The Status of Sensing Technology for Traffic Information in Korea

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ABSTRACT

Since ITS (Intelligent Transport Systems) in Korea was introduced in 1994, ITS have brought many positive effects such as experience in construction and operation for about 20 years and provision of various traffic information. However, an existing ITS project which is steadily being expanded, has several limitations by stage of traffic information. In order to overcome the limitations of ITS and improve the efficiency of ITS, there is need of comprehensive study about collecting, processing and providing stages, which can bring the integrity in the system-wide level. Thus, as a starting point of comprehensive study, the purpose of this study is to review the status of sensing technologies and research relating to collecting-stage, and suggest implications and future research directions for developing a new sensing technology in transportation and road environment.

Keywords: Sensing technology, Traffic information, ITS, Weather

1. INTRODUCTION

ITS (Intelligent Transport Systems) have caused many beneficial impacts such as experience for deployment and operation and providing a variety of traffic information since ITS in Korea was adopted in 1994. Now, ITS in Korea is entering to advanced maturation stage through foundation phase of the 1990’s, unit-based service phase of the early 2000’s, and growth and spreading phase of the late 2000’s. Also, it is expected that the spreading of wireless technology such as V2I (Vehicle-to-Infrastructure) and V2V (Vehicle-to-Vehicle) communication brings major changes to the existing ITS environment, and a new way to collect, process and provide will be possible due to the wireless data transfer.

In order to overcome the limitations of ITS and improve the efficiency of ITS, there is need of comprehensive study about collecting, processing and providing stages, which can bring the integrity in the system-wide level. Also, as a starting point of comprehensive study, collecting-stage should be studied first. Thus, the purpose of this study is to review the status of sensing technologies and research relating to collecting-stage and suggest implications and future research directions for developing a new sensing technology in transportation and road environment.

2. SENSING TECHNOLOGY

Sensing technology used for traffic information can be divided into two groups, sensing technology for spot data and sensing technology for link (spatial) data, according to its usage. Spot sensing technology collects traffic information by measuring traffic volume, speed and occupancy of a spot, whereas link (spatial) sensing technology collects not only traffic information but also travel patterns, accidents and unexpected incident detection using travel information of vehicles between spot A and spot B. Recently, link (spatial) sensing is enabled due to replacement of HD-CCTV, high-end processing system and switching of communication infrastructure as optical communications.

2.1 Sensing Technology for Spot Data

2.1.1 Road and Weather Information

Drivers’ need for road surface and weather information is increasing due to the traffic problem such as accidents caused by bad weather, and also safety management of road is needed for bad weather conditions. Recently, RWIS (Road Weather Information System)
comprising Environmental Sensor Stations (ESS) in the field, a communication system for data transfer, and central systems to collect field data from numerous ESS has installed on some sections of National Highway and Expressway in Korea and gradually expanded to other areas [1]. Yang et al. [2] presented how to determine priorities of RWIS installation on national highways within the limited budget using AHP (Analytical Hierarchy Process) and GIS analysis. As one of RWIS, ITS road and weather information system was developed by HWA HEUNG Road Safety System and installed on several locations of National Highway and Expressway. Fig. 2 shows the structure of ITS road and weather information system.

Fig 2: The structure of ITS road and weather information system [3]

RWIS has advantages such as the diversity of information from sensing different types of road condition; however, purchase cost and installation cost for RWIS are too high.

Recently, KOTI (Korea Transport Institute) developed a system for the fog occurrence which identify the presence and speed of a vehicle using a vehicle speed sensor and give a warning to speeding drivers by LED warning lights installed on the roadside through development of new technologies for traffic safety of on the road, and this system is being operated on the testbed [4].

Most information about fog is obtained from the fog sensor and the device for collecting road and weather information. Research related to fog warning in Korea can be divided into two groups, fog dissipation and fog warning system, and as an active way, fog dissipation is applied to a cost-effective place such as airports and as a passive way, fog warning system is applied to mainly expressways.

2.1.2 Vehicle Plate Recognition

As shown in Fig. 4, generally plate recognition system goes through vehicle recording, plate extraction, pre-processing and plate recognition [1].

![Vehicle recording]

- Camera
- Recording at front
- Still image
- Passenger/Non-passenger car

![Plate extraction]

- Plate detection
- Vehicle front plate
- Width Height = 2:1 and 5:1
- Binary image

![Pre-processing]

- Calibration of the plate slope
- Shading correction
- Noise removal

![Plate recognition]

- Setting of standard font (Korean/number)
- Matching letters and numbers

Fig 4: The process of vehicle plate recognition

a. Vehicle Recording

Black and white, color, or infrared cameras can be used for vehicle recording, and by recent technology a color camera is more often used than an infrared camera since a color camera is cheaper than an infrared camera.

b. Plate Extraction (detection)

Most common methods for plate region detection are horizontal / vertical edge method, method using changes in the intensity of plate region, color information method, Hough transformation method, etc.

Horizontal/vertical edge method detects plate region through detecting horizontal and vertical edge image in a vehicle image and setting the detected rectangle as a candidate region [5]. The method using the changes of the intensity of vehicle plate region is based on
the characteristic of vehicle plate that fluctuation of brightness between the text and background is large and the number of variations is significantly greater than other areas [6]. Color information method use the additional color information that contrast images do not have, which is based on that color information of plate region is different from that of background [7]. Under assumption that there are few vertical lines except plate border in front of vehicle, hough transformation method detects plate region by exploring vertical and horizontal line group using hough transformation after detecting edges from vehicle images using Sobel operator.

c. Pre-processing

During this pre-processing, skew correction, shadow removal and noise removal are mainly used. Affine transformation or linear regression equation is used for correcting skew. In the case of shadow removal, there is need of pre-processing for shadow before/after plate detection since a serious error occurs by partial shading when plate region is extracted as gray image. Also, for noise removal, labeling technique or geometric method is used to remove noise in plate region.

d. Plate recognition

Most common methods for plate recognition are structure analysis, statistical analysis, template matching, neural network, etc.

Structure analysis uses structural information such as correlation or inter-connectivity between characters, which has a strong advantage that it is robust to the size and slope of a character and disadvantage that it is not easy to find exact structural information between characters with the quantification of structural information. Template matching method which is a method for improving the geometric matching method recognizes characters by matching images input to the standard pattern. It has weakness that a recognition rate is lowered if there is noise or an image is tilted and the standard pattern has to be reconfigured when the environment changes. Neural network method input the divided region of consonant and vowel to neural network instead of detecting component of consonant and vowel after classifying types of characters. Given the type of Korean character, we can know the location and region of each consonant and vowel, and thus the fixed part of consonant and vowel can be used as input region of neural network for detecting consonant and vowel. Neural network method can adaptively respond to various situation such as the changes of recording angle, brightness, ambient lightning, etc. Thus, it recognizes characters using neural network which is capable of self-learning [8]. However, there is need to select appropriate input feature vector and neural network model since the performance of neural network method depends on the input feature vector or neural network model.

2.1.3 Thermal Infrared Detectors

a. Industry Trends of Thermal Infrared Detector

Video image detector is representatives of non-buried type of traffic detector and most of the domestic ITS detectors are video image detectors. Construction and maintenance cost for non-buried type of traffic detector is much better than that for buried type.

However, image processing technology of video image detector is a kind of the emulation of buried type detector to obtain a result using virtual loop, tripwire, spatial-temporal analysis, and tracking. The reliability of the result by non-buried type detector is lower than that by buried type of detector, and non-buried type detector shows lower reliability for the environment change.

As non-buried type of detector, thermal infrared detector has higher reliability for the environment and are not yet active in domestic ITS. It uses wavelengths in the range of Far-Infrared and can be easily used for remote monitoring through the optimum control of the lens.

Fig 5: Application of thermal infrared detector [1]
method is the highest. Developing H/W for precise control of PAN/TILT is constantly being made, but this development is being applied to only integrated-type cameras.

2.2 Sensing Technology for Link (Spatial) Data

2.2.1 Standard Detector for ITS

As a standard detector, portable standard detector using laser developed by HITECOM is being used, which is developed to allow portable using reflection-type laser like a fixed standard detector. Korea Institute of Construction Technology and Korea Expressway Corporation are utilizing this detector for performance evaluation, examination and correction of ITS equipment. Table 1 shows the characteristics and functions of laser-type portable standard detector.

<table>
<thead>
<tr>
<th>Characteristics and functions</th>
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<tr>
<td>Real-time collection of vehicle data (Volume, speed, occupancy, and video information)</td>
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<td>Storing and analyzing vehicle information</td>
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<td>Easy for maintenance, safe structure and install method</td>
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<td>Portable by vehicle and appropriate size to carry it</td>
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<td>Diversification of detection method using tape switch</td>
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A tape-loop-type standard detector was developed by combining a tape switch sensor and a loop sensor. It can maintain more than 99% for accuracy of traffic volume and speed data, but the accuracy of occupancy is about 96% due to the characteristics of a loop sensor. The usage of this type detector is usually low due to safety problem that entering road is necessary to install it and installation is relatively time-consuming.

A pole-type standard detector using a laser has high accuracy of data, but its utilization is very low due to the big size and difficulty of movement and installation.

Also, there is a vehicle-type standard detector which can detector two lanes using a reflection-type laser installed on the remodeled vehicle. It has convenient mobility and most functions can be controlled in the vehicle, but the cost for purchasing and remodeling is too high.

2.2.2 DSRC on National Highway and Expressway

Dedicated short-range communications (DSRC) are one-way or two-way short-range to medium-range wireless communication channels specifically designed for automotive use and a corresponding set of protocols and standards. Recently, this technology has been applied to ITS for collecting traffic information as shown in Fig 9.
Currently, 97 DSRCs are being operated on national highway to replace old VDS (Vehicle Detecting System). Also, Korea Expressway Corporation established the system which provides link traffic information utilizing Hi-pass OBU (Onboard Unit) through construction of traffic information system based on Hi-pass, and Hi-pass system has been built on 911 sections of expressway by Dec. 2012.

The accuracy of travel time based on DSRC is higher than that of VDS, but as the characteristic of DSRC, there is a possibility that time sag happens for traffic delay. It is necessary to develop data processing algorithm and establish the standards of location and interval for installing DSRC by the road type since the error by time sag appears differently according to the road type.

2.2.3 Application of Aerial Images

Satellite images are used for the facility management, disasters and environmental monitoring, and the main application fields of satellite images are remote sensing, GIS, and disaster monitoring.

Remote sensing is to analyze the properties of object through recording reflected or emitted electromagnetic wave from the object or photographing the object using a mounted sensor on the aircraft or a satellite without contacting the object. As the media of remote sensing, there are satellite, airship, aircraft, etc. The methods of remote sensing can be divided into two groups. One is to use an optical or radar sensor and the other is to use satellite or aerial images. In the case of remote sensing using satellite or aerial images, it is being utilized in the fields of urban planning, environmental and geological survey, and tourism with measurement data such as image map, distribution of land cover, vegetation and water quality distribution and sea water temperature. Also, for GIS field, satellite or aerial imagery is being used to generate 3D data of a building and its application range is very wide. Airship aerial survey for disaster monitoring has been tried, which enabled to monitor real-time recording area through internet using PCS (Personal Communication Services) communication network. Also, unmanned helicopter was used for monitoring flood of the Nakdong River upstream in 2000.

Research results related to traffic information based on satellite or aerial images is insufficient. Also, many attempt to improve the performance of image detectors using a variety of algorithms have been made rather than collecting wide-area traffic information using satellite or aerial images. Recently, KICT and MLTM has conducted the project of infrastructure construction for collecting wide-area traffic information and development of technology for collecting traffic information using aerial images [1] as shown in Fig 10.

In this project, selection of target areas, small unmanned airship, and image stabilizer for making a real airship were designed and made, but it was analyzed that its utilization on the transport sector was less feasible through economic assessment and feasibility survey for airship making in the future.

3. CONCLUSIONS

From the current status of sensing technology for traffic information, implications and suggestions are summarized as follows.

In the existing sensing system for traffic information, it is not easy to judge and provide reliably various information and traffic conditions since various detectors such as VDS, AVI, CCTV, etc. have been installed in each individual facility, and it adopts the method that provides information through collecting and processing a part of traffic information for a spot or link section by a sensor. In order to overcome this problem, there is need for developing a next generation of sensing system for integrated traffic information which can detect and provide reliable information.

The existing traffic information system using mainly VDS has difficulty for identifying traffic condition, accident or incident of a relatively long section of road since it collects only spot data of traffic. Thus, it is necessary to use DSRC or develop a vehicle tracking technology which can be utilized for identifying the
characteristics of traffic flow and obtaining information of traffic conflict for a section of road.

Also, the introduction and research of sensing system capable of ensuring reliability in bad weather condition is required to overcome the problem that it is difficult to provide reliable, quick information for users with non-accurate prediction of traffic information due to the changes of weather condition such as bad weather.

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REFERENCES


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