GIS-BASED ROAD GUIDE SIGN MANAGEMENT DECISION SUPPORT SYSTEM

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Abstract: A road guide sign is an important traffic facility which guides drivers in the direction to go. Since a road is being newly built and an existing road is temporarily being closed, such information has to be linked to a road guide sign and to be updated in time. However, road guide signs are not properly managed at this time in Korea. This is because of the large amount of information and the fact that the road guide signs are being managed manually through paper maps. In this study, the concept of Geographic Information Systems (GIS) will be introduced to facilitate data management for road guide signs. A GIS-based decision-making framework has been developed for managing road guide signs. It is entitled "Road Guide Sign Management Decision Support System". This system has mainly three different modules; database management, spatial analysis, and graphic representation modules. The database management one deals with digital maps and attribute data for road guide signs. The spatial analysis one provides a couple of simulation models, such as the manipulation of statistics, landmark linkages along the traffic corridor and automatic design of a signboard's content. The graphic representation one supports a decision maker with various colorful outputs. Finally, this system has been applied to the Kangnam district in the city of Seoul for a case study.

1. INTRODUCITON

1.1 Background of the Problem

A variety of traffic facilities, such as traffic signals, road markings, road signs etc., are needed for continuous traffic flow as well as traffic safety. Road guide signs are an important traffic facility which guides drivers in the direction to go. Roads are being newly built and/or and existing roads are temporarily being closed in metropolitan areas. This makes the traffic situation change rapidly. Such information has to be linked to road guide signs and to be updated regularly. Inefficient management of this information, such as inappropriate location of road guide signs and wrong information of road guide signs can mislead drivers. The result is unexpected traffic accidents and unnecessary wondering on roads.

However, road guide signs are not properly managed at this time in Korea. This is because of the large amount of information and the fact that road guide signs are being managed manually through paper maps. There are more than 7,000 road guide signs in Seoul while only one person is in charge of all the road guide signs.

1.2 Research Objective and Approach

The purpose of this study is to develop a decision-making framework which can manage a variety of information about road guide signs. It is based on the concept of GIS (Geographic Information Systems).

In order to achieve the research objective, current problems of road guide signs and corresponding countermeasures will be identified first. Then, the GIS concept will be introduced as a tool for facilitating data management related to road guide signs. A decision-making framework called " Road Guide Sign Management Decision Support System" will be developed on the basis of GIS. Finally, this system will be applied to the Kangnam district in the city of Seoul for a case study.

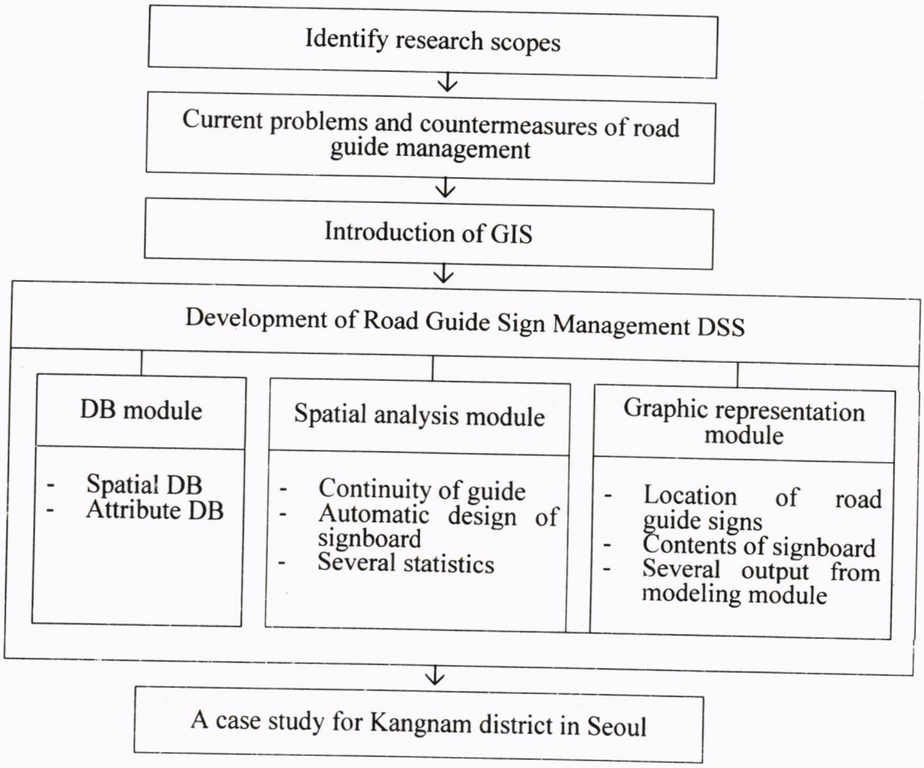

Figure1. A Flow Chart for Research Approach

2. CURRENT PROBLEMS OF ROAD GUIDE SIGNS MANAGEMENT

The current problems of road guide signs can be boiled down into two categories: i) No existence of signs where they should be, ii) Signs with wrong or invisible information. The former includes the lack of numbers and inappropriate location of road guide signs. The latter includes road guide signs hidden by obstacles, ambiguous information or discontinuity of landmarks, and mismatching information between a road guide sign and other information.

2.1 No Existence of Signs Where They Should Be

A general rule of road guide signs around intersections is to install three different signs consecutively; first a direction notice sign, followed by a direction guide sign and a direction identification sign. However, this rule is not kept well because of the shortage of funds and incomplete criteria.

Moreover, information signs which show the road name and/or the road number on the road is also needed along the road. This is also not available.

Figure2. Missing Road Guide Signs at Main Intersection

2.2 Signs with Wrong or Invisible Information

2.2.1 Invisible Information Inside Road Guide Signs

The size of letters in road guide signs must be determined by considering the speed limit and geometric designs of each road segment. However, the letter signs are uniform regardless of each road's characteristics. Some road guide signs are barely visible since they are hidden by street trees or traffic signals.

Figure3. An Invisible Road Guide Sign Hidden by Street Trees

2.2.2 Ambiguous Information or Discontinuity of Landmarks

Since landmarks on road guide signs have been selected without any criteria, some of them are ambiguous. For example, a landmark called "Seochogu" inside the Seochogu area is misleading information.

Also, landmarks along a traffic corridor are not closely linked. In some cases, they are different than each other even though they represent the same location or facility.

2.2.3 Mismatching Information Between A Road Guide Sign and Other Information

The information between a road guide sign and other signs such as road markings conflict at the same intersection. This can happen because road guide signs are maintained by a local government, while road guide markings are done by the Local Police Agency. This misleading information sometimes causes drivers to change lanes and to cause an accident.

Figure4. Mismatching Information between a Road Guide Sign and Other Information

3 COUNTERMEASURES OF ROAD GUIDE SIGNS MANAGEMENT

3.1 Establishment of Criteria

In principal, three different signs, which are notice, guide, and identification signs, have to be installed around intersections. However, it might confuse a driver if the distance between adjacent intersection is short. Therefore, a kind of criteria for installing road guide signs is needed. Installation criteria of road guide signs are suggested according to road types at intersections. That is, any intersection between trunk roads (auxiliary) should keep the notice, guide, identification signs in sequence. On the other hand, any road type meeting collection roads should have a guide sign with a notice sign and an optional identification sign.

Table 1. The Proposed Criteria for a Road Guide Sign Information

Cross / Forward	Trunk road	Auxiliary trunk road	Collection road
Trunk road	A, B, C	A, B, C	(A), B, (C)
Auxiliary trunk road	A, B, C	A, B, (C)	(A), B, (C)
Collection road	(A), B, (C)	(A), B, (C)	(A), (B), (C)

A: Notice sign, B: Guide sign, C: Identification sign
( ) : Installed in case of necessity

3.2 Reasonable Landmark Selection

All the facilities used as a candidate for landmarks should be represented as a point, a line, or a polygon. A landmark can be understood clearly if it is figured as a point or a line rather than polygon.

The best way to select reasonable landmarks is to distribute survey questionnaires for a specific area. The typical landmark alternatives are city hall, subway stations, hospitals, museums, sport complex, bridges, etc.

3.3 Continuity of Landmarks Along the Traffic Corridor

A reasonable landmark has to be linked along a traffic corridor. Otherwise, a driver can be confused even though landmarks are clearly understood.

3.4 Adaptation of GIS Techniques

The maintenance and improvement of road guide signs can not be done manually since it is data intensive and laborious. An advanced computer technique called Geographic Information Systems (GIS) is the optimal solution for effectively managing road guide signs.

4 INTRODUCTION OF GIS

4.1 Element of GIS

GIS consists of three distinct elements: Database, Spatial Analysis, and Graphic Representation elements. The database element covers digital maps(spatial data), usually converted from paper maps and attributes of objects (attribute data) in digital maps. The spatial analysis element indicates an engine of Decision Support System(DSS) which can support decision-making through database management. The graphic representation element displays the outcomes of spatial analysis and database inputs for the end-users who are usually not specialists.

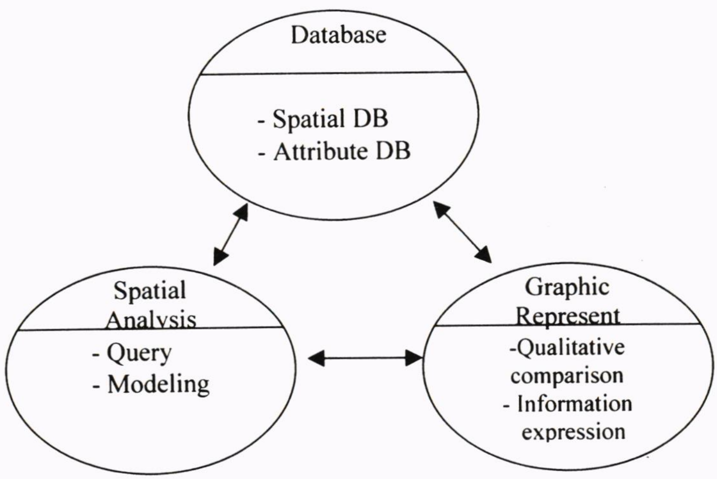

Figure5. Three Basic Elements of GIS

4.2 Efforts of GIS Development of Korea

The Korean government plays a major role in the construction of NGIS (National Geographic Information Systems), focusing on the development of spatial databases.

Three scales of digital mapping of topographic maps are being made, which are supposed to be finished by 2000

- 1/1,000 scale : 78 urban cities(except mountain areas)
- 1/5,000 scale : whole nation (except mountain areas)
- 1/25,000 scale : mountain areas

9 different layers are being constructed at the same time. The layers are railways, rivers, roads, buildings, tributaries, facilities, topography, jurisdiction boundaries, and a legend.

4.3 Data File Format of Digital Map

A national basic digital map is being made in the DXF format, which is the format of a commercial software program, AutoCAD. A DXF file is simply an ASCII text file. The overall structure of a DXF file has four different sections, plus the "End of file" marker. The selections are HEADER, TABLES, BLOCKS, ENTITIES sections.

HEADER section	TABLE section	BLOCK section	ENTITIES section
$ACADVAR	LAYER TABLE	BLOCK1	POINT
$ANGBASE	LTYPE TABLE	BLOCK2	TEXT
$ANGDIR	STYLE TABLE		LINE
•	APPID TABLE	•	POLYLINE
•	DIMSTYLE TABLE	•	ARC
$EXTMAX	VIEW TABLE	•	CIRCLE
$UCSYDIR	UCS TABLE	•	INSERT
$USRTIMER	VPORT TABLE	BLOCKn	•
			•

Figure 6. The Structure of DXF Format

The HEADER section has general information about the drawing. Each parameter has a variable name. The TABLES section contains several tables, each of which contains a variable number of table entries. The BLOCKS section contains block definition entities that make up each block in the drawing. The ENTITIES section contains the drawing entities.

Each section is composed of many groups, each of which occupies two lines in the DXF file. The first line in the group is a group code, which is a positive integer value. The second line in the group is a group value, either a string or a number.

Group codes range from 0 to 1079. . Each value has its own value type. The important group codes and associated value type used in digital maps are as follows:

Table 2. Main Entity Group Codes and Value Type Used in National Basic Digital Maps

Group Code	Value Type	Group Code	Value Type
0	Start of entities	10-19	X value
2	Entity name	20-29	Y value
8	Layer name	30-37	Z value

Out of the four sections, national digital maps in NGIS are only associated with the ENTITIES section. This Section has 12 entities. They are line, point, circle, arc, text, insert, polyline, vertex, solid, shape, 3d-face, and trace. Among those entities point, line, polyline, and text entities are mainly used.

Each entity name and its associated X, Y, and Z values are the backbone of national base digital maps. Since their group codes and X, Y coordinates can be extracted, the DXF file is easily accessible to any type of graphic software.

5 DEVELOPMENT OF ROAD GUIDE SIGN MANAGEMENT DECISION SUPPORT SYSTEM

5.1 Database Module

5.1.1 Spatial database

Basically, spatial data is composed of three feature types which are a point, a line, and a polygon. For GIS-T, these features can be represented as a network, facility or jurisdiction. Transportation representations and features depend on the scale of the map. For example, a terminal can be treated as a point on a small scale map such as 1:1,000,000, however it should be treated as polygon on a large scale map such as 1:1,000. A transportation network can be represented by a link (line feature) and a node (point feature). A transportation facility such as a signal, road sign board, or terminal can be represented by point. A polygon feature can represent jurisdiction or a green belt area, for example.

The relationship between the feature type and the transportation representation is shown in the following table.

Table 3. Relationship between feature type and transportation representation

Feature Type	Transportation representation
Network(point + line)	Transportation network with a link(line feature) and a node(point feature)
Point	Transportation facility such as a signal, road sign board, terminal,...
Polygon	Jurisdiction,...

A national basic digital map with the scale of 1:5,000 is used for this study. Only road, jurisdiction boundary, and building layers are extracted.

Network topology (Node & Link) is built on the top of a basic digital map directly from the computer screen. An intersection is represented by a node. The link is the road segment between adjacent nodes. A road guide sign has been represented as a point.

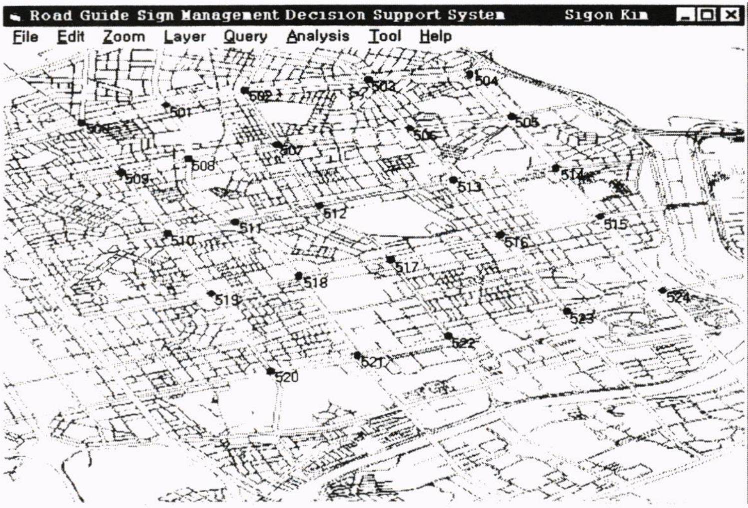

Figure 7. Spatial Database for Kangnam area as a Case Study Area

5.1.2 Attribute Database

A simple random access type of database structure has been adopted to represent the information of a point, a node, and a link separately. Information of the road guide markings is attached to each node representing an intersection. Geometric design and traffic flow data are linked to each link. The information of road guide signs is connected to a point along the street.

5.2 Spatial Analysis Module

5.2.1 Landmark Selection and Linkage

A landmark will be suggested as one of the most popular facility names or street names. According to the criteria suggested in this study, signs for notice, guide, and identification are to be checked automatically. Then, the selected landmark is to be linked along a traffic corridor.

5.2.2 Automatic Design of Signboard

If a specific point around an intersection is chosen, a draft design of a signboard can be produced automatically.

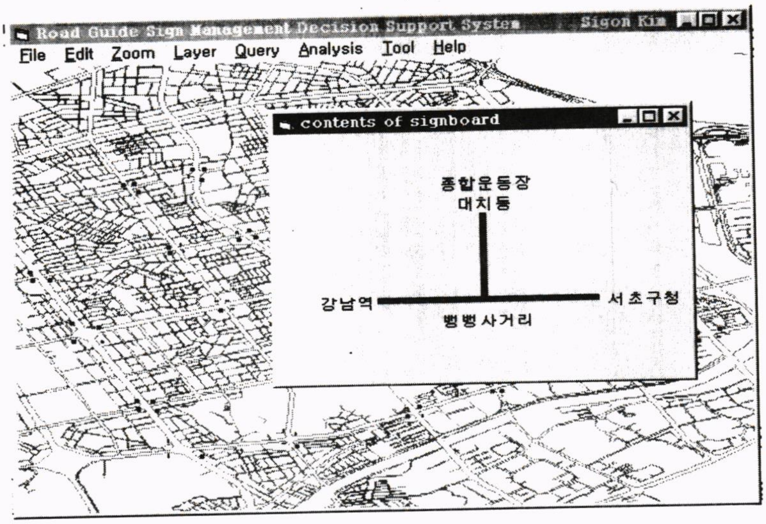

Figure8. An Example of Automatic Design of Signboard

5.2.3 Inventory Statistics and Maintenance

Information on road guide signs describe the location, landmarks, and historical data of signs. They include the location of the signs, a maintenance agency, or historical data for installation and maintenance, landmarks, and size of road guide signs.

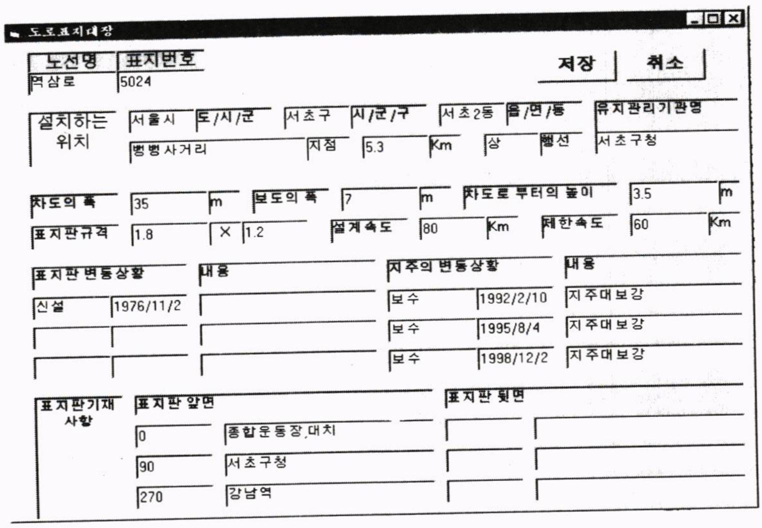

Figure9. An Example of Inventory Form of Road Guide Sings

Replacement and maintenance are scheduled and prioritized according to the level of damage and the budget available.

5.3 Graphic Representation Module

All the information output from the database module and the analysis module can be shown in several ways. For example, they can be shown on a color computer monitor or on hardcopies from a printer or plotter. The location and distribution of road guide signs in the Kangnam area are displayed in figure 10.

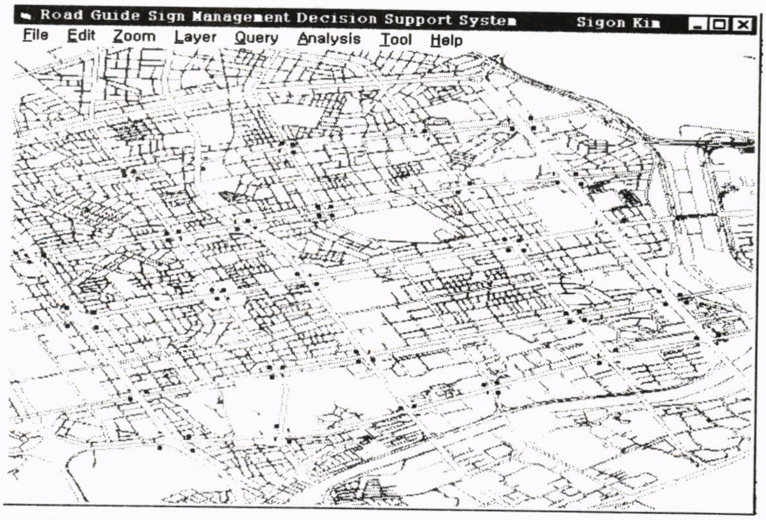

Figure10. Distribution of Road Guide Signs at Kangnam Area

6 CONCLUSIONS

Information about road guide signs is a typical geo-spatial database. The "Road Guide Sign Management Decision Support Systems" developed in this study can be used as a tool for effectively managing the massive information of road guide signs. Specially, the most appropriate landmarks for each sign can be selected. A draft design of signboard can be produced automatically. Inventory statistics can be maintained with fewer people and a smaller budget.

Finally, in order to utilize the suggested "Road Guide Sign Management Decision Support System", more GIS-oriented spatial analysis techniques need to be developed.

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