006: Stockholm congestion charge.

3.5 Collision Avoidance Systems

Japan has installed sensors on its highways to notify motorists that a car is stalled ahead.

3.6 Emergency Management Services

Emergency Management Services are greatly enhanced by traffic control centers that continually monitor road-way conditions.

When an incident occurs, the nearest emergency service vehicle is located electronically and dispatched to the scene.Highway managers then alert other drivers of the incident through dynamic message signs. These services reduce response times, help save lives, and reduce the occurrence of secondary incidents.

Fig.: Emergency vehicle

IV. BENEFITS OF ITS

The following is a list of identified benefits of ITS projects :

1. Reduced rush hour congestion and delay

2. Increased safety and personal security
3. Time savings and operation efficiencies
4. Reduced fuel consumption and emissions
5. Improved customer service and reduced frustration
6. Reduced road accidents and fatalities and
7. Enhanced economic productivity.

V.CONCLUSION

The investments in ITS will help increase the benefits and efficiencies of transportation systems, thereby reducing the need for much costlier physical expansion of systems. This optimism is not to be confused as any kind of illusion that new infrastructure expansion in India can be avoided altogether by resorting to ITS. Significant expansion of infrastructure will still be needed in India for a long time to come. But including ITS in the overall development strategy of India's transportation system can increase the number of beneficiaries of the system, significantly enhance the transportation-related safety which is a major concern in most parts of India and in some cases reduce the scale of infrastructure expansion.

Thus, a realistic approach to ITS deployment in India would consist of a balanced component of ITS as part of the ongoing expansion of transportation system. ITS initiatives in industrialized countries have clearly identified a number of benefits associated with such projects. Even though ITS projects are implemented with specific objectives with specific benefits in mind, the overall benefits to the society may prove to be quite substantial in many cases.

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