Journal of the Korean Society of Surveying, Geodesy, Photogrammetry and Cartography
Vol. 33, No. 6, 589-594, 2015
http://dx.doi.org/10.7848/ksgpc.2015.33.6.589
ISSN 1598-4850(Print)
ISSN 2288-260X(Online)
Original article

A Study on Prediction of Traffic Volume Using Road Management Big Data

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Abstract

In reflection of road expansion and increasing use rates, interest has blossomed in predicting driving environment. In addition, a gigantic scale of big data is applied to almost every area around the world. Recently, technology development is being promoted in the area of road traffic particularly for traffic information service and analysis system in utilization of big data. This study examines actual cases of road management systems and road information analysis technologies, home and abroad. Based on the result, the limitations of existing technologies and road management systems are analyzed. In this study, a development direction and expected effort of the prediction of road information are presented. This study also examines regression analysis about relationship between guide name and traffic volume. According to the development of driving environment prediction platform, it will be possible to serve more reliable road information and also it will make safe and smart road infrastructures.

Keywords : Road Information, Driving Environment, Prediction, Road Management System

1. Introduction

As expressways are advanced, the scale of roads has been expanded and use rates have greatly increased. Accordingly, predicting the driving environment has become a significant issue. In addition, as real-time traffic information is rapidly increasing in such media as black boxes and CCTVs in connection with the technological advancement of smart phones and personal electronic devices, it is expected that in the area of road traffic, the use of big data will be promoted to predict the driving environment. Accordingly, it is necessary to develop road traffic information service technology in utilization of big data (Kim, 2014; Park *et al*., 2006).

As the necessary is increasing, a number of studies about development platform and information system using the traffic information were conducted. According to a number of studies and works, many kinds of related systems are in operation. TOPIS (Traffic Operation and Planning Information System) and OASIS (Operations Analysis and Supportive Information) are operated as typical traffic information centers in Korea. These centers collect, process, and provide the traffic flow information, traffic accident data and traffic pattern analysis information (Lim *et al*., 2014; Kim *et al*., 2014).

The larger amount of road/traffic big data will be generated through these traffic information centers and management systems. The development of exclusive platform that can be collect the road/traffic big data only. In addition, the platform needs to have a real-time data

Received 2015. 12. 01, Revised 2015. 12. 11, Accepted 2015. 12. 31
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collecting function from social media such as Twitter.

This study examines road information analysis technologies, home and abroad, and actual cases of road management systems with the aim to develope the driving environment prediction platform. Based on the result, limitations of existing technologies road management systems are analyzed. Also, a direction for ways to apply domestic road management systems is Presented.

2. Road Management Systems in Foreign Countries

This chapter examines road information analysis systems and road management systems in foreign countries. A case study was conducted to grasp road information analysis technologies in major advanced countries as well as the level of technology advancement of road management systems.

2.1 Case study of road management systems in foreign countries

In the U.S., an integrated road management system has been operated since 1990 to enhance safety in road management. To prevent road slope collapses, a landslide monitoring system is being operated in application of LHP (Landslide Hazard Program) technology. Applying the road pavement management system in the U.S. has been an obligation specified by the land transportation laws over all states since 1993. To prevent calamities in cities, potential risks of disaster occurrence are predicted and preventive measures are taken accordingly in application of the DIN (Disaster Information Network) (Shin, 2006; Lee, 2013).

In Japan, MICHI (Ministry of Construction Highway Information Database System), a comprehensive road management system, is operated at each local construction bureau. In 1965, the world-first road pavement investigation equipment was developed and has been applied to the road pavement management system (Lee, 2013). As for road slope collapses, optical fiber sensors have been utilized since the beginning of 2000 to monitor safety of road slopes and to take preventive measures. Traffic volume control facilities include CCTVs, broadcasting facilities, emergency calls, remote monitoring control facilities, and road information display facilities for efficient operation of a disaster preventive system (Osima *et al*., 2007).

In Europe, a system to prevent and monitor bridge fire incidents is being operated. It is obligatory to operate systems to deliver climate information including fogs, weather, and temperature as well as to maintain standpipe systems. In addition, the concepts of bridge management system and road pavement management system were introduced in the 1980s and have been applied to DISK in Netherlands, DANBRO in Denmark, BRUTUS in Norway etc. (Shin, 2006).

2.2 Limitations of existing technologies and a direction for development

A number of related technologies and road management systems were examined in the technology trend analysis of this study. These are road information analysis means based on basic physical information such as distance, speed, etc. and past event information, and they do not reflect various specific factors and real-time data.

Accordingly, it is necessary to develop technology for road environment prediction platform that utilizes various road data and real-time data such as traffic information, climate information, and road condition information as well as analyzes multiple data sets comprehensively. Besides, demands among users are to be reflected in technology development in order to develop highly reliable real-time road management system in connection with traffic information.

3. Domestic Road Management Systems and Suggestions for Their application

3.1 Road management systems and road information in Korea

In Korea, the MOLIT (Ministry of Land, Infrastructure, and Transport) have developed since the 1990s and operated various road management systems stated below in order to maintain bridges and road facilities as well as prevent and cope with road slope collapses and traffic congestions: ROAS (Road Occupation Access System, BMS (Bridge

Management System), PMS (Pavement Management System), CSMS (Cut Slope Management System), RSMS (Road Sign Management System) and TMS (Traffic Management System). The configuration of systems is illustrated in Fig. 1 (Choi *et al*., 2010).

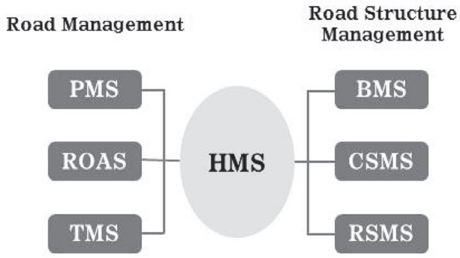

Fig. 1. Configuration of road management systems

The types and usability of road data collected through a road management system are presented in Table 1. ROAS provides data sets such as road occupation spots, areas, goals, and periods. It is expected that this system makes it possible to analyze road risks according to goals of road use and events. BMS collects safety-related data such as bridge load and structural information as well as basic information such as bridge length, width, and types. Based on the collected data, it will be possible to analyze bridge movements and risks as well as to control the volume of traffic. PMS collects various data sets such as pavement and maintenance records, crack rates, and grades of pavement status. In application of this database, it is possible to analyze the grade of pavement cracks in relation to the volume of traffic and road importance. CSMS utilizes slope detailed investigation data, constant measurement data, and maintenance status data, based on which, it is possible to predict risks of slope collapse and operate a disaster prevention system efficiently. TMS utilizes various types of traffic volume data. It is expected that the combination of various road data sets will contribute significantly to the analysis of traffic congestion. RSMS provides data sets such as guide name of road sign and connectivity of road in accordance with the guide name (Choi *et al*., 2010).

3.2 Development of big data platform using road management system

Road data continues to be accumulated in various road management systems. Accordingly, it is necessary to develop road information service and prediction platforms for 'smart road' realization. The road management systems and traffic/road information service based on road information that are suggested in this study are summarized in Fig. 2. The integrated analysis of road information and certain semi-structured data collected through various road management systems will make it possible to provide more reliable road traffic information (Kim *et al*., 2012).

Table 1. Road information of management systems

Class.	Road Information	Application of Information
ROAS	Occupation spot, area, goal, and period	Analysis of risks depending on the occurrence of events
BMS	Bridge type, load, design loading, year of completion, length, width, and structural info.	Traffic volume control based on the analysis of bridge risks
PMS	Year of initial pavement, crack rates, plastic deformation, flatness, grade of pavement status, maintenance history	Analysis of road importance depending on the grade of pavement cracks
CSMS	Detailed investigation info., constant measurement info., maintenance status	Prediction of risks of road slope collapse
TMS	Annual average volume of traffic, traffic volume of each vehicle type, traffic volume in each road section	Analysis of traffic congestion in combination of various road data sets
RSMS	Road sign info., guide name connectivity of roads	Analysis of traffic volume in accordance with guide name

In this study, big data acquisition and recorder platform for collect the road management system data was developed with suggested direction. Hadoop, Kafka, Sqoop, Flume were applied to collect the road management system data as open source. Scoop was applied to collect weather data, traffic accident information, traffic flow information, event information in time or day interval. Flume was applied to collect weather data, traffic accident information, traffic flow information, and social media data from Twitter in minutes interval or instantly. Kafka was applied to collect and upload the measurement data collected by the equipment.

Through the developed platform, weather information from KMA (Korea Meteorological Administration), traffic volume information from EX (Expressway), incident information, VMS information, construction information from ITS (Intelligent Transport Systems), accident information from Road traffic authority, road traffic information from road management systems and conprehensive traffic information from Twitter can be collected.

Collected road traffic information through each collection device such as Kafka, Scoop, Flume is stored in data storage Hadoop distributed file system and NoSQL. Stored information is replaced through arrangement analysis module such as Hive, Pig, Hadoop MapReduce.

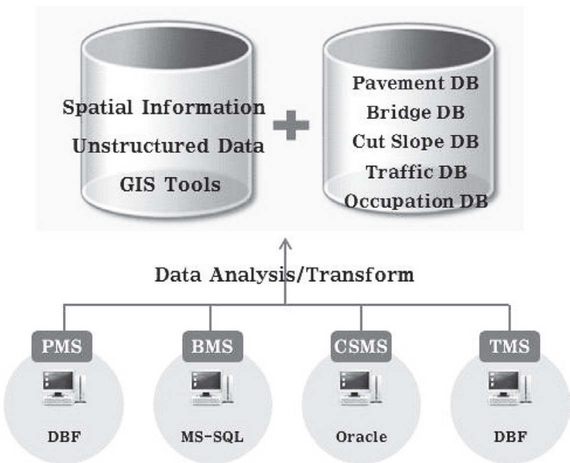

Fig. 2. Development of big data platform using road management system

4. Prediction of Traffic Volume Using Road Information from Big Data Platform

Big Data platform will be used to provide the collected road/traffic information from various management systems and open-source. This study shows that the new road/traffic information can be created from a combination of existing informations that have different properties.

In this study, prediction analysis of traffic volume using road information from big data platform was performed. To predict the traffic volume, the correlation of road sign guidance and traffic volume was applied.

A number of studies of correlation between road sign guidance and traffic volume were carried out and also, the researchs about development of road sign guidance naming programs, connectivity systems were conducted.

Among these studies, through the research using AHP (Analytic Hierachy Process) investigation method, the road sign guidance selection factors are population, area, traffic volume, public finance, and etc. (Chun *et al*., 2011). The traffic volume and population showed the greatest in importance by 0.35. The area was appeared by 0.1 and the public finance was appeared by 0.2 (Kwon *et al*., 2009).

In this study, regression analysis was conducted using a daily traffic information in the inlet and oulet of National way No.1 and Guide names of road sign in Korea. In this analysis, daily traffic and number of road sign in new town was predicted using equation derived through a regresstion analysis. The daily traffic volume and number of road sign collected through RSMS and TMS are presented in Table 2.

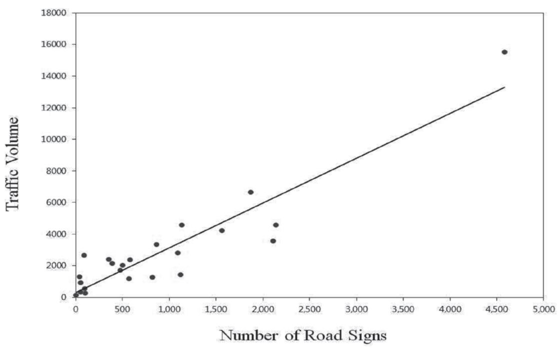

Fig. 3. The regression analysis of traffic volume and number of road signs

Table 2. Traffic volume and number of road signs

	Guide Name	No. of Road Sign	Traffic Volume		Guide Name	No. of Road Sign	Traffic Volume
1	Seoul	4,583	155,053	**11**	Hwanggan	107	2,452
2	Suwon	1,871	66,335	**12**	Gumi	394	21,453
3	Giheung	42	12,766	**13**	Chilgok	57	3,025
4	Dongtan	95	26,477	**14**	Daegu	2,144	45,647
5	Ansung	586	23,644	**15**	Kyeongsan	357	23,939
6	Mokcheon	57	8,982	**16**	Youngcheon	824	12,515
7	Cheongju	1,126	14,125	**17**	Geoncheon	103	5,246
8	Daejeon	2,110	35,687	**18**	Kyungju	1,096	27,997
9	Okcheon	570	11,508	**19**	Yangsan	508	20,077
10	Guemgang	10	1,232	**20**	Busan	1,139	45,742

Table 3. Prediction of the traffic volume derived by equation

Guide name	No. of road sign	Traffic volume from TMS	Traffic volume by equation
Osan	869	33,412	27,659
Cheonan	1,568	42,071	47,428
Oigwan	479	17,021	16,614

The result of regression analysis is graphed in Fig. 3 and equation derived through a regresstion analysis is presented in Eq. (1). Explanatory showing the relationship between the data and the accuracy of expression is analyzed by 0.859.

$$y = 2.83x + 305.5 \tag{1}$$

where x : Number of road signs, y : Traffic volume

It can be derive the traffic volume in accordance with the number of the road signs using Eq. (1). Conversely, It can be expected to derive the number of required road signs in accordance with the traffic volume. In this study, the traffic volume in new town was derived using Eq. (1). Also, comparative analysis was performed using the traffic volume from TMS and Eq. (1). The result of comparative analysis is presented in Table 3. As a result, the traffic volume in new town were analyzed in a similar level compared with the data from TMS and value derived by Eq. (1). Conversely, the number of road signs in Osan and Oigwan were analyzed as insufficient in accordance with the traffic volume.

5. Conclusion

The suggested way of predicting road information utilizes various types of road information from road management system for more reliable prediction of road Environment. As prediction of road environment is also taken into account, the predicted traffic information will help drivers drive safely on the road and realize smart road use. In addition, it will enhance the quality of driving conditions, which will increase the level of satisfaction among road users as a result.

Drivers are provided with predicted traffic information according to their specific needs, which will save time on the road and pleasant, satisfactory use of roads to the destination. Besides, it is expected that traffic congestion will be alleviated and environmental pollution also will be reduced accordingly.

In addition, this study shows that the new road/traffic information can be created from a combination of existing informations that have different properties.

It is expected that the integrated analysis of road data accumulated by multiple road management systems will make it possible to develop road/traffic status prediction technology. It will be possible to develop more reliable prediction systems and technologies in application of various types of road information, which also will realize safe and smart use of road infrastructures.

Acknowledgments

This research was supported by a grant from a Strategic Research Project (Development of driving environment prediction platform based on big data) funded by the Korea Institute of Civil Engineering and Building Technology.

References

Choi, W.S., Nah, H.S., Seo, M.B., Jeong, S.Y., and Lim, J.T. (2010), Asset management information in the social infrastructure, *Journal of the Korea Contents Association*, Vol. 10, No. 11, pp. 68-79. (in Korean with English abstract)

Chun, S.H., Kwon, S.K., Lim, H.S., Nam, D.S., and Lee, Y.I. (2011), Analysis of spatial influential zone for road sign using the variable radius buffer model, *Journal of the Korean Society of Transportation*, Vol. 29, No. 2, pp. 71-80. (in Korean)

Kim, D.M., Jeong., Y.M, and Min, S.Y. (2012), A study on building the platform and development of algorithm for collecting real-time traffic data, *The Korean Institute of Information and Communication Sciences Conference*, KIICE, 26 May, Seoul, Korea, pp. 535-538. (in Korean with English abstract)

Kim, H.T. (2014), Utilization of space big data - focused on the metropolitan public transport system analysis, *The Korean Geographlcal Society Conference*, 30 June, Seoul, Korea, pp. 284-285. (in Korean)

Kim, S.H., Shin, H.S., and Son, S.H. (2014), A study on large-scale traffic information modeling using R, *Journal of KIISE : Computer Systems and Theory*, Vol. 41, No. 4, pp. 151-157. (in Korean with English abstract)

Kwon, S.K., Chun, S.H., Lim, H.S., Nam, D.S., and Lee, Y.I. (2009), Development of the roadsign naming program, *Journal of the Korean Society of Transportation*, Vol. 60, pp. 3895-390. (in Korean)

Lee, J. (2013), Develop a road disaster prevention network in Korea through the analysis of system in Japan, *Journal of the Korean Society of Road Engineers*, Vol. 15, No. 4, pp. 5-8. (in Korean)

Lim, J.T., Kim, K.H., Kim, J.K., and Oh, H.K. (2014), Design and implementation of a realtime optimal traffic route guidance system through big data analysis, *The Korea Contents Society Conference*, 20 November, Seoul, Korea, pp. 297-298. (in Korean)

Osima, H., Matsita, T., Matsura, T., and Kim, M,C. (2007), Economic and policy trends in the japanese construction industry, *Research Institute of Construction and Economy*, Japan, http://www.rice.or.jp (last date accessed: 6 November 2015)

Park, H.S., Park, T.H., and Ha, T.J. (2006), A study on B/C analysis of improvement projects of high accident locations in highway (about safety facilities), *Korean Society of Civil Engineerings Conference*, 12 October, Gwangju, Korea, pp. 3939-3942. (in Korean)

Shin, H.C. (2006), An introductory study for developing asset management system of road facilities, ISBN 978-89-5503-225-3 93530, KOTI, Sejong, Korea, pp. 18-60. (in Korean with English abstract)