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Overview of Data Collection Methods for Intelligent Transportation Systems

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----------ABSTRACT----------
The collection of high quality traffic data is one of the basic requirements for traffic studies. It is unquestionable that traffic data is the primary source for any kind of traffic and transportation projects and necessarily the data should be reliable and precise. The manual method of data collection involves deployment of huge number of man power and there are relatively more chances for errors in data collection. The technological advancements have brought out much advancement in of traffic data collection. This paper provides the overview of data collection methods for Intelligent Transportation Systems.

Keywords: Intelligent Transportation system, Data Collection, ITS Probe Vehicle Systems.

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I. Introduction

Transportation or transport sector is a legal source to take or carry things from one place to another. With the passage of time, transportation faces many issues like high accidents rate, traffic congestion, traffic & carbon emission air pollution, etc. In some cases, transportation sector faced alleviating the brutality of crash related injuries in accident. Due to such complexity, researchers integrate virtual technologies with transportation which is known as Intelligent Transport System.

A. Motivation

Intelligent Transport Systems (ITS) take a vital part in global world. Intelligent Transportation System (ITS) is the conventional system for the development of next-generation technologies. It is a novel field that interoperates in different fields of transportation system, such as transportation management, service control, infrastructure, operations, policies and control methods, etc. There is a wide range of reimbursement that obtained from ITS deployments. Intelligent Transportation System can play a major role in reducing risks, high accident rate, traffic congestion, carbon emission and air pollution. On the other hand increasing safety and reliability, travel speed, traffic flow and satisfied travellers for all modes. In current Transportation systems, it frequently happens [1, 2] that local events and singularities are escalated into large scale faults due to lack of transparency in information. Steps have been taken to increase transparency by constructing an adaptive sensing network that enables automatic collection of information about road conditions and traffic load. As such systems developed, it will be very difficult for human beings to keep track of the large amount of information. So there is a need of spatiotemporal data mining algorithm for the predictions that guide human decisions. The following steps should be followed for applying data mining algorithms.

- **Data collection**: Intelligent Transportation System is capable of capturing a range of roadway information, from the number of vehicles passing a certain point and their average speeds. ITS technology can even follow the positioning of vehicles through mobile phone tracking or satellite-based systems.
- **Data transfer and processing**: Following collection, ITS can communicate the data to central units where it is aggregated and transformed into information used for determining future actions.
- **Informed decision-making**: This processed data can then be applied in a number of ways to ensure the efficient operation of road networks. For example, a road operator can use ITS data in the context of highway management; or a road user, on the other hand, can alter his route upon receiving updated traffic information.

This paper mainly deals with various methods of data collection, advantages, and drawbacks. Data Collection is the process of gathering and measuring information on variables of interest, in an established systematic fashion that enables one user to answer stated research questions, test hypotheses, and evaluate outcomes. There [3] are three different techniques for collecting the data for Intelligent Transportation Systems namely Site based data collection, Floating Car data and Wide area data collection. Each one has different technical characteristics and operation principles that include structure of data measurement accuracy and coverage of network. These techniques are explained in the following sections.

II. Site based Data Collection Technique

The traffic data measured using sensors [4], which is located along the roadside with different technologies and application techniques. For example inductive magnetic loops, pneumatic road tubes, piezoelectric loop arrays and microwave radars are used for many years. New sensors came out with advanced technologies which is flexible, multipurpose and cost effective. Example of such sensors are ultrasonic and acoustic sensor systems, magnetometer vehicle detectors, infrared systems, LIDAR light detections, ranging and video image processing detection. Some of the site based data collection methods are explained below.

A. Video Graphic Method

In this method, [4,9] data is collected using CCTV camera. To ensure data accuracy, footage can be verified as required. For fixing camera, an appropriate vantage point is selected to cover the interested road stretch at best. For required duration the selected stretch is recorded. Then it is processed either through image processing or by counting manually and sometimes by quasi manual counting.

B. Infra-Red Based Data Collection Method

This is a traffic surveillance system which works on the principle of intervention of Infra-red beams. The Infra-Red Traffic Logger consists of one transmitter and one receiver. They have to be placed at the carriageway edges. The transmitter emits infra-red beams, the receiver receives the beam. Using a novel light based technology, the receiver counts, classifies, and determines the lanes, the beam overlap yields four different paths of light. In this two are parallel beams and two are crossed beams. Each vehicle wheel interrupts each of the four beams when it passes between the transmitter and receiver. Breaking of these beams is known as beam event. To compute the exact velocity and lane of vehicles, precise time detection of the beam event is used. The direction of the vehicle is detected based on the order in which the break events occur. Based on its axle width, the vehicles are classified. They are classified as Bicycles, two wheelers, three wheelers, Tractor, Tractor with trailers, SCV (2 axle Small Commercial Vehicles), LMV (2 axle Light Motor Vehicles), LCV (2 axle Light Commercial Vehicles), MCV (2 axle Rigid Truck or Bus), HCV (3 axle Rigid Truck or Bus), HCV (3 axle Articulated Truck or Bus), MAV (Rigid Truck), MAV (Articulated Truck) and OSV (Oversized Truck).

Advantages of Site based data Collection

- Video Graphic Method and Infra-Red Based Data Collection Method reduce the manpower to large extent.
- Video Graphic Method also improves the data collection accuracy.

Drawbacks of Site based data Collection

- The coverage is limited.
- The implementation and maintenance cost is more.

The alternative data sources like Floating Car Data are a promising cost-effective solution to cope with some limitations from fixed detectors. This would improve traffic management and also help to satisfy the growing demand of drivers who are willing to pay service providers as long as they have access to relevant real-time information: will there be any congestion on my usual route today? How to avoid it? If not, how long will it last? Etc. Such questions require traffic data to be accurate, reliable, timely and as complete as possible. The following section gives answer for the above questions.

III. Floating car data/floating cellular data

Floating car data collection [5] 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:

A. Triangulation method

In the mid-2000s, mobile phones were used as anonymous traffic probes. The Signal of any mobile phones which are inside the vehicle moves as car moves. Using triangulation, the network data is measured and analysed with the help of pattern matching or cell-sector statistics (in an anonymous format), the data will be converted into traffic flow information. With more congestion, there are more cars, more phones. In theory, accuracy increases when the distance between antennas is shorter.

Advantage: No infrastructure needs to be built along the road; only the mobile phone network is leveraged.

Drawback: This method is complicated, especially in areas where the same mobile phone towers serve two or more parallel routes. By the early 2010s, the popularity of the triangulation method was declining.

B. Vehicle re-identification

This method requires set 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. By comparing the time at which a specific device is detected by pairs of sensors, travel times and speed are calculated. This can be done using the MAC addresses from Bluetooth or other devices, or using the RFID serial numbers from Electronic Toll Collection (ETC) transponders.

C. GPS based methods

An increasing number of vehicles are equipped with in-vehicle satellite navigation/GPS systems that have two-way communication with a traffic data provider. To compute vehicle speed, position readings from vehicles are used. Modern methods may not use dedicated hardware but instead uses Smartphone. Smartphone-based rich monitoring is used to track traffic speed and density. To find out traffic speed and road quality, the car drivers use accelerometer data from smart phones. Audio data and GPS tagging of smart phones enables identification of traffic density and possible traffic jams.

Advantages of Floating car data

- The cost is low compared to sensors or cameras
- By including all locations and streets it gives more coverage
- Set up is faster and maintenance is less
- Works in all weather conditions, including heavy rain

Examples of FCD sensors are: license plate recognition (LPR), automatic vehicle identification (AVI) transponders including probe vehicles and electronic toll tags.

Drawback of Floating Car data

- Delay is more
- Congestion level is more.

IV. Wide-area data Collection

This method aims to carry out wide-area traffic flow monitoring capabilities based on multi-sensor tracking options such as photogrammetric processing. The sensors [8] involved are Satellite sensors, RFID readers, microphones, accelerometers, etc.

A. Satellite Sensors

This kind of sensors provides pictures, aerial photographs and images. Then they are processed using photogrammetric processing. Photogrammetric processing is the science and technology of making measurements. Measurements are captured from overlapping pairs of photographs using stereo. Orientation and triangulation are fundamental photogrammetric processing tasks. Orientation is the process of creating a stereo model suitable for viewing and extracting 3-D vector coordinates that describe geographic objects. Triangulation (also called ‗block adjustment') is used to assemble a collection of images into a single model so that accurate and consistent information can be obtained from large areas. Ortho images are images corrected for variations in terrain using a DEM.

Advantage: Photogrammetric is a very cost-effective data capture technique that is sometimes the only practical method of obtaining detailed topographic data.

Drawback: It is usually not possible to have both very high spectral and spatial resolution simultaneously [11].

B. RFID Technology

RFID technology is a simple method of exchanging data between two entities namely a reader/ writer and a tag. This communication allows information about the tag or the element carrying the tag to be determined and in this way it enables processes to be managed more easily.

Advantage: Vehicle tracking - RFID technology can be used to determine when vehicles have passed particular points and in this way their location can be approximately determined.

Drawback: RFID is an expensive technology.

C. Dedicated-Short Range Communications (DSRC)

DSRC [6] is a subset of radio frequency identification (RFID) technology. DSRC is a short- to medium-range wireless communication channel, operating in the 5.8 or 5.9GHz wireless spectrum, specifically designed for automotive uses. Critically, DSRC enables two-way wireless communications between the vehicle (through embedded tags or sensors) and roadside equipment (RSE).

Advantage: DSRC is a key enabling technology for many intelligent transportation systems, including vehicle-to-infrastructure integration, vehicle-to-vehicle communication, adaptive traffic signal timing, electronic toll collection, congestion charging, electronic road pricing, information provision, etc.

Drawback: DSRC is also an expensive technology.

D. Mobile Telephony

ITS applications can transmit information over standard third or fourth generation (3G or 4G) mobile telephone networks. Mobile phones have an **accelerometer** which measures its tilting motion and orientation.

Advantage: Its wide availability in towns and along major roads. However, additional network capacity may be required if vehicles are fitted with this technology, and network operators might need to cover these costs.

Drawback: Mobile telephony may not be suitable for some safety-critical ITS applications since it may be too slow.

More recently, new technologies arisen both from road infrastructure and vehicle side, in the first instance established for vehicle-to-infrastructure and vehicle-vehicle cooperation. Those identifiable vehicles, equipped with wireless communications devices, are able share mobility data each other and with roadside devices. Finally wireless cell also provides important mobility data about moving mobile phones intensity and times along the road network. Along the roadway, technologies, either based on intrusive or nonintrusive techniques, revealed necessary but not sufficient because of their limited coverage and expensive costs of implementation and maintenance. In the recent years, several sources emerged, driven by innovative methods and models. By combing the advantages of Floating Car data and wide area data, a innovative method is proposed. That is Wide-area network through board equipped vehicles and airborne sensors which is called as ITS Probe Vehicle System.

V. Probe Vehicles or Devices.

Vehicles which are equipped with DSRC or other wireless technology that report their speed and location to a central traffic operations management centre called [7, 10] Probe Vehicles. That probe data is aggregated to generate an area-wide picture of traffic flow and to identify congested locations. Extensive research has also been performed into using mobile phones that drivers often carry as a mechanism to generate real-time traffic information, using the GPS-derived location of the phone as it moves along with the vehicle.

A. Advantages of ITS probe vehicle systems

- Low cost per unit of data
- Continuous data collection
- Automated data collection
- Data are in electronic format
- No disruption of traffic

B. Drawbacks of ITS probe vehicle systems

- High implementation cost
- Fixed infrastructure constraints
- Requires skilled software designers
- Privacy issues
- Not recommended for small scale data collection efforts

C. Types of ITS Probe vehicle Data Collection Systems

1. **Signpost-Based Automatic Vehicle Location (AVL)** : This technique has mostly been used by transit agencies. Probe vehicles communicate with transmitters mounted on existing signpost structures.
2. **Automatic Vehicle Identification (AVI)**: Probe vehicles are equipped with electronic tags. These tags communicate with roadside transceivers to identify unique vehicles and collect travel times between transceivers.
3. **Ground-Based Radio Navigation**: Often used for transit or commercial fleet management, this system is similar to the global positioning system (GPS). Data are collected by communication between probe vehicles and a radio tower infrastructure.
4. **Cellular Geo-location:** This experimental technology can collect travel time data by discretely tracking cellular telephone call transmissions.
5. **Global Positioning System (GPS)**: Probe vehicles [12] are equipped with GPS receivers and two-way communication to receive signals from earth-orbiting satellites. The positional information determined from the GPS signals is transmitted to a control centre to display real-time position of the probe vehicles. Travel time information can be determined from the collected data.

VI. Conclusion

In the recent years, several sources emerged, driven by innovative methods and models. One of such method is ITS probe vehicles. Probe vehicles are equipped with embedded GPS receivers in vehicles. On-board units receive signals from several different satellites to calculate the device's (and thus the vehicle's) position. The positional information is transmitted to control server for further analysis. The Server process the data using different algorithms and gives the information to the ITS users.

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