A Review Paper on :INTELLIGENT TRANSPORTATION SYSTEMS
"When technology lays the right foundation"

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Abstract

The Intelligent Transportation Systems (ITS) program is a worldwide initiative to add information technology to transport infrastructure and vehicles. It aims to manage factors that are typically at odds with each other such as vehicles, loads, and routes to improve safety and reduce vehicle wear, transportation times and fuel costs**.** It has improved transportation safety and mobility and enhances productivity through the use of advanced communications technologies**.** Intelligent transportation systems (ITS) encompass a broad range of wireless and wire line communications-based information and electronics technologies. When integrated into the transportation system's infrastructure, and in vehicles themselves, these technologies relieve congestion, improve safety and enhance a country's productivity. Intelligent Transportation Systems (ITS) are identified as the means to achieve sustainable and environmental friendly transportation for the 21st Century. Advanced information and communication technologies are required for ITS. These include Data Storage & Processing Equipment, Wire line & Wireless Communication Systems, Global Positioning Systems (GPS), Sensors, Smart Cards etc. In addition to the above technologies, institutional and market factors play an important role in successful ITS deployment. ITS application functionality includes collection and processing of real-time data, generating and utilizing information for various purposes such as controlling and managing traffic, handling fleet operations (public transport and private carriers), emergency management and assisting users in their travel related decisions. The benefits of ITS include Reduction of traffic congestion, Enhanced safety, Mitigation of environmental impacts of transportation systems, enhanced energy performance, and improved productivity.Many governments are appreciating the benefits of ITS and deploying them in their regions. As a first step, National ITS architectures were designed by the respective nations, to provide overall guidance to ensure deployment strategy, systems compatibility and interoperability. ITS architecture defines user services, physical subsystems, information flows between subsystems, and communication requirements for deploying ITS applications. As many new technologies arise, ITS technologies are undergoing an evolutionary process. This presents the greatest challenges of deploying ITS systems integration. Challenges presented by ITS deployment include standardization, addressing security and privacy concerns, institutional and inter-agency barriers, and availability of funding, public-private partnership. ITS technologies are user service centric and have been driving ITS development across the world.

Introduction

Interest in ITS came from the problems caused by traffic congestion worldwide and a synergy of new information technologies for simulation, real-time control and communications networks. Traffic congestion has been increasing worldwide as a result of increased motorization, urbanization, population growth and changes in population density. Congestion reduces utilization of the transportation infrastructure and increases travel time, air pollution and fuel consumption.

Technology has been driving the developments in the realm of transportation from the times of Industrial Revolution to the present day Digital Revolution. Until the 20th century, technology in transportation was focused on two objectives – (i) meeting the demand of faster mobility by different modes and (ii) building capacity and expanding network facilities to accommodate growing traffic needs. The constraint on the available space, growing vehicle population and number of trips led to severe traffic congestion, resulting in environmental degradation. This situation has resulted in innovative shift of infrastructure management through advanced technologies, to ensure efficient and environment friendly user services. Development of vehicle detection and information technologies on top of communication technologies has offered ways to collect the real-time traffic data for processing at a central facility. Processed information is used for various management purposes such as control, traveler information, incident detection and response. ITS have thus addressed the need for working towards regionally integrated transportation systems.

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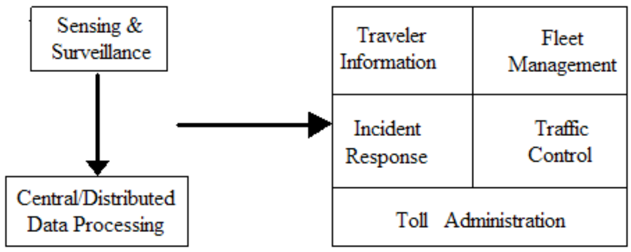
Major ITS Functional Areas

The major ITS application areas can be classified into the following functional groups:

- Advanced Public Transport Systems (APTS)
- Advanced Traffic Management Systems (ATMS)
- Advanced Traveler Information Systems (ATIS)
- Electronic Toll Collection and Traffic Management (ETTM)
- Commercial vehicle Operations (CVO)

Figure 1 illustrates basic ITS activities like Data Collection, Processing (Data Computing), Communication and Information Utilization. In all these activities, technology plays a vital role for 21st Century Surface Transportation Demand Management.

Figure 1: Categorization of ITS Activities



Intelligent Transportation Technologies

Intelligent Transportation Systems vary in technologies applied, from basic management systems such as car navigation, traffic light control systems, container management systems, variable message signs or speed cameras to monitoring applications such as security CCTV systems, and then to more advanced applications which integrate live data and feedback from a number of other sources, such as realtime weather, bridge de-icing systems, and the like.

Additionally, predictive techniques are being developed, to allow advanced modeling and comparison with historical baseline data. Some of the constituent technologies typically implemented in ITS are described in the following sections.

In the period from 1992 to around 1995 the ITS sector was known as Intelligent Vehicle Highway Systems (IVHS). At the time it was recognised that all forms of transport could benefit from the application of information and communications technologies. However the term ICT had not yet been described in popular vernacular. The global leaders in ITS at the time then determined that there needed to be a term to describe the application of ICT to transport and coined the term Intelligent Transport Systems.

Wireless Communications

Various forms of wireless communications technologies have been proposed for intelligent transportation systems. Short-range communications (less than 500 yards) can be accomplished using the Dedicated Short Range Communications(DSRC).

Longer range communications has been proposed using infrastructure networks such as IEEE 802.12, Global System for Mobile Communications (GSM) or 3G. Long-range communications using these methods is well established, but unlike the short-range protocols these methods require an extensive infrastructure beyond what is installed in a vehicle. There is lack of consensus as to what business model should support this infrastructure.

Computational Technologies

Recent advances in vehicle electronics have lead to a move toward fewer more capable computer processors on a vehicle. A typical vehicle in the early 2000s would have between 20 and 100 individual networked 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 (computing) allow for more sophisticated software applications to be implemented, including model-based process control and artificial intelligence. Perhaps the most important of these for Intelligent Transportation Systems is artificial intelligence.

Sensing Technologies

New sensing technologies have greatly enhanced what can be done using Intelligent Transportation Systems. Sensing systems can be either infrastructure systems or vehicle based systems. Infrastructure sensors tend to be devices that are installed in the road or around the road, usually as part of road construction/maintenance, while vehicle sensors tend to be those sensors that are found installed in a vehicle

Speed measurements

Inductive loop detection

Inductive loops can be placed in a roadbed to detect vehicles as they pass over the loop by measuring the vehicle'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 weight 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.

Video vehicle detection

Closed Circuit Television Cameras

Traffic flow measurement using video cameras is another form of vehicle detection. Since video detection systems 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 black-and-white or color 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 four 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.

A good load-tracking system will help deliver more than 95% of its loads via truck, on planned schedules. If a truck gets off its route, or is delayed, the truck can be diverted to a better route, or urgent loads that are likely to be late can be diverted to air freight. This allows a trucking company to deliver a true premium service at only slightly higher cost.

The controlled routes allow a truck to avoid heavy traffic caused by rush-hour, accidents or road-work. Increasingly, governments are providing digital notification when roadways are known to have reduced capacity.

A good system lets the computer, dispatcher and driver collaborate on finding a good route, or a method to move the load. One special value is that the computer can automatically eliminate routes over roads that cannot take the weight of the truck, or that have overhead obstructions.

Usually, the drivers log into the system. The system helps remind a driver to rest. Rested drivers operate the truck more skillfully and safely.

When these systems were first introduced, some drivers resisted them, viewing them as a way for management to spy on the driver.

A well-managed intelligent transportation system provides drivers with huge amounts of help. It gives them a view of their own load and the network of roadways.

Electronic toll collection

Toll roads

Electronic toll collection (ETC) makes it possible for vehicles to drive through toll gates at traffic speed, reducing congestion at toll plazas and automating toll collection. Originally ETC systems were used to automate toll collection, but more recent innovations have used ETC to enforce cordon zones in city centers and ETC Lanes.

Until recent years most ETC systems were based on using radio devices in vehicles that would use proprietary protocols to identify a vehicle as it passed under a gantry over the roadway. More recently there has been a move to standardize ETC protocols around the Dedicated Short Range Communications(DSRC) protocol that has been promoted for vehicle safety by the Intelligent

Transportation Society of America, ETICO and ITS Japan ITS Australia also facilitated via its National Electronic Tolling Committee representing all jurisdictions and toll road operators interoperability of toll tags in Australia for the multi lane free flow tolls roads.

Other systems that have been used includes:

- Barcode stickers
- License plate recognition
- Infrared communication systems
- Radio Frequency Identification

Automatic number plate recognition

Automatic number plate recognition (ANPR)

Is a mass surveillance method that uses optical character recognition on images to read the licence plates on vehicles. As of 2006 systems can scan number plates at around one per second on cars travelling up to 100 mph (160 km/h). They can use existing closed-circuit television or road-rule enforcement cameras, or ones specifically designed for the task. They are used by various police forces and as a method of electronic toll collection on pay-per-use roads, and monitoring traffic activity such as red light adherence in an intersection.

ANPR can be used to store the images captured by the cameras as well as the text from the licence plate, with some configurable to store a photograph of the driver. Systems commonly use infrared lighting to allow the camera to take the picture at any time of day. A powerful flash is included in at least one version of the intersection-monitoring cameras, serving to both illuminate the picture and make the offender aware of his or her mistake. ANPR technology tends to be region specific, owing to plate variation from place to place.

The software aspect of the system runs on standard PC hardware and can be linked to other applications or databases. It first uses a series of image manipulation techniques to detect, normalise and enhance the image of the number plate, and finally optical character recognition to extract the alphanumerics of the licence plate. ANPR/ALPR systems are generally deployed in one of two basic approaches; one allows for the entire process to be performed at the lane location in real-time, the other transmits all the images from many lanes to a remote computer location and performs the OCR process there at some later point in time. When done at the lane site, the information captured of the plate alphanumeric, date-time, lane identification, and any other information that is required is completed in somewhere around 250 milliseconds. This information, now small data packets, can easily be transmitted to some remote computer for further processing if necessary, or stored at the lane for later retrieval. In the other arrangement there are typically large numbers of PCs used in a server farm to handle high workloads, such as those found in the London congestion charge project. Often in such systems there is a requirement to forward images to the remote server and this can require larger bandwidth transmission mediums.

Concerns about these systems have centered on privacy fears of government tracking citizens' movements and media reports of misidentification and high error rates. However, as they have developed, the systems have become much more accurate and reliable.

ANPR systems may also be used for/by:

- Section control, to measure average vehicle speed over longer distances
- Border crossings

- Filling stations to log when a driver drives away without paying
- Car parks or road entry systems to control access
- A marketing tool to log patterns of use
- Traffic management systems, which determine traffic flow using the time it takes vehicles to pass two ANPR sites

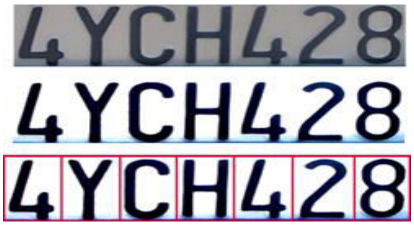
ANPR is sometimes known by various other terms:

- Automatic licence plate recognition (ALPR)
- Automatic vehicle identification (AVI)
- Car plate recognition (CPR)

Licence plate recognition (LPR)

ANPR uses optical character recognition (OCR) on images taken by cameras. When Dutch vehicle registration plates switched to a different style in 2002 one of the changes made was to the font, introducing small gaps in some letters (such as P and R) to make them more distinct and therefore more legible to such systems. Some licence plate arrangements use variations in font sizes and positioning – ANPR systems must be able to cope with such differences in order to be truly effective. More complicated systems can cope with international variants, though many programs are individually tailored to each country.

The cameras used can include existing road-rule enforcement or closed-circuit television cameras as well as mobile units which are usually attached to vehicles. Some systems use infrared cameras to take a clearer image of the plates.



Difficulties

There are a number of possible difficulties that the software must be able to cope with. These include:

- Poor image resolution, usually because the plate is too far away but sometimes resulting from the use of a low-quality camera.

Cordon Zones

Cordon zones are used primarily in urban centers where mass transit is an alternative to driving. Drivers entering a cordon zone are charged a toll that exceeds the cost of mass transit.

Cordon zones have been implemented in Singapore and in London, England where a special toll is collected (Congestion Charge) when entering a congested city center using Electronic Toll Collection, licence plate.

Automated highway system

An automated highway system (AHS) or Smart Road, is an advanced Intelligent transportation system technology designed to provide for driverless cars on specific rights-of-way. It is most often touted as a means of traffic congestion relief, since it drastically reduces following distances and thus allow more cars to occupy a given stretch of road.

How it works

The roadway has magnetized stainless-steel spikes driven one meter apart in its center. The car senses the spikes to measure its speed and locate the center of the lane. Further the spikes can have either magnetic north or magnetic south facing up. The roadway thus has small amounts of digital data describing interchanges, recommended speeds, etc.

The cars have power steering, and automatic speed controls, but these are controlled by the computer.

Steps 2, 3 and 4: The licence plate is normalised for brightness and contrast and then the characters are segmented ready for OCR

- Blurry images, particularly motion blur and most likely on mobile units
- Poor lighting and low contrast due to overexposure, reflection or shadows
- An object obscuring (part of) the plate, quite often a tow bar, or dirt on the plate
- A different font, popular for vanity plates (some countries do not allow such plates, eliminating the problem)
- Circumvention techniques

Blurry images make OCR difficult – ANPR systems should have fast shutter speeds to avoid motion blurr.

The cars organize themselves into platoons of eight to twenty-five cars. The platoons drive themselves a meter apart, so that air resistance is minimized. The distance between platoons is the conventional braking distance. If anything goes wrong, the maximum number of harmed cars should be one platoon.

Freeway service patrol

A freeway service patrol, alternatively known as a motorist assistance patrol, roadway service patrol, or a courtesy patrol, is the umbrella term for a variety of programs implemented by government agencies, typically state Highway Patrols or Departments of Transportation, to reduce traffic congestion and improve highway safety by having specially marked and equipped vehicles patrol designated sections of roadway. In general, though, the purpose of a freeway service patrol is to use rapid response to reduce traffic congestion.

Conclusion

ITS has been proved to be the optimal solution to the enigma of building and operating transportation systems to meet expeditiously growing urban travel demand in developed countries. We all have acceded to the fact that the acme of the transportation, i.e. Intelligent Transportation is the requirement of present day-today life. Such facilities which are already enjoyed by the people of America etc. and also the Government of our country have taken steps in this very field. This accolade transportation if included in the upcoming Highway Development Projects of our Government will certainly help in upgrading the standards of our Highway Systems to the utmost quality. Accompanying the benefits of better performance and cost effectiveness, these technological innovations give rise to the challenges of implementation (integration), support and funding. Scalability and adaptability to current and future local user needs are seen as the key factors influencing selection of the appropriate technology.

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