RESEARCHERID
THOMSON REUTERS

[Jang, 5(7): July 2018]
DOI: 10.5281/zenodo.1324096

ISSN 2348 – 8034
Impact Factor- 4.022

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

A STUDY ON THE RELIABILITY OF ROAD SIGN DATA THROUGH THE APPLICATION OF LINEAR REFERENCING SYSTEM

Younmi Jang
Research Specialist, Korea Institute of Civil Engineering and Building Technology, South Korea

ABSTRACT

A variety of road facility management systems, such as the highway management system, pavement management system, which are systems for the site itself, and systems for the various road accessories suchas road signs and street lamp, haverecently been established to systematically manage road facilities. This has increased the effectiveness of the management of road structures;however, theyoften cause statistical inaccuracies such as information entry, interworking, and other errors, or causes various problems in use. The same problem existswith the road sign management system, which manages approximately170,000 road signs in Korea. The management of road signs based on the road is necessary to address problems such as incorrect entry error of the most basic road information, limitations inusability due to simple location identification of road signs, and inaccuracies in analyticalstatistics of structures.

A method of applyingthe linear referencing system technology to extend to road alignment-based systems and to effectively manage road signs is proposed herein. Through this management technique, which is controlled by connecting road signs based on road alignment, data can be reliably secured by reducing errors in road sign entry and management. It is also easy to detect and correct information errors on connected road signs if the information in the road alignment changes. If the road alignment changes, it is expected that the road signs will be automatically calibrated and that the road signs will be connected to the wrong road to prevent managed errors.

Key words: *Road alignment, Road sign, Road Sign Management System, Road management System, Linear Referencing System.*

I. INTRODUCTION

As the need and importance of road facilities information becomes increasingly apparent, the various technologies have been developed andtested for GIS-based road facilities-road sign management. Particularly, effective facility management techniques have been actively investigated by using the location of road facilities as well as the correlation between road facilities and road alignment [1] - [3].

Conventional GIS management systems have only manage the attributes and location-based spatial information of facilities;thereby providing the alignment information correlated with facilities in the form of a background map [4]. Conventional GIS management systems have been focused on the individual facility management functions to manage basic facility information separately from the spatial alignment information, which is the matrix of the facility. This approach could lead to various problems including limited usage of the facilities as well as inaccuracy in analysis and statistical propertiesregardingthe facilities due to the lack of correlation between the alignment and the corresponding facility. On the other hand, the alignment-based facility management is aimed at achieving more efficient management by integrating these alignment management systems into a coherent system;thus,eliminating redundant and inefficient tasks such as reproduction of information. [5]-[6].

In this paper, we introduce and extend the linear referencing system (LRS) technology, which has recently been attracting attention, for a road alignment-based system. In this regard, we first introduce alignment-based facility management technologies. Subsequently, we present three techniques for alignment based facility management technologies within road signs, including road alignment-based road sign reference technique, road alignment information management system for error correction of road signs, and road sign location correction technique for

road alignment modification. In thisstudy, alignment reference system technology was applied to ensurethe reliability and stability of the road sign data

II. OVERVIEWONALIGNMENTBASEDFACILITYMANAGEMENTTECHNOLOGY

To the focus of this study was to apply the alignment-based facility management technology as a road sign management technique to demonstrate a road sign management technique based on road alignment.
Alignment-based facility management technology, which is a type of a location reference system, refers to a GIS-based system that queries and identifies the location of events (attributes, facility information, etc.), present on alignment objects such as a road, based on relative measurement values. Linear forms of facilities such as roads, railways are expressed as a link,whichincludes the alignment information and the facility itself, and a node that represents the intersection between the roads Thenode is composed of the information on the intersection as well as a link connected to the corresponding node [1]. In applying this alignment information to the road, the information management and analysis based on the alignment unit is very effective compared to conventional systems.Furthermore, the data reliability is ensured because this technology can detect errors in the information [7].
The alignment-based facility management technology provides a smart environment for alignment network management linked with various GIS spatial information based analysis functions, in addition to lookup operations based on the linear object unit. This technology alsoprovides more intuitive representations of events for users, which are managed based on the road alignment, compared to conventional management systems. Moreover, this technology is advantageous in that the linked events and facility information can be easily updated and corrected having a correlation when the alignment information is modified.This is because events are linked and managed in the alignment with directionality.

III. APPLICATIONPLANOFALIGNMENTBASEDFACILITYMANAGEMENTTECHNOLOGYINROADSIGNS

To apply the alignment-based facility management technology to the road signage area, we first define a correlation between the road signs and the road alignment (network).Subsequently,wepresent a management method. Second, based on the correlation with the road alignment, we provide a management method that can correct and reduce the errors in road sign information. Finally, we propose a method to correct road signs along the movement of road alignments.

Road Alignment based Road Sign Reference
Linear facilities such as roads and railways are managed by connecting them to neighboring linear (road or rail) facilities. Thesenetworksare thendivided into nodes, whichare intersectionsat which roads meet, and links, which represent the alignment information of the road itself. The link has information such as shape, length, and grade of the alignment, and the node has information regarding theintersection as well as the i the link connected to the corresponding node. This alignment reference technique, which links and manage road signs (facilities) to road alignment, can increase the efficiency of road sign management and reduce input and management errors.

The most important task needed to apply the road alignment-based road sign reference techniqueis to establish reference relationships between road alignment and the facilities. The reference relationship between the road alignment and the road sign is expressed by the road alignment ID, which is installed with the road sign, the sequence number from the road alignment point, and the direction (clockwise/counterclockwise). The corresponding information is listedin Table 1.

[Jang, 5(7): July 2018]
DOI: 10.5281/zenodo.1324096
ISSN 2348 – 8034
Impact Factor- 4.022

Table 1. Reference information between road alignment and road sign

Category	Description
D	Road sign ID
Road alignment ID	Road alignment ID connecting the road sign
SEQ	Connected rank
M	Distance from the point of connected alignment
CW	Clockwise based on the progress direction of road alignment
Input position	Input position of road sign
Compensated position	Compensated position of road sign

The reference information derivation process requires theroad alignment ID, thenormal line between the road alignment and the installation position of the road sign, and an intersection point P ' which is wherethe normal line and the road alignment meet is and is calculated as shown in Fig. 1.

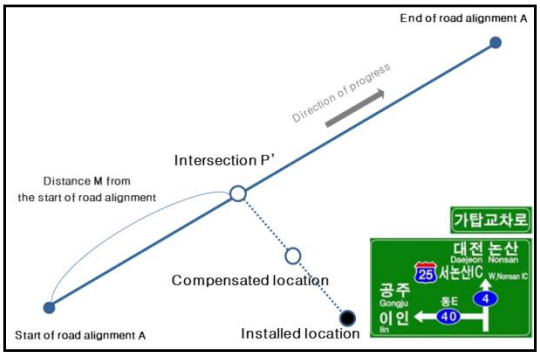


FIG.1: Referencing between road alignment and road sign

After calculating the intersection point P ', the corrected position is calculated.This is accomplished by measuringthe distance M from the start of the road alignment start to the intersection point P' and using the sequence number (SEQ). Using this algorithm, the connection information is generated to build the cross-reference between the road sign and the road alignment, and the connection information is managed to compare the modified information with the information stored in the road alignment in the eventof subsequent modification of the road sign information to determine the error. The execution sequence for the algorithm is shown in Fig. 2.

[Jang, 5(7): July 2018]
DOI: 10.5281/zenodo.1324096

ISSN 2348 – 8034
Impact Factor- 4.022

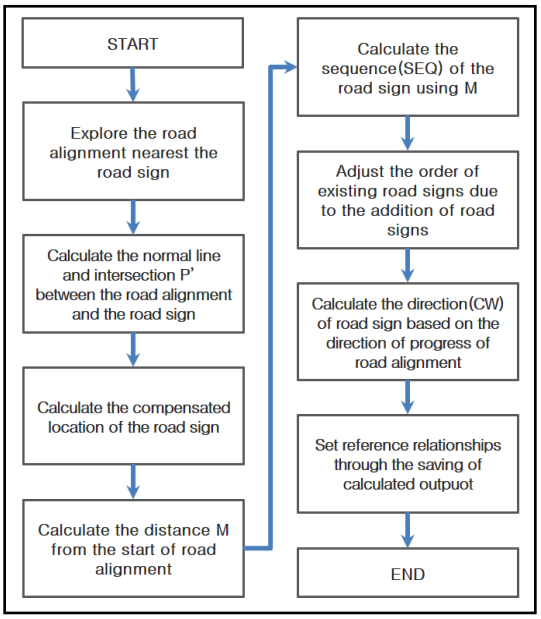
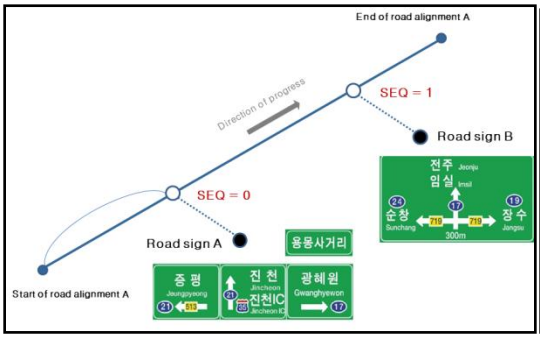


FIG. 2: Algorithm for setting reference relationship

In this study,the sequence numbers (SEQ) of the road signs are stored usingthe reference information to manage the sequence of road signs in the road alignment.If road sign C is newly installed, as shown in in Fig. 3, the sequence numbers are automatically aligned as shown in Fig. 4.



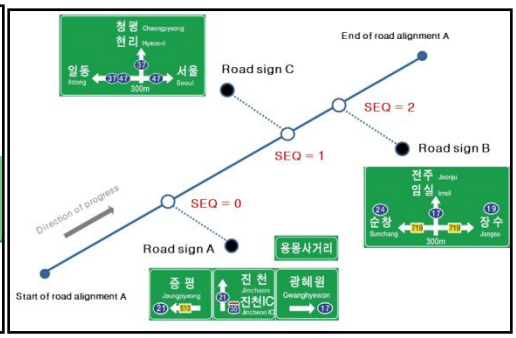


FIG. 3: Sequence management of road signsFIG.4: Change order of existing road signs when the road signs are added

The road sign sequence number enableseasy identification of the sequences of road signs along the entire road (route).Whenan update inthe roadalignment occurs, it is possible to perform an effective linear update operation by simply adjusting the sequence numbers. Fig. 5 shows the advantage of using thealignment-based system.The figure shows thatthe sequence numbers of road signs are easily identified by using the sequence number (SEQ) when analyzing road route units.

[Jang, 5(7): July 2018]
DOI: 10.5281/zenodo.1324096
ISSN 2348 – 8034
Impact Factor- 4.022

FIG. 5: Locate road signs on the whole road through SEQ

Road alignment information management for error correction of road signs

In this study, the cross-reference between road alignment and road sign are defined based on thelocation and pre-assigned critical management information regardingroad alignment to reduce errors of road sign attributes. Table 2 liststhe management information.

Table 2. Road alignment management for error reduction

Category	Description
Management agency	Management agency for road and road sign
Road type	Expressway, National highway, Provincial road, or City
Route number	Route number of road alignment
Road name	Road name from Ministry of the Interior and Safety
Up/down line	up/down line of road(when expressway and national highway)
Intermediate line	All sharedroads (when multiple routes are sharing one road)

When a road sign is installed, the road alignment to be installed must first be selected and entered. In this case, the management organization, route number, road name, and upstream/ downstream information of the selected road alignment are automatically set on the road sign to prevent input errors. Fig. 6 shows an example of detecting incorrect input information based on the attributes of the road alignment by using the alignment-based reference technique when the installed road sign is entered into the system.

When a road is relocated or a road type is modified, the information such, as the management organization, is modified. In this case, if the information of all the connected road signs are not individually corrected, then the connected mark is retained as an error sign. In the alignment based management technology, if the attribute of the

[Jang, 5(7): July 2018] ISSN 2348 – 8034
DOI: 10.5281/zenodo.1324096 Impact Factor- 4.022

road alignment is modified, it is possible to automatically check whether any of the connected signs are erroneous, and consistently update the erroneous information.

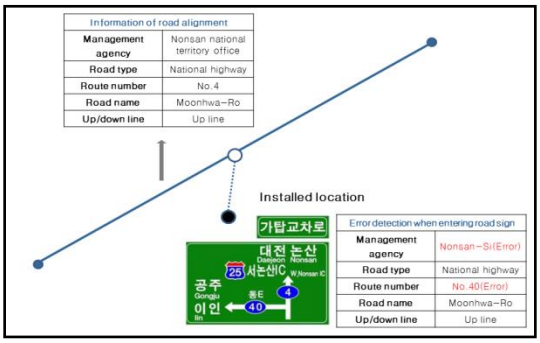


FIG. 6: Reduced errors for entering road sign data

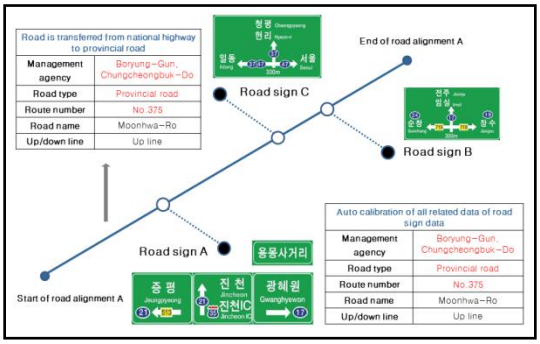


FIG. 7: Automatic detection and calibration of error sign

Road Sign Location Correction Technique for Road Alignment Modification

Finally, this study proposes a method to ensure the reliability of the information by automatically updating the referenced road signs if the wrong road alignment is corrected. Conventionalpoint-based systems canchangethe road alignment, leaving the road signs in their original position, when modification are made to theroad alignment. The alignment-based system utilizes the reference information (correlation) between the road alignment and the road sign to enable the road signs to be movedaccordingly when the road alignment changes.

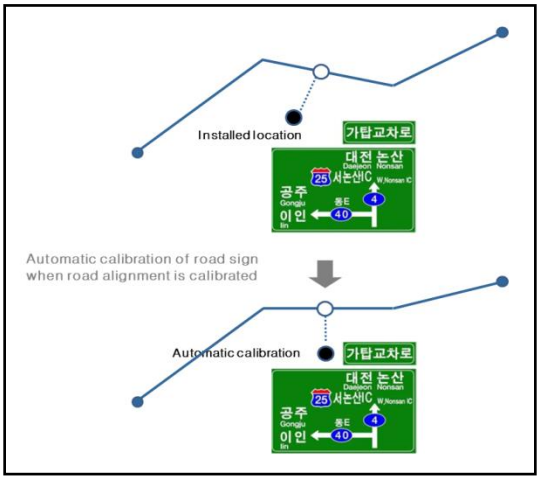


FIG. 8: Automatic calibration of road sign position when road alignment is updated

ISSN 2348 – 8034
Impact Factor- 4.022

We applied the alignment-based management technology to the road sign management system. The road sign management system is currently applied to a total of 170,000 signs, and is a system that is usedby over 240 officers in charge of signs in the land management office and municipalities. The road sign management system was operated for two years by applying the alignment-based management technology,starting inJuly 2014, and the results of operating the long-term alignment based road sign management system are listedin Table 3.

Table 3. Number of error signs improvement (2016. 10)

Error	Before(cases)	After(cases)
Management agency	6,560	2,599
Road type	3,915	392
Route number	5,813	338
Road name	1,408	471

As of October 2016, the number of errors having occurred at managementagencies decreased from 6,560 to 2,599; the number of road type errors decreased from 3,915 to 392; the number of road number errors decreased from 5,813 to 338; and the number of road name errors decreased from 1,408 to 471. Table 4 liststhe reduction rates of error signs.

Table 4. Rate of signs improvement errors

Error	Before	After	Reduction(%)
Management agency	3.73%	1.48%	60.38%
Road type	2.23%	0.22%	89.99%
Route number	3.31%	0.19%	94.19%
Road name	0.80%	0.27%	66.55%

The application of the proposed system resulted in a reduction in the number of errors in road signs.

IV. CONCLUSION

In this study, we applied analignment reference technology to the road sign management system and investigated the effect onroad sign management and the error reduction method for road sign information. Furthermore, we proposed a method to define the correlation between road alignment and road signs and build the cross-reference between them. The information error detection and correction methods for road signs connected to road alignment were investigated.

The results of this study confirmthat the proposed system significantlyreduced the information error for road signs compared to the conventional systems.The results prove that this alignment based management technique canbe applied to the various facilities that are operated basedonalignment information, such as roads, railroads, and rivers, in addition to road signs

REFERENCES

1. *C. H. Hong, Development of Linear network-based Public Infrastructure Management Technology and Commercialization, Korea Institute of Civil engineering and Building Technology, R&D report, 2014.*
2. *D. G. Kim, Study on using linear feature for management of railroad facility in GIS environments, Pusan National University, Master thesis, 2005.*
3. *W. S. Lee, J. Y. Na, J. Y. Woo, Development of Web GIS Based Road Sign Integrated System for Enhancing Management Efficiency, Journal of Spatial Information Research, Vol. 15, No.3, pp.335-346, 2007.*

[Jang, 5(7): July 2018] ISSN 2348 – 8034
DOI: 10.5281/zenodo.1324096 Impact Factor- 4.022

4. *K. C. Choi, B. Y. Suh, I. C. Park, A GIS and Expert System Based Transportation Facility Management System for Local Government, Journal of the Korean Society for Geospatial Information Science, Vol.5, No.2, pp.179-192, 1997.*
5. *J. U. Won, A GIS and Expert System Based Transportation Facility Management System for Local Government, Journal of the Korean Society for Geospatial Information Science, Vol.5, No.2, pp.179-192, 1997.*
6. *Y. S. Bang, K. Y. Yoo, Line Matching Method for Linking Wayfinding Process with the Road Name Address System, Journal of the Korean Society for Geospatial Information Science, Vol.24, No.4, pp.115-123, 2016.*
7. *H. K. Sung, K. S. Jung, A Study on Securing the Stability of Road Sign through Analysis of wind data according to types of measurement, Journal of the Korea Academia-Industrial Cooperation Society, Vol.18, No.2, pp.77-84, 2017.*