A STUDY ON THE METHODOLOGY FOR AUTOMATIC DB UPDATE
IN THE ROAD SIGN MANAGEMENT SYSTEM

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Abstract

Ministry of Land, Infrastructure and Transport Affairs of Korean government has launched the Road Sign Management Center in May 2005, which has been carrying out the various works such as installation, management, maintenance, update and education etc. of road sign (or Road Sign Management System, which is on-line system). However, it requires a lot of man-power and huge budget (estimated annually $4.8 million) to survey the road signs in the field and enter the data into the DB in the on-line system. So that is very inefficient and often conflicts with reality. It needs to improve. MOLIT decided to develop the Road Sign Recognition and Analysis Vehicle Platform (RRAP). RRAP is designed to transform the road sign image captured from natural road environment while moving into the text through the pattern recognition. As a part of this project, this research is aim to develop data-screening process and automatic update (or replacing or newly producing) algorism for the present DB in the Road Sign management System using the data from RRAP. We expect that RRAP can decrease labor and budget need to maintenance the Road Sign Management System.

Keywords: Road Sign Recognition and Analysis Vehicle Platform (RRAP), Road Sign Management System(RSMS), Automatic Update for the database, ID Matching, Unrecognized Road Sign Identification, Mobile Mapping System(MMS)

1. Introduction

Road Sign is Road facility that performs the functions to guide and induce road users for their destination quickly and comfortably. Road sign needs to be sensitive to about various changes in a variety of environments like establishment or change of place name or roadway because problems associated with road user’s safety can bring about when incorrect information is provided. The synchronization is a meaning whether information provided by the road signs is adapted to the actual local environment. And consistency is a meaning whether informed place name is provided by standard regardless of area. For this, Ministry of Land, Infrastructure and Transport (MOLIT) Affairs of Korean government is developing Road Sign Management System (RSMS) and propelling maintenance business annually. Road Administration across the country (about 300 including Korea Expressway Corporation, National Road Maintenance and Construction Office, local government, private road administration, etc.) can maintain, share, check-up, and then improve problems of the road sign information on the internet.

Korea Institute of Construction Technology (KICT) annually has built or updated DB of road sign of 5~13 national road lines through field survey since 2003. In 2010, KICT completed survey about whole national road (56 lines) and made an improvement scheme of road sign. From 2011, KICT is performing resurvey focusing on previously
surveyed line in consideration of changes of surrounding environments. The effort to maintain synchronization between DB in RSMS and road sign in the field is dependent on the field survey, so the number of lines which can be researched for one year is limited and research cycle for specific line is about 5 years averagely.

From September 2012, MOLIT is performing research about Development of Road Sign Image Data Recognition and Analysis Equipment to reconsider economic & time efficiency of field survey. In this research, road sign image is extracted by Mobile Mapping System (MMS) installed vehicle and data is extracted through pattern recognition. Based on this, analysis module which can automatically renew RSMS DB is developed.

Therefore, this research develops automatic update methodology of RSMS DB using data from MMS vehicle and pattern recognition. The aim of the research is decreasing labor & budget for road sign field survey and maintaining synchronization of road sign.

The rest of this paper is organized as follows: In Chapter 2, differentiation is derived through examination of relevant studies about road sign attribute data analysis. In Chapter 3, current state and problem of road sign management is presented. In Chapter 4, automatic analysis methodology of DB is developed. Finally, conclusions and future researches are stated in Chapter 5.

### 2. BACKGROUND THEORY AND LITERATURE REVIEW

#### 2.1 Type of road sign

Road signs are divided into 6 types (Boundary, Mileage, Direction, Road Number, Junction, Others) and each road sign provides information according to their unique characteristics. Direction road sign occupies more than 60% of whole installed road sign. The subjects of this research are 5 types of road signs (except others).

<table>
<thead>
<tr>
<th>Road sign</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boundary</td>
<td>Signs providing the boundary of Division</td>
</tr>
<tr>
<td>Mileage</td>
<td>Signs indicating distance to the destination</td>
</tr>
<tr>
<td>Direction</td>
<td>Signs guiding the direction or toward</td>
</tr>
<tr>
<td>Road Number</td>
<td>Signs providing the road number and hierarchy (ex, national highway etc.)</td>
</tr>
<tr>
<td>Junction</td>
<td>Signs guiding the road number of crossed road in front of intersection</td>
</tr>
<tr>
<td>Others</td>
<td>Tourist sign, Yield sign, Climbing lane sign, Induced sign, Rest area sign, Pedestrian sign, Bus-stop sign, Parking lot sign, Motorway sign, Bridge sign etc.</td>
</tr>
</tbody>
</table>

#### 2.2 Analysis of current state and problem of road sign management

##### 2.2.1 Current state of road sign management

Road Sign Management Center(RSMC) establish field survey plan and perform, also manage and examine road sign installed on the road which is (re)constructed annually. Now RSMS manages 163, 160 road signs according to data in January 2013. Table 2 shows road lines (annual average is 5~8) that completed road sign investigation from 2003 to 2012.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sum</th>
<th>Surveyed road number</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>5</td>
<td>Line 1, 39, 43, 47, 48</td>
</tr>
<tr>
<td>2005</td>
<td>12</td>
<td>Line 3, 7, 11, 12, 14, 16, 21, 32, 45, 82, 95, 99</td>
</tr>
<tr>
<td>2006</td>
<td>13</td>
<td>Line 2, 4, 6, 17, 22, 25, 26, 38, 36, 44, 46, 67</td>
</tr>
<tr>
<td>2007</td>
<td>5</td>
<td>Line 5, 31, 37, 79, 87</td>
</tr>
</tbody>
</table>

Table 1 Type of road sign

Table 2 Surveyed road number of national highway
2.2.2 Limit of field survey and Implications

Administrators of each Road Administration perform field survey for whole road sign of national road and manually renewed RSMS DB based on survey results. For this process, survey costs (including cost of data coding and analysis) are consumed enormously (about 5.2 billion won annually). But, maintaining synchronization between DB and established and changed road sign is difficult because of time and labor limits of field survey.

There are two methods to curtail procedural inefficiency. The first method is to equip the facilities on field survey vehicle so that field survey and DB update done at the same time. In this case, time and labor limit of field survey can be relieved most effectively. The second method is to improve inefficiency of the administrative procedure. Now administrators of each Road Administration update changes by local environment, road expansion and reconstruction manually. But, task about road sign is small part of Road Administration’s work. And there’s a time gap between environmental change and DB update in RSMS because of administrative procedures. This inefficiency of administrative procedures is hard to improve and spends a lot of time to relieve institutionally.

Therefore, this research suggests method to maintain synchronization between road sign and RSMS DB through solving time and labor limits.

2.3 Literature review

There are not many case studies about road sign over the past decade, and studies about place name selection of road sign are mostly performed. But, there are only 9 papers (38%) related to attribute data of road sign. Just recently, papers about MMS and character recognition are increasing.

In Figure 1, studies related to recognition of road sign are about finding out appropriate location of road sign in the terms of distance which driver have to recognize road sign and travel speed (Choi et al., 2001; Kim et al., 2007). Studies related to attribute of the sign treat aptness of guided place name and the number of guided information (Lee et al., 2006; No et al., 2007; Lee et al., 2008). Studies related to guided place name tried to set the impact zone of important place and facility. Choi et al. (2003) and Cheon et al. (2011) performed the study to reflect the influence area to the guideline.

Tim Aunan (2003) and Mariano Malpili (2005) suggested recent technology trend related to image information and character recognition through MMS, but they didn’t derived requirements of attribute data of road sign. Other studies (Chung et al., 2010; Kim et al., 2011) were about service improvement, connectivity, adequacy and management efficiency.

![Figure 1 Topic review of related research ('01~'12)](image-url)
3. METHODOLOGY

3.1 Automatic update process of RSMS DB

In the automatic update process of RSMS DB, road sign attribute data of RSMS DB and data collected from MMS installed in survey vehicle are automatically compared whether they match each other. Automatic update process of RSMS DB will be installed in survey vehicle, which is called Road Sign Recognition and Analysis Vehicle Platform (RRAP). RRAP consists of 3 modules in the serial order. First, image information acquisition module extracts road sign image from natural environment. Next, pattern recognition module extracts road sign attribute data from road sign image through pattern recognition. In this module, image information is converted into text information. Finally, analysis module analyzes text information and updates RSMS DB automatically. Also, image information acquisition module uses attribute data in GIS network, and analysis module is set to be linked with RSMS DB at the same time.

Automatic analysis process for automatic update of RSMS DB proceeds as shown in Figure 2. Before automatic update of DB, raw data from RRAP is classified into two groups, which is ID matched data and non-ID matched data, based on ID matching algorithms between RRAP data and RSMS DB. ID matched data is automatically updated to RSMS DB and non-matched data is newly generated with new ID in RSMS DB. Unrecognized data is reported to manager and it needs to survey in field.

3.2 Input data

3.2.1 RSMS DB

RSMS DB is road sign database of Road Sign Management Center System (established by MOLIT in May 2005) and consists of 48 tables and 709 fields. Among these, 6 road sign tables which need technical possibilities and automatic update are selected. These are automatically updated data based on results of field survey by MMS installed vehicle. And 6 road sign tables followed the rules of RSMS DB as shown in Table 3 to secure continuity of RSMS operation and efficiency of automatic update.

Table 3 Database form of RSMS

<table>
<thead>
<tr>
<th>Sign ID</th>
<th>Road_types</th>
<th>Azimuth</th>
<th>Overpass</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NR</td>
<td>S</td>
<td>N</td>
</tr>
<tr>
<td>2</td>
<td>NR</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>3</td>
<td>ER</td>
<td>W</td>
<td>N</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

3.2.2 RRAP DATA

RRAP data consists of basic data from field survey by MMS installed vehicle and attribute data extracted from image information using pattern recognition. Basic data, which includes road sign management administration, road type, road azimuth, etc., is difficult to know through field survey. Also basic data is same regardless of road sign type. Therefore it is extracted from GIS data included in RRAP. Attribute data is contained in the road sign. It means place name, route number, administration area name, distance, etc. and collected by pattern recognition module in RRAP.

Common 12 basic data and 70 attribute data of each road sign are extracted from RRAP and they become analysis data. Data input form is set to follow the current rules of RSMS DB.
Figure 2 Architecture of automatic update of database in Road Sign Management System (RSMS)
### Table 4 RRAP data

<table>
<thead>
<tr>
<th>Table name</th>
<th>No. of fields in RSMS</th>
<th>RRAP DATA</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of basic data</td>
<td>No. of attribute data</td>
<td></td>
</tr>
<tr>
<td>T_PANEL</td>
<td>64</td>
<td>12</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>(19%)</td>
<td>(8%)</td>
<td>(46%)</td>
</tr>
<tr>
<td>T_PANEL_.BOUNDA Y</td>
<td>7</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>(43%)</td>
<td>(43%)</td>
<td></td>
</tr>
<tr>
<td>T_PANEL_.MILEAGE</td>
<td>7</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>(71%)</td>
<td>(71%)</td>
<td></td>
</tr>
<tr>
<td>T_PANEL_.ROADNUM</td>
<td>7</td>
<td>-</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>(86%)</td>
<td>(86%)</td>
<td></td>
</tr>
<tr>
<td>T_PANEL_.BRANCH</td>
<td>8</td>
<td>-</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>(88%)</td>
<td>(88%)</td>
<td></td>
</tr>
<tr>
<td>T_PANEL_.DIRECTION</td>
<td>59</td>
<td>-</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>(83%)</td>
<td>(83%)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>152</td>
<td>12</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>(8%)</td>
<td>(8%)</td>
<td>(46%)</td>
</tr>
</tbody>
</table>

3.3 ID Matching Algorithm

ID matching is needed to update RSMS DB and RRAP data automatically because ID can’t be extracted through field survey. Therefore, if RRAP data without ID matches with RSMS DB, RRAP data becomes perfect data through taking road sign ID of RSMS DB. ID matching algorithm as follows:

- Step 1 : To read X, Y coordinate, road kind, route number, direction (up & down), panel code from RRAP DATA without ID and panel code
- Step 2 : To filter RSMS DB based on data of Step 1
- Step 3 : To calculate the distance between filtered X, Y coordinate in RSMS DB and X, Y coordinate in RRAP DATA
- Step 4 : To select the nearest data with RRAP DATA
- Step 5 : To check whether selected data comes in valid error range(±1m) or not
- Step 6 : To give matched ID if selected data comes in error range
- Step 7 : Automatic update of RSMS DB

In step 6, data which comes in error range can be updated automatically because both RSMS DB and RRAP DATA exist and match each other. But, there are two cases that RSMS DB and RRAP DATA don’t match because one of them doesn’t exist. First, RRAP DATA doesn’t exist if road sign is actually removed or unrecognized due to surrounding environment. Second one is new installation of road sign that previously didn’t exist.

![Figure 3 Algorithm for ID Matching between DB in RSMS and RRAP data](image)

3.4 Automatic Update Algorithm For the Database

Automatic update for the database is analysis process of updating or creating DB by RRAP DATA after checking whether RRAP DATA and RSMS DB match each other or not. First, after checking whether RRAP DATA and RSMS DB match each other or not, RRAP DATA which matched with ID updates RSMS DB. For RRAP DATA that ID matching is not performed, new road sign ID is given and corresponding information is
created on RSMS DB. Automatic update algorithm for the database as follows:

- Step 1: To divide input data into matched and non-matched data
- Step 2: To update DB automatically if ID matched
- Step 3: To generate new DB (give new ID) if ID doesn’t matches
- Step 4: To update DB and make newly generated DB list
- Step 5: Administrator confirmation

Figure 4 Algorithm for automatic DB update

3.5 Unrecognized Road Sign Identification Algorithm

Unrecognized road sign identification algorithm applied when non-matched RRAP DATA exists on RSMS DB but doesn’t exist on newly surveyed RRAP DATA. There are 2 cases. One is the case that field data didn’t extracted because of unrecognition from equipment due to missing of road sign or surrounding environment. Another is the case of removal or damage of road sign.

Unrecognized road sign identification algorithm as follows:

- Step 1: To decide field survey area (Extracting survey subject data from RSMS DB)
- Step 2: Field survey (Making RRAP DATA)
- Step 3: ID matching algorithm (Comparing RSMS DB vs RRAP data by field survey)
- Step 4: To extract road sign ID which doesn’t exist in RSMS DB
- Step 5: Administrator confirmation

unrecognized road sign because of the error of RRAP vehicle (to remain data from RSMS DB)
- removed road sign (to remove data from RSMS DB)

Figure 5 Algorithm for unrecognized road sign

4. CASE STUDY

4.1 Selection of target road

Target road for analysis is a part of Chang-won main street in Changwon city, Gyeongsangnam-do, South Korea. There are 11 direction signs on that road. When to start survey with RRAP vehicle, survey date and range of target road is manually
inputted to increase work efficiency.

![Figure 6 Target road – Chang-won Main Street](image)

4.2 Analysis scenario set-up

Analysis scenario consist of 3 cases which can be occur in field survey such as Table 5. In scenario 1, which road sign on RSMS DB and road sign on RRAP DATA match each other, DB is normally updated. ID matching is performed through considering information such as X, Y coordinate, route number, direction (up & down stream) and panel code. After ID matching, DB is updated, that is, basic data and attribute data for one road sign are integrated.

In scenario 2, road sign ID is not matched because road sign on RRAP DATA doesn’t exist in RSMS DB so that give new ID and generate RRAP DATA additionally in DB.

Lastly, in scenario 3, road sign is unrecognized because of missing, removal and damage. So, road sign data exists only in RSMS DB.

Table 5 Analysis Scenario and results treatment

<table>
<thead>
<tr>
<th>Scenario</th>
<th>DB in RSMS</th>
<th>RRAP DATA</th>
<th>ID Matching</th>
<th>Results Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario_1</td>
<td>○</td>
<td>○</td>
<td>Matching</td>
<td>DB update</td>
</tr>
<tr>
<td>(S1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scenario_2</td>
<td>×</td>
<td>○</td>
<td>Not matching</td>
<td>Generation of New ID and DB</td>
</tr>
<tr>
<td>(S2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scenario_3</td>
<td>○</td>
<td>×</td>
<td>Not matching</td>
<td>Report to Confirm the sign</td>
</tr>
<tr>
<td>(S3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.3 Results of Analysis

We applied the algorithm for automatic update of RSMS DB to case study section. Accuracy of algorithm is verified whether field state is classified automatically and treated accordingly.

In case of scenario 1, 8 road sign IDs matched each other among 11 road signs in RRAP DATA. And it is appeared to reflect field state well because RRAP data (basic information and attribute data) for each ID is updated to current RSMS DB.

In case of scenario 2, new ID is generated and gave to 3 road signs which is not matched each other among RRAP data. And RRAP data given each new ID is added to current RSMS DB.

In case of scenario 3, 2 road signs (except 8 road signs which DB is updated among 10 road sign data in RSMS DB at target road) is extracted and classified as unrecognized road sign in the field. And unrecognized road sign is reported to administrator for site confirmation.

5. Conclusion

Ministry of Land, Infrastructure and Transport (MOLIT) is developing Road Sign Recognition and Analysis Vehicle Platform (RRAP), which updates RSMS DB automatically and secures synchronization between road sign and RSMS DB, to overcome time and labor limit of field survey about 160,000 road signs in the whole country. RRAP consists of image information acquisition module which extracts road sign from natural environment, pattern recognition module which changes road sign image to text data, and analysis module which analyzes attribute data of road sign and updates RSMS DB.

This research developed the methodology for automatic update of RSMS DB by analyzing attribute data of road sign which is extracted through pattern recognition. The results will be used to utilize as automatic analysis module in RRAP system. Automatic update of RSMS DB is performed through ID matching algorithm between RSMS DB and RRAP data, automatic updating algorithm for the database, identification algorithm for unrecognized road sign.

These algorithm is applied to real world, that is a part of Chang-won main street in Changwon city. The result is deducted that the algorithm reflects field state accurately and treat DB as planned in advance. Scenario 1 updated DB, scenario 2 searched non-matched road sign and newly generated and added to RSMS DB. Lastly, scenario 3 extracted road sign list which is unrecognized by
RRAP and reported the lists for site confirmation. This research targeted only direction sign, which occupies over 80% among whole road signs. So it is needed to add analysis function and consider case studies for other types of road sign. When RRAP is fully developed, we can expect RRAP to be applied to 160,000 road signs in the whole country.

Further RRAP is expected to offer the integrated system, which can investigate, analyze and report field investigation results and it is necessarily needed to operate RSMS. RRAP has the potentiality to expand functionally, and then RRAP can analyze the connectivity and the suitability of road sign in terms of road network and guidelines as well as analyze automatically and update RSMS.

We can also say that this research is significant in the two following points: first, RRAP will effectively maintain synchronization between DB in RSMS and road sign in the field by reducing labor and budget and enhancing the accuracy of the survey, second, RRAP will serve to increase the value of RSMS DB in information economy era because RSMS DB becomes a direct guideline for road sign own.

ACKNOWLEDGEMENTS

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