A GIS Search Technique through Reduction of Digital Map and Ontologies

Bong-Je Kim[+], Seong-Hyun Shin[++], Hyun-Suk Hwang[+++], Chang-Soo Kim[++++]

ABSTRACT

GIS systems have gradually been utilized in life information as well as special businesses such as traffic, sight-seeing, tracking, and disaster services. Most GIS services focus on showing stored information on maps, not providing a service to register and modify their preferred information. In this paper, we present a new method which reduces DXF map data into Simple Geographic Information File format using format conversion algorithms. We also present the prototype implementation of a GIS search system based on ontologies to support associated information. Our contribution is to propose a new digital map format to provide a fast map loading service and individual customized information on the map service.

Keywords: GIS, Ontology-based Search, Semantic Web, Digital Map Data Format, RDF Content

1. INTRODUCTION

Geographic Information Systems(GIS) with a geographical information in the mobile computing environment are widely used in disaster tasks, location tracking, and security with GPS Information as well as the traffic and the sight-seeing [1,2]. In particular, GIS is a main technique of telematics and Location Based Services(LBS)[3,4]. Now GIS has developed as fast as the growth of a wireless

※ Corresponding Author : Chang-Soo Kim, Address :
(608-737) 599-1 Daeyeon-3 dong, Nam-gu, Busan,
Korea, TEL : +82-51-620-6394, FAX : +82-51-620-6390,
E-mail : cskim@pknu.ac.kr
Receipt date : Nov. 1, 2006, Approval date : Nov. 30, 2006
[+] Department of Information Engineering, Pukyong
National University
(E-mail : kbj0430@netian.com)
[++] Division of Electronics, Computer and Telecommuni-
cations, Pukyong National University
(E-mail : ccary001@hanmail.net)
[+++] Research Institute of Industrial Science and Technol-
ogy, Pukyong National University
(E-mail : hhs@pknu.ac.kr)
[++++] Division of Electronics, Computer and Telecommuni-
cations, Pukyong National University

Internet technique[5].

General formats of Drawing eXchange Format (DXF) and Shape include as many real-world spatial objects as possible. GIS applications in Mobile environments such as car navigation systems and mobile tourist guide systems have several limitations such as low processing power, low memory, small screen size, and limited communication environment. Thus, it is considered that methods to efficiently process general spatial data.

We live in knowledge society where it is important to get customized information from amount of dispersed data. As the growth of Web, we can attain huge quantity of information. Users want to get abstracted and customized information in huge Web content. Thus, the Semantic Web has been presented as next generation of Web to provide intelligent services[6].

Ontologies, which are an essential component of the semantic Web, are defined as common words and concepts used to describe and represent an area of knowledge. The ontologies in some domains such as travel, education, and medical data have been constructed to integrate different data structures on the Web and to provide semantic in-

formation[6,7]. The ontologies are linked to each domain on the Web, and the linked ontologies can be supported to various applications with shared terminologies and understanding. Therefore, information searching on the semantic Web can provide the inferred search results with less redundant and integrated terms.

In this paper, we focus on proposing a reduced digital map format to provide fast map loading time and a customized GIS searching technique using ontologies. The paper is organized in the following manner. In the next section, we describe related works about the DXF map format and ontologies. In section 3, we design a GIS search service based on ontologies with two related formats of map, Simple Geographic Information File(SGIF) and URL Data File(UDF) format. We implement a prototype example based on the ontology of classified building and location in section 4. Finally, we summarize this research and describe future works.

2. RELATED WORKS

2.1 DXF Map Format

Digital map data is the set of information of digital format using vector data model to express the information of map on computers. The vector data model shows spatial information with entities such as points, line, and polygons. DXF format provided by National Geographic Information Institute (NGII) in Korea consists of an ASCII file and many groups with code and value of each group as shown in Table 1.

Table 1. Group Code of DXF Format

Group Code	Value	Group Code	Value
0-9	String	210-239	Floating-point
10-59	Floating-point	1000-1009	String
60-79	Integer	1010-1059	Floating-point
140-147	Floating-point	1060-1079	Integer
170-175	Integer	999	Comment(String)

The DXF files consist of six types of sections which are header, classes, tables, blocks, entities, and objects[8]. The header section includes declare environment variables, and the tables section stores information of items such as fonts, layers, coordinates, lines with referred name for definition. The blocks section contains the definition of recursion units. The entities section includes the definition of the shapes.

The DXF format maintains data compatibility by defining many environment variables on the header section and tables section, but the defined variables can cause computers to happen overhead. The format needs much space to store geographical information because of the ASCII file format, so it needs much time for searching.

2.2 Ontology-based Search and RDF Generation

Semantic Web is a technology to add well-defined content on Web for computers as well as people to understand meaning of documents more easily and to automate works such as information searches, interpretation, and integration[6]. Research about semantic issues to adaptive information to users on the move in LBS has been processed within recent years. The CRUMPET project of the EU [9] is to provide new information delivery services in Mobile Tourism Services and is to find the user validation which focuses on location-based and personalized services. Yu et al. [10] has proposed a multi-layered abstraction method to organize the users' heterogeneous data. The research has demonstrated as a method to satisfy users' needs on mobile services. However, there still remain several challenges to overcome the limitations of data integration issues, agents for meditation, and static and dynamic information.

Resource Description Framework(RDF) based on XML is used to express content of semantic Web and must be generated from ontologies which can define hierarchy and association of resources

[6,7]. Recent most researchers have used the Protégé/OWL tool [11] to construct data structures and content for supporting the semantic Web. The Web Ontology Language (OWL) is widely accepted as a standard language for sharing semantic Web content[12-15].

3. A GIS SEARCH SYSTEM DESIGN

Figure 1 shows an entire system structure for providing GIS search services based on ontologies with the information of user's preference. It largely consists of the Client component for map services, the Web Server component for a search service based on ontologies, and the Web Interface Module for their connection.

The Client has the Map Display Module which shows a map on the screen, the Map Edit Module which appends and edits new items, and the GPS Module which sends current location coordinates of objects. The Map Display Module requires the Simple Geographic Information File(SGIF) which is digital map files with reduced size format and URL Data File(UDF) which has information for connecting to a related Web site on a map. The Map Edit Module is connected with UDF files and the Web Interface module of the Client for providing search results considering preference information of users.

The Web server contains the search module based ontologies and related ontologies. The Ontology Search Module requires user's RDF content which includes users' preference information and a location of related buildings.

3.1 Map Module

We propose the SIGF format for reducing size of map and the UDF format for connecting with Web sites. The two files are needed to display and edit information on a map.

SGIF Format. The DXF map format provided by National Geographic Information Institute (NGII) in Korea needs a minimum of 12 bytes for marking a plane coordinate because it consists of an ASCII file. We design an efficient map data format called Simple Geographic Information File (SGIF) to reduce size of map. In order to convert the existing DXF format to SGIF, as shown in Figure 2, we perform four steps; extraction of essential layer, redefinition of layer, division of digital maps, polygon generation, and format conversion.

The first step extracts essential layers from DXF format files, which have many layers such as road, building, contour line, area boundary, and others. The elimination can lessen time of map loading because all the detail information of layers is not needed in various GIS solutions. An extracted digi-
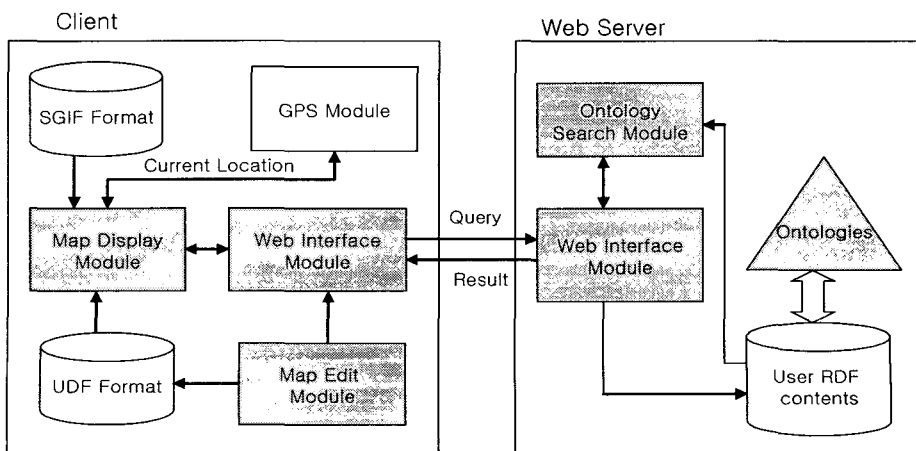

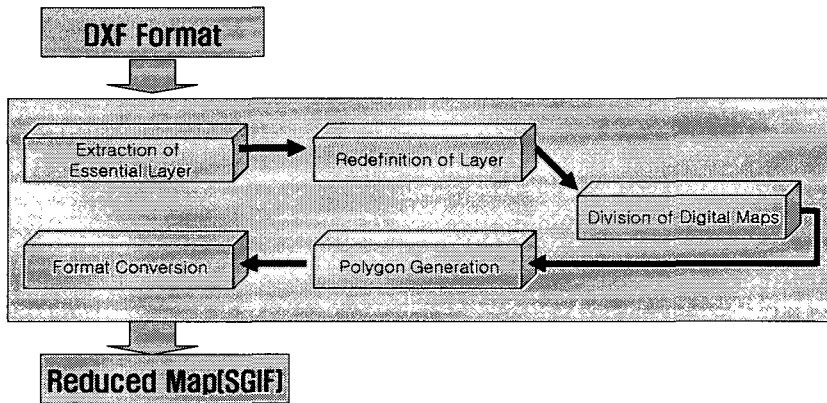Fig. 1. Ontology-based GIS Architecture.

Fig. 2. Extraction Process of Reduced Digital Map.

tal map file is lessened up to twenty-three percent compared with a DXF map file.

The second step is to redefine extracted layers. The NGII made a standard format to make more exact maps. Through the standard is categorized into layer codes and feature codes, a map viewer with various and original layers is complex, and loading time become long. Thus, some layers are categorized into specific items to provide more efficient information.

The third step divides digital maps into suitable areas for efficient loading of maps because searching of UDF files and map handling are often occurred. We divide the original map into 700x700 resolution display.

In the fourth step, polygons are created. The digital map generally consists of many lines and polylines. Because storing and processing the many geographic objects is inefficient, we try to create a polygon by combing lines and polylines to diminish size of digital maps. The new generated polygons such as tunnels, roads, high way, and bridges, which are originally line/polyline types of objects, can be filled with a color and can provide better visuals compared with lines and polylines.

In the last step, we convert a DXF format with an ASCII format to our proposed SGIF format with a binary format. The DXF format requires 12 bytes at least to indicate on geographic position. If it is converted to binary, our SGIF format needs only

8 bytes.

Therefore, our proposed file format can provide fast map loading time by extracting essential layers and by converting an ASCII format with 12 bytes to a binary format with 8 bytes for a plane coordinate. Figure 3 shows the structure of the SGIF format which is categorized into the header and the recorder.

UDF Format. The Map Display Module requires UDF files for connecting to a requested Web site. Table 2 expresses structure of the UDF format including coordinates and a URL name of buildings. When a user puts a mouse arrow on a display screen, an icon type of a mouse arrow is changed, and the user can connect the sites if information of Web sites is included in UDF files. We make 40×40 area of coordinates of the current location to display and handle location information on the screen.

3.2 Search Module based on Ontologies

The Ontology Search Module of the Web Server provides users with search results from RDF files which have individual preference information through the Web Interface Module. The RDF content files are produced from the defined ontology in each domain. Ontology contains information of hierarchy and relation between defined items. Therefore, the ontology-based search can provide associated search information between resources.
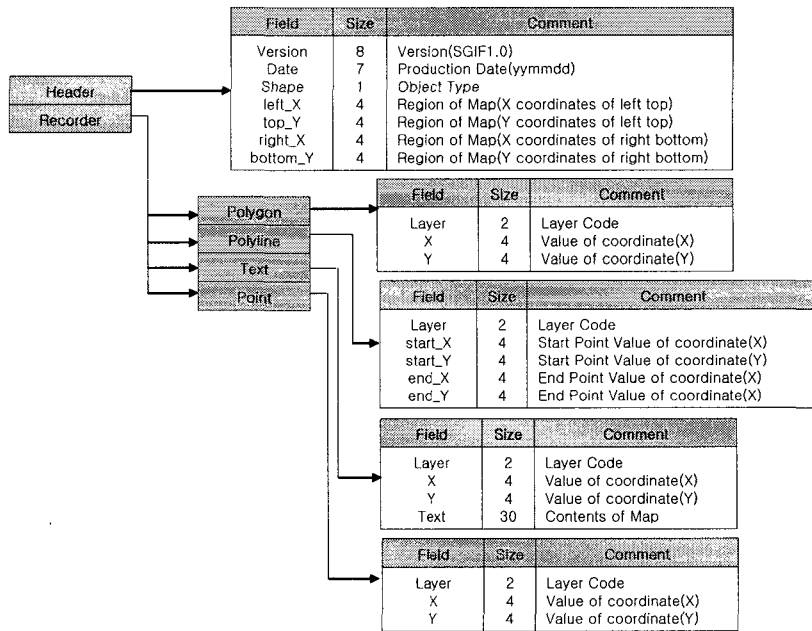
Field	Size	Comment
Version	8	Version(SGIF1.0)
Date	7	Production Date(yymmdd)
Shape	1	Object Type
left_X	4	Region of Map(X coordinates of left top)
top_Y	4	Region of Map(Y coordinates of left top)
right_X	4	Region of Map(X coordinates of right bottom)
bottom_Y	4	Region of Map(Y coordinates of right bottom)

Field	Size	Comment
Layer	2	Layer Code
X	4	Value of coordinate(X)
Y	4	Value of coordinate(Y)

Field	Size	Comment
Layer	2	Layer Code
start_X	4	Start Point Value of coordinate(X)
start_Y	4	Start Point Value of coordinate(Y)
end_X	4	End Point Value of coordinate(X)
end_Y	4	End Point Value of coordinate(X)

Field	Size	Comment
Layer	2	Layer Code
X	4	Value of coordinate(X)
Y	4	Value of coordinate(Y)
Text	30	Contents of Map

Field	Size	Comment
Layer	2	Layer Code
X	4	Value of coordinate(X)
Y	4	Value of coordinate(Y)

Fig. 3. Structure of SGIF Format.

Table 2. Structure of UDF Format

Field Name	Value	Comment
X	Integer	Current X -20
Y	Integer	Current Y -20
nX	Integer	Current X +20
nY	Integer	Current Y +20
Structure Name	String	Building name on current location
URL Name	String	URL on current location

3.3 Web Interface Module

We organize the Web Interface Module to connect a search service of the Web server with the Map Service of the Client. If a user sends information of preference and location, a RDF file of the user is generated or modified on the Server. The HTTP protocol and the Get method for connecting the Client with the Server is used, and JSP and Servlet for user interface is used.

4. IMPLEMENTATION OF PROTOTYPE SYSTEM

We implement a prototype of GIS search system based on ontology. The client system of Map services is developed in a .NET environment, and the Web server module of the search service is developed in the Java Web Services Developer Pack 1.1(JWSDP) environment.

4.1 Expression of the Digital Map

Figure 4 shows an entire process to express a related map on the screen by connecting information of a digital map and Web between records of SGIF and UDF on clients.

The system shifts a map to a memory buffer instead of marking the objects to be drawn on the screen immediately. When the maps to be displayed were represented, the content of the map are displayed in the memory buffer on the screen. Therefore, our map system can prevent the screen twinkling phenomenon, and memory management is easy.

4.2 Ontology and RDF Generation

Figure 5 is an ontology expressing the hierarchy and relation among building, location, and person
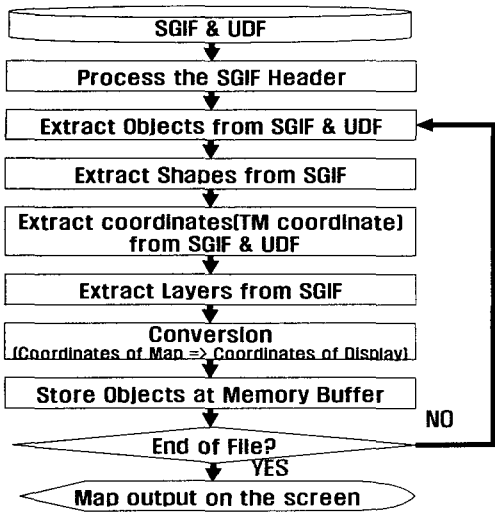
Fig. 4. Process of Digital Map Display.

object for providing a GIS search as to individual preferences.

The circles represent the objects, shade rectangles mean the object properties for connection among between objects, and non-shade rectangles mean the data properties of instances. We construct the Building and Location ontology with more categories the Building class including School, Hospital, and Restaurant, and Location

class including CityDo, GuGun, DongRee, ZipCode. Also, the Korean class is categorized into Bulgogi, Califonia Roll, Noodles classes. In this paper, we use Protégé/OWL tool to create the ontology and RDF contents files.

4.3 GIS search based on User's Preference

We imagine that users want to register restaurants as to their preference of food on a GIS map, and to connect to its Web site to get more specific information as well as that of the location as to the user preference. Figure 6 shows an interface screen which users can register and edit building information such as building name, URL, and preference information. The preference condition of the users is stored in an individual RDF content file of the Web server. The URL information for connecting to a related Web site and building location is also stored in the individual UDF file.

Figure 7 shows a search result which indicates coordinates of restaurants with bulgogi food in registered information of a user and connects automatically to a web site of the nearest restaurants. In order to search preference information, we use
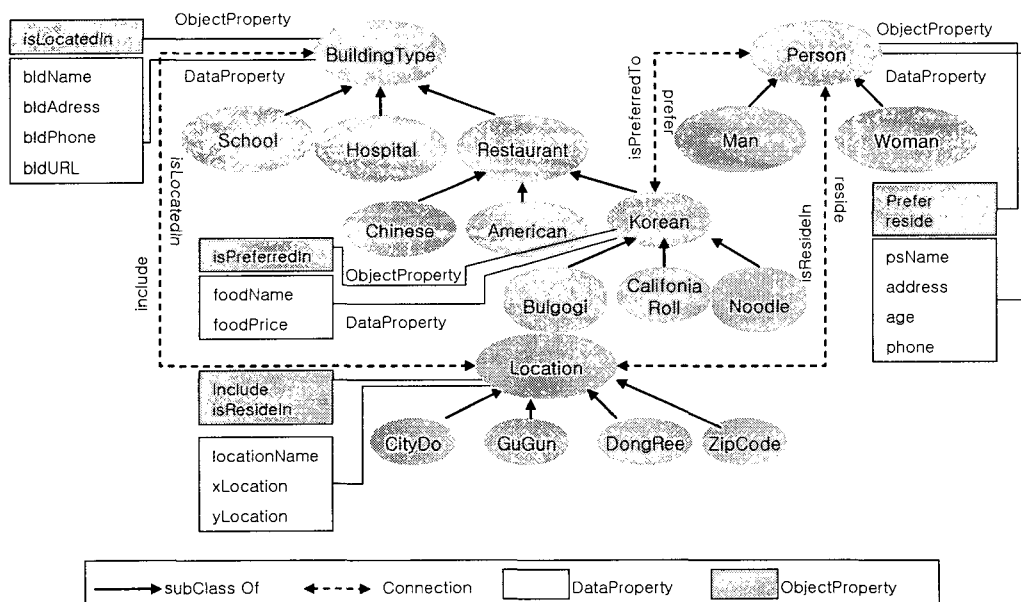

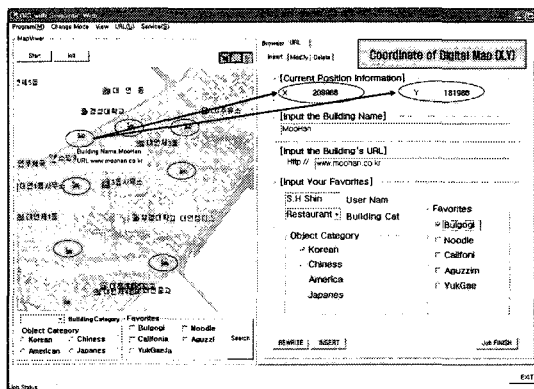Fig. 5. Ontology for Location, Building, and Person Object.

Fig. 6. Registration Interface of URL and Preference Information.
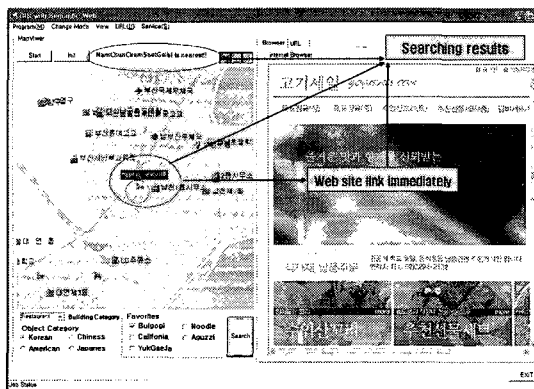

Fig. 7. A Search Result for Preference Information.

RDF Query Language(RDQL) which is a query language of RDF.

5. CONCLUSIONS

We designed and implemented a simple prototype of GIS search system that users can append and edit their preference information on maps. We proposed the SGIF format for reducing size of map and the UDF format for connecting to Web sites. Also, we constructed the ontologies of location and building to provide associated information. Therefore, users can attain categorized and associated information based on their preference information on maps.

Our future works are follows. We will develop a knowledge-based search module of GIS which can provide only required information of users

from many search results of Web. The system can integrate the scattered information on Web and can provide association and inferred information. Next, an interface module for generating RDF files must be developed.

6. REFERENCES

[1] K.Virrantaus et al., "Developing GIS-Supported Location-Based Services," *Web Information System Engineering*, Vol. 2, pp. 66-75, 2002.

[2] Q. Li, H.Xiaobin, and S.Wu, "Applications of Agent Technique on GIS," *IEEE*, Vol. 1, pp.238-243, 2001.

[3] D. Tilson, K. Lyytinen, and R. Baxter, "A Framework for Selecting a Location based Service (LBS) Strategy and Service Portfolio," *IEEE Computer Society*, pp. 78-87, 2004.

[4] I.K Adusei, K. Kyamakya, and F. Erbas, "Location -based Service: Advances and challenges," *Electronic and Computer Engineering*, Vol. 1, pp.1-7, 2004.

[5] T.Shuichi, "GIS on the Fly to Realize Wireless GIS Network by Java Mobile Phone," Vol. 2, *IEEE Computer Society*, 2002.

[6] T. Berners-Lee, J. Hendler, and O. Lassila, "The Semantic Web," *Scientific American*, Vol. 284, No. 5, 2001.

[7] M. Uschold and M. Gruning, "Ontologies: Principles, Methods, and Application," *Artifical Intelligence Applications Institute* (AIAI), the University of Edinburgh, 1996.

[8] Drawing Interchange and File Format Release 12, Autodesk Inc., 2000

[9] A. Zipf, "Personalized mobile Maps for Telecommunication," *Human Factors in Telecommunications Symposium*, Sophia Antipolis, 2006.

[10] S. Yu, S. Spaccapietra, N. Cullot, M. Aufaure "User Profiles in Location-based Services : Make Humans More Nomadic and Personal-

ized," *Proceedings of the IASTED I International Conference on Databases and Applications,* pp 17-19, 2004.

[11] M. Horridge, H. Knublauch, A. Rector, R. Stevens, and C. Wroe, *A Practical Guide to Building OWL Ontologies Using the Protege- OWL Plugin and CO-ODE Tools,* The University of Manchester, 2004.

[12] H.S. Hwang, K.S Park, and C.S Kim, "Ontology-based Information Search in the Real World using Web Services," *ICCSA,* 2006.

[13] B. Schmidt-Belz, A. Nick, S. Poslad, and A. Zipf, "Personalized and Location-based Mobile Tourism Services," *Workshop on Mobile Tourism Support Systems in Conjunction with Mobile HCI '02,* 2002.

[14] H. Knublauch, R.W. Fergerson, N.F. Ray, N. Noy, and M.A. Musen,"The Protege OWL Plugin : An Open Development Environment for Semantic Web Applications," *Third International Semantic Web,* 2004.

[15] H. Knublauch, O.Dameron, Olivier, and M.A. Musen, "Weaving the Biomedical Semantic Web with the Protégé OWL Plugin," *First International Workshop on Formal Biomedical Knowledge Representation,* 2004.

Bong-Je Kim

He received a BS degree in Computer Science from Kyungnam University, Korea, in 1987, and a MS degree in Computer Information from Pukyong National University, Korea, in 1997. He received a Ph.D. Certification in Computer Science from Pukyong National University, Korea, in 2004. He has been a teacher at the department Computer Information, Daejin High School of Information & Communication, Korea, since 1996. His research interests are in the area of ubiquitous sensor networks, context-aware system.
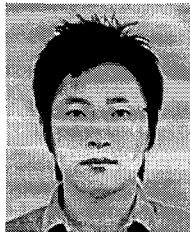
Seong-Hyun Shin

He is going to receive the BS degree in Computer and Multimedia Engineering from Pukyong National University, Busan, Korea in 2007. His current research interests are in the area of Location Based Service/ Geographic Information System, Ontology, and information searching technique.

Hyun-Suk Hwang

She received a MS degree in Computer Science and a Ph.D. degree in Management Information System from Pukyong National University of Korea in 1995 and 2001 respectively. She worked the program of Post-Doc. at Kyungname University from 2001 to 2002 and at University of Missouri, Kansas City(UMKC) from 2003 to 2004. Her current research interests are in the area of LBS/GIS system, ontology, data mining, wireless sensor networks, and u-prevention system.

Chang-Soo Kim

He received a BS degree in Computer Science from Ulsan University, Korea, in 1979, and a MS degree in Computer Engineering and Ph.D. degree in Computer Engineering from Chungang University, Korea, in 1984 and 1991 respectively. He has been a professor at the division of Electronics, Computer and Telecommunication, Pukyong National University, Korea, since 1992. His research interests are Operating System, Geographic Information System/Location Based Service, USN/RFID, and Urban Disaster Prevention System.