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온톨로지 방법론을 이용한 지역지리 지식으로서 도시이미지의 표현

홍일영[1※]

Representing City Image as Regional Geographic Knowledge: Ontology Modeling Approach

Il-Young HONG[1※]

ABSTRACT

Nowadays, the navigation system is very popular to general public and the study of landmarks has an important role to develop the cognitive systems for regional navigation. The city image is composed of landmarks that are well-known to regional community and they are the reference frame for place recognition in urban navigation. In general, the case of navigation can be categorized as two kinds. The first is to explore the new region and the second is to navigate the familiar region. In case of latter, the city image has a critical role in place recognition for regional community. Place recognition of a community might be a knowledge-based inference on the basis of city image which is composed of the systematically connected places. In this study, the mental structure of urban image is regarded as a hierarchical knowledge and represents it as domain ontology for the regional navigation of a community. The city image of a community is assumed as the collection of landmarks, which are categorized as anchor, distant and local according to spatial familiarity of community. Representing city image as a regional knowledge using ontology modeling method is an essential step to make the geographical assumption of a regional community explicit and reusable for the regional agents who will provide the regional guide in LBS age.

KEYWORDS : City Image, Ontology Modeling, Navigation

요　약

최근 네비게이션 시스템이 대중화되면서 랜드마크 연구는 도시지역 이동을 위한 인지적 시스템 개발에 중요한 연구주제가 되고 있다. 지역 커뮤니티에게 있어서 랜드마크로 구성된 도시이미지는 지역 네비게이션에 있어서 장소인식을 위한 참조프레임 역할을 담당한다. 일반적으로 네비게이션은

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1 Dept. of Geographic Information System Engineering, Nam Seoul University 남서울대학교 지리정보공학과
※ 연락저자 E-mail : ilyoung.hong@nsu.ac.kr

새로운 지역을 이동하는 탐험(Exploration)과 친숙한 지역을 이동하는 네비게이션으로 구분할 수 있다. 후자의 경우, 도시이미지는 지역 커뮤니티에게 있어서 장소인식에 있어서 핵심적인 역할을 담당한다. 커뮤니티의 장소인식은 시스템적으로 연결된 장소들로 구성된 도시이미지에 기반을 두어 이루어지는 지식기반의 추론의 과정이다. 본 연구에서 도시이미지의 구조는 계층적 지식으로 간주하여 커뮤니티를 위한 지역이동을 위한 도메인 온톨로지로 표현하였다. 커뮤니티에게서 수집된 도시이미지는 커뮤니티의 인지정도에 따라 엥커(anchor), 디스턴트(distant)와 로컬(local)분류하였다. 온톨로지 모델링 기법을 이용한 도시이미지의 표현은 지역 커뮤니티의 지리적 지식으로 명시화하고 도시지역 안내를 위한 에이전트를 위해 재사용이 가능한 지식으로서 유용한 의미를 갖는다.

주요어 : 도시이미지, 온톨로지 모델링, 네비게이션

INTRODUCTION

Recently, it is very popular to obtain a route direction from the Internet web sites such as Yahoo Maps or Google Maps for urban navigation. While the machine's direction uses a list of nodes and paths that instructs navigation, the human communication focuses on recognizing the unknown place with the aid of landmarks (Golledge, 1992). Furthermore, if a destination is matched to one's own spatial experiences, one's own way can be found, rather than following the list of paths and nodes. Generally speaking, the case of navigation can be categorized as two kinds. First is to explore the new region as a traveler and the second is to navigate the familiar region as a resident. In the latter case, if wayfinding is not the kind of the explorer type(Allen, 1999), the most important element in direction is how the unknown places can be recognized by one's own cognitive spatial representation.

In human navigation or wayfinding, the dependency on the familiar landmarks is the highest priority(Deakin,1996;Golledge, 1999;Lynch,1960;Raubal and Winter, 2002). In the case of the communication for a route direction between regional community members, a route instructor can expect the partial knowledge of a route seeker and the starting point of direction is the place that are known to both of them. In case of regional community, wayfinding activities are implemented on the basis of the city image, which is considered as a shared geographical knowledge for a regional community.

This research gives an importance to the relative relationship between places. If we take an account of wayfinding activities as the spatial problem solving activities(Downs and Stea 1966), the process to search a certain destination can be thought of as the transition of the spatial experience from the experienced one to the non-experienced. The process of the place recognition in regional community might be regarded as a kind of knowledge inference that extends one's own understanding by linking the landmarks to others. Thus, regional navigation for community is a knowledge-based activity with the help of externalized city image which is composed of the systematically related places (Allen, 1997). Taking into account that regional navigation falls within the knowledge-based activities that expand the spatial experience, the internal configuration of the cognitive map might be linked and related to each others systematically.

The goal of this study is to explore the cognitive process and formal model in the regional navigation of a community and represent the geographical semantics between places with ontology modeling approach. For these purpose, this paper is composed of 5 sections. Section 2 reviews the related works in urban regional navigation. Section 3 is the conceptual arguments and explains the way of development of knowledge structure. Section 4 is the experiential work to represent the structural characteristics of urban image of a community and section 5 is conclusion.

RELATED WORKS

Navigating in a large-scale space develops the cognitive map, as an internal mental structure. Cognitive maps are the clue to understanding human wayfinding. Cognitive map is the term to describe a mental representation of spatial information used for navigation. On the other hands, cognitive mapping has drawn attention to geographers and psychologists as a research topic (Freundschuh and Kitchin, 1999). Cognitive mapping research has an interest in how people think about space, and how those thoughts are used and reflected in human spatial behavior. It seeks to comprehend how we can have understanding of spatial relations gained through spatial experience or study of maps. The common factor of these researches is that a cognitive map is generated unconsciously after spending a long time in a certain place(Garling, 1995).

Although cognitive map research covers the internal aspects, the externalization is equally attractive research, because it can be systematically applied. A method to represent cognitive map was the use of sketch map techniques to make more imaginable and readable one. To Lynch, legibility is the key concern, which means that a city should be easily readable and easy for navigation (Lynch, 1960). To make a city apparent, imaginable, and readable is the essence of his idea. His major methodology consisted of the qualitative interview with residents. One of his first findings was that people who have lived in a city for a long time have a shared image. In other words, the image of city is the thing that created from a long-term stored memory. Meanwhile, it was Sigel and White who suggested the functions of the model, in spatial representation. They indicated two main functions of the spatial representation (Siegel and White, 1975). The function is to facilitate location and movement within the larger physical environment and the second is to act as an organizer of experience. They suggested three elements of the model: landmarks, routes, and survey knowledge. They argued that spatial representation was functionally composed of landmarks and that it was connected by routes. The configurational knowledge is composed of the set of landmarks and routes. On the basis of the externalized structure and functional model, Kuipers developed the TOUR model which is the computational model for wayfinding (Kuipers, 1978). It describes how spatial knowledge is stored and used, and how a cognitive process operates upon it. He defined the cognitive map as a common sense geographic knowledge and pointed out that it could not be composed immediately and depends on people's movement and empirical experience.

Along with the evidence of salient geographical feature, the hierarchical structure is another verified fact in the study of cognitive maps. Many different experimental studies reveal that spatial knowledge can be represented hierarchically. Salient landmarks play a key role in mental organization and retrieval. It was Stephens and Coup(1978) who first mentioned this structure from the errors that was caused by super and sub-ordinate hierarchical knowledge framework. Hirtle and Jondies(1985) showed the evidence of hierarchical structure with the recall order of landmarks with ordered tree analysis. McNarama(1986) pointed out three classes of theories of the spatial mental representation; non-hierarchical, strongly hierarchical and partial hierarchical theories. Holdings(1994) provided the further evidence of the existence of hierarchical ordering information, by referencing priming.

While GIS concerns itself with computerizing spatial problems with systematic approach, a cognitive approach attempts to suggest a semantic solution for spatial matters. A cognitive view on a large scale space is an important subject in cognitive science (Mark, 1999). The research of cognitive science is also the critical topics in spatial information. It was the concern of experiential realism that gave more emphasis on the human subjective cognition instead of objectivism which was popular concern of systematic positivism. They argued that the difficulty of GIS was caused by the tradition of objectivism and they suggested that the image-schemata might help to develop the better user interface in GIS as a common sense geographical knowledge. The image-schemata, the key concept of experiential realism, was the mental image of common-sense that was owned by most ordinary people and usually it was related to spatial aspects, such as container, path, and surface. Raubal et al. developed image-schemata based spatial representation for wayfinding tasks as an experiential and formal method for GIS (Raubal et al., 1997).

The study of geospatial ontology is one of the research streams in GIScience to promote semantics in spatial information. Ontology of a specific domain enables us to make semantic search and the geospatial ontologies makes it possible to perform semantic spatial search within spatial dataset, based on the taxonomy or category of geographical concepts (Jones et al., 2001). The study of semantic web in the area of spatial information is called semantic geospatial web, where it is defined as a spatial search system that have the capability of processing the request with various degrees of geospatial contents that users obtain results to match their tasks (Egenhofer, 2002). The geospatial semantics is also useful research for spatial decision support in spatial navigation, and semantic web can work together with Location Based Service (LBS) to provide useful navigation guidance or wayfinding tasks (Casey and Austin, 2002). LBS is typically related to spatial problem solving, such as identifying self location, searching location for services and how to reach destination. Geographic references that include geographic relations to well-known locations might be useful for explaining these requests (Hiramatsu and Reitsma, 2004). The software agents will find the meanings of terms and the geospatial ontology are the repositories of these machine-interpretable meanings. Thus, if we want that machine can give the best reference for regional navigation, the regional geographical knowledge should be ready as a machine processible format.

CONCEPTUAL ARGUMENTS

1. Process in Human Communication to Get a Route Direction

Allen(1999) categorizes wayfinding tasks as three kinds: commute, explorer, and quest. Commute is defined as travelling between known places along a familiar route, explorer as travelling to unknown places through an unfamiliar environment, and quest as travelling that begins at a familiar place but ends at an unfamiliar destination. Except the case of a person traveling to inexperienced regions, most of the ordinary person's wayfinding tasks in daily life are commuting or questing in their region. In the case of regional navigation, not all of users follow exactly the route direction that is produced on the basis of Euclidian geometry (Egenhofer and Mark, 1995). Instead of selecting the optimal path, some might prefer the direction which is directed with the help of familiar landmarks.

Couclelis(1996) suggested a conceptual model of verbal direction giving. She indicated that the core of the direction-giving is a mental model of the state of affairs as represented in the direction-giver's mind. She developed five major stages in the model: initiation, representation, transformation, symbolization, and termination. Though she categorized the direction-giving process into five stages, the most important stage is the second one, representation. At this stage, the relative frame of reference between direction seeker and respondent is established. Depending on whether he/she knows a certain landmark in the vicinity of destination, the communication might be successful or not.

FIGURE 1 shows the usual process of verbal communication for direction-giving among community members. When we want to go to a certain destination, we may ask directions from a person who has more experience at the destination. The direction giver will suggest a referential landmark to the seeker who wants to reach the destination. The most important process is the recursive question and answer process to find out the nearest landmark which the route seeker can understand. Through this procedure, route giver will repeatedly give the landmark that will be the nearest and well-known landmark to the destination, from lowest level to highest level according to his/her hierarchical structure of place names, until seeker finds a recognizable one. After they find a shared landmark, the route giver will give detailed directions from the agreed landmark to the destination. Therefore, a starting point is the shared location that is well-known to both of them. This is the critical difference with current systems, which do not have any clue to guide the destination using referential landmarks.

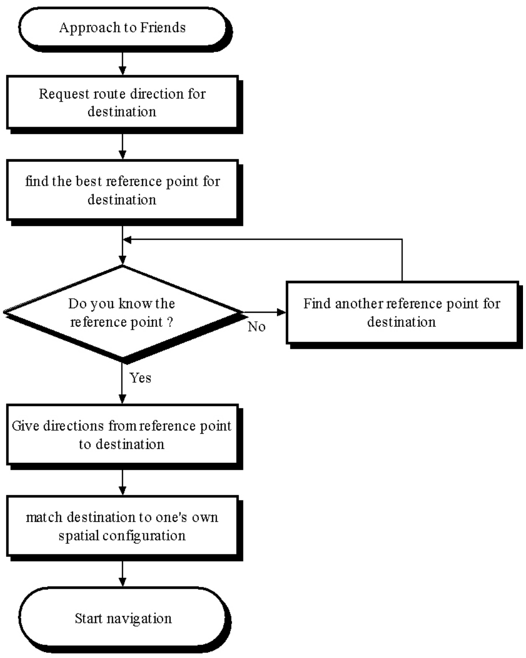

FIGURE 1. Direction-giving procedure in human communication

2. Landmark Categories for Regional Navigation

Diverse categories of landmark are possible according to the different point of view. Natural and socio-cultural landmarks are categorized according to human intervention. If we consider the scales that they cover, there might be state, regional and local level landmarks. In addition, the shape of the image is also a factor for categorization such as point, aerial landmarks, or a linear route-mark. However, if the major role of a landmark is supposed to be the spatial reference point which serves as a descriptor of an unknown place, the essential class of landmarks can be categorized by their familiarity. With respect to familiarity, Lynch suggested a basic and simple category of landmarks as two kind; distant and local (Lynch, 1960). Couclelis et al. proposed the anchor type landmark which endures throughout in a person's life (Couclelis et al., 1987).

TABLE 1 explains the three kinds of landmarks that might be frequently referenced in verbal communication as reference points, because of their familiarity. Firstly, an anchor type landmark is defined as a place which has the highest spatial prominence and organizes other spatial information into a layout. Though an anchor is the specialized place to limited people who has similar interests, it has a critical role as a spatial learning place. An anchor indicates places that are familiar through regular interaction such as shopping mall, grocery markets, or work place. Thus, the type of wayfinding for anchors is the commute. Secondly, a distant landmark is defined as a global landmark. It includes a tower or mountain that is visible from a large area and a major road and that can be recognized by most regional residents. Distant places can be reached without additional navigation devices. Commute and quest is the type of wayfinding to reach the distant place. Lastly, a local landmark is defined as a local cue that indicates a detailed location or object at decision point that is visible only from a small distance. Generally, a local landmark is place which can be easily inferred from a distant or anchor landmark or easily detected because of its visibility. A shared set of landmarks for a community can be represented with a structure that is composed of anchor, distant and local. Local, distant, and anchor landmark is the basic category and they are naturally conceptualized by community members. Community members who have a long-term residency probably frequently use these landmarks for their verbal communication for directions and introduce the unknown location from these.

TABLE 1. Landmarks types for regional navigation for community

Type	Property	Example	Type of wayfinding
Anchor	Starting location of spatial learning	work place, school, church, shopping mall	Commute
Distant	Global cues. All people know. Radial references.	city hall, highway, major road, major intersection, restaurant	Quest or Commute
Local	Local cues. Some people know. Location can be inferred from distant landmarks.	Local grocery, local road, local intersection.	Quest or Explorer

Landmarks describe the other unknown locations, via relative reference frames, on the basis of these three kinds of landmarks. FIGURE 2 shows a possible spatial representation with three kinds of landmarks. It shows the subordinate and hierarchical relationships and the main function of this is to serve as a reference frame to explain a location. TABLE 2 demonstrates a feasible direction and description that is composed of these landmarks. Using familiar landmarks, two kinds of general guides can be observed in verbal communication. The first is a description that indicates an approximate and relative location from landmarks. The second is a direction to a destination with details that are composed of nodes and paths. The critical semantic fact in both cases is the selection of landmarks as the starting point of the directions. Usually, the selection of landmarks as a reference point utilizes the distant and anchor types. The direction that is generated between community members is composed of the combination of these landmarks. Anchor and distant is used for the starting point of direction as they are regarded as common ground to them. Therefore, for regional navigation, the collection of distant and anchor is the shared geographical knowledge to regional community. Thus, regional geographical landmarks are the geographical vocabulary for direction and the common understanding in a community. They are the fundamental grounds to guide the other places.

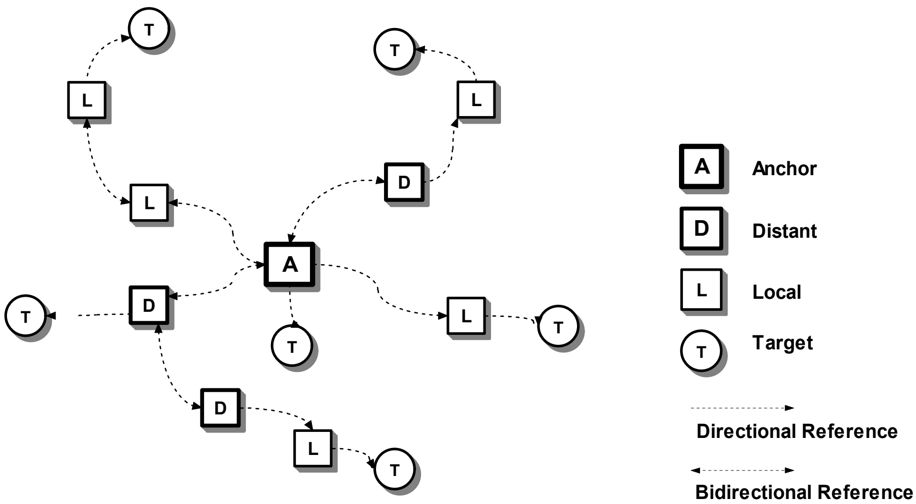

FIGURE 2. Spatial representation of landmarks

TABLE 2. Cases of target description and directions

Cases	Type
Local → Target	Description
Distant → Target	Description
Anchor → Target	Description
Local → {Local…} → Target	Direction
Distant → { Local…} → Target	Direction
Anchor → { Distant…| Local…} → Target	Direction

3. City Image as a Conceptualized Knowledge for Regional Navigation

City image might be regarded as a collection of anchors and landmarks that are connected to each other as a reference point. The linkage can be generated according to the community's perception and the link is a kind of meta information that summarizes the regional understanding of a community. In other words, those geographic places that are widely used might be configured as domain knowledge and the meta information are conceptualized and modeled for information systems that can assist in spatial decision making. On the basis of this knowledge, the regional navigation system can suggest the best reference for the destination.

FIGURE 3 explains the conceptual model of regional navigation. A regional community is the owner of city image which are composed of places. The well-known locations of a community are the set of landmarks and these serve as important geographical reference frame. They are used as a kind of geographic metadata, which describes other locations. There is a connection between two geographic places. The connection between target and landmark might have spatial relationship such as topological, directional or metrological, relationships, depending on the shape and relative location.

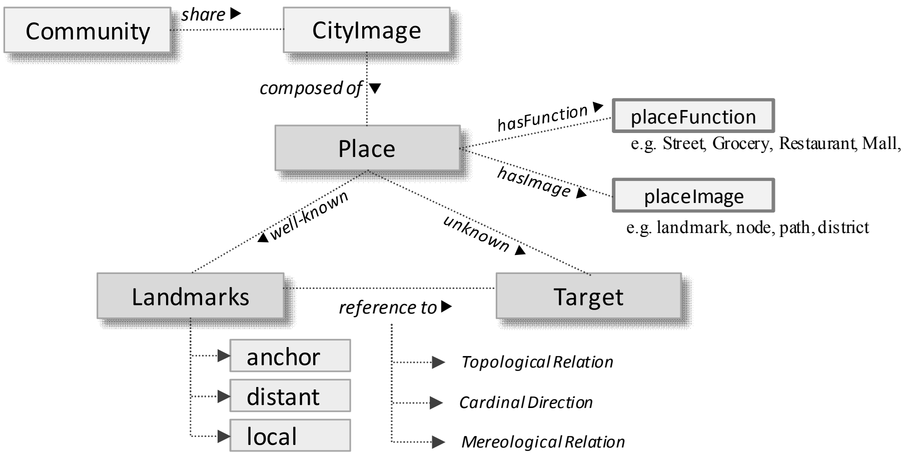

FIGURE 3. Conceptual model for city image of community

Large numbers of geographical locations are learned from anchor type landmarks. In other words, regional navigation can be summarized as an explanatory process that uses a small number of landmarks to explain other locations. Thus, effective direction giving depends on what the critical reference point is selected for a destination. If the relationships and connections among landmarks and other places are connected into database system representing domain knowledge, it will be a great help to generate familiar directions for a community.

Taking an account that regional navigation is the knowledge-based activities that expand the spatial experience from the anchor style landmark, the internal configuration of the map might be linked and related to each other systematically. The shared common knowledge of a community can be examined by knowledge representation. Ontology modeling is a plausible methodology that represents it as a formal structure. Thus, the major concern in ontology modeling of this study is how the essential idea of the cognitive map, salient landmarks and hierarchical organization of places can be adjusted with the current ontology modeling method.

4. Representing City Image, Using Ontology Modeling Approach

In recent years, semantic web method is a widely used as an ontology modeling methodology and can link or relate the existing web resources semantically. The vision of the semantic web is to extend the existing web with conceptual metadata that are more useful to machines, revealing the intended meaning of web resources (Berners-Lee, 2001). Ontology is a central building block of the semantic web and it defines domain concepts and the relationships, and provides a domain language that is meaningful to both humans and machines on the basis of trusts. Representing social network is one of the substantial semantic web applications to build a web of trusts. For example, FOAF(Friends of a Friend) is the exemplary project which creates a web of machine-readable homepages describing human relationships (Mika, 2004). The collected FOAF data makes it possible to operate the processes based on trusts, such as identifying spam email or searching the web resources according to personal interests. As like FOAF project, Landmarks might be the geographical places that reflect the social network of community and the geospatial semantics between places can be implemented on semantic web for spatial decision supports on the basis of regional preference or familiarity.

In geo-reference, a naive inference is assumed when community members explain the countless locations. It is common to learn a certain unknown place from a social network that we belong to. In this process, the unknown place is introduced by a place that people share. Thus, the collection of landmarks might be regarded as the geography of social network and the geographical knowledge that is known by each other as a common -sense. To community folks, the countless unknown locations can be more familiar or closely recognized by landmarks and the relationship between places to person or person to place is one that can be organized by ontology modeling method. The city image which is composed of familiar landmarks plays an important role in explaining another location. With the help of city image, we estimates or reproduce distance or direction of the location of a place from other locations of places.

The place direction and description are composed of the combination of connections of landmarks and it is converted as ontologies. Using the geo-location agent that connects major spatial components such as GIS, spatial database, and routing server to geo-spatial ontology of a regional city image, the urban resident can easily orient his/her current location, which is relative to the familiar landmarks, and reach a destination from friendly points. Thus, geographic references that include geographic relations to well-known locations are useful for explaining real world information. With the help of ontological structure of city image, we can think about the possible queries about properties and constrains of a location. For example, what is the meaning of the place Boulevard Mall, to the UB(University at Buffalo) community? There might be a lot of different "Boulevard Mall" for different people in different locations. It is a well-known distant, outstanding landmark. It is located 2-3 miles southwest from the UB North Campus. It has a district image and a shopping mall function. Based on these class relationships, ontology modeling method allow an agent to obtain the relative location of unknown place from well-known location and the agent can produce the direction that starts from the best reference point for destination.

Experiential Work: Collecting, Linking, Representing City Image

1. Procedure of Implementation

No city consists of a set of isolated elements and urban region is composed of a dense set of connection. A connected image of city is like an interconnected web, which is composed of various elements. The images of urban environment remind us of other images (Milgram and Jodelet, 1976) and they have the connections to each other as a reference. These relationships generate the connection between places and they enable us to remind the locations of the destination. In this context, the city image can be thought of as the geographical knowledge that is composed of various conceptualized places and referential relationships.

To represent the concept, property and relationship, a range of methods and techniques have been reported in the literature regarding ontology building methodologies and there is still an ongoing debate within ontology research about what the best method is to build them (Lopez, 1999; Noy and Mcguinness, 2001; Uschold and Gruninger, 1996). Though various ontologies development methods have their own procedures by which they were developed, they are generally modified or scaled down to fit a specific purpose (Cui et al., 2008; Lee, 2009.). FIGURE 4 shows the simplified procedure of ontology development in this case study which is adopted from these previous researches.

FIGURE 4. Procedure of Ontology Development

The first step is to identify the purpose, scope and users. The purpose of this case study is to develop the city image as ontologies to support the urban regional navigation. The details are already discussed in previous section. The next step is domain analysis and knowledge acquisition. This step is composed of three kinds of analysis. Firstly, from the first survey, the commonly used geographical terms and locations are collected on the basis of familiarity measures. Secondly, the centrality measure is analyzed using two-mode network analysis. Lastly, the referential relationships between places are measured, from the second survey. Stage 3 is to represent the conceptual ontology as a physical output. Using ontologies composer Protégé OWL, the city image is formalized as reusable structure according to the final product of survey analysis. After the ontological model is implemented, the final step is to test and evaluate the whole structure.

2. Data and Methods

For the case study, students at the University at Buffalo were selected. The first survey was conducted with 47 undergraduate students who were recruited from maps and mapping class, which was an introductory level of cartography and GIS. To measure and quantify the geographic knowledge of the Buffalo-Amherst region, the previous behavioral geographer's methodologies were adopted(Gale et al., 1990; Golledge et al., 1982; Gould and White, 1974). To measure the familiarity of landmarks, 60 locations were selected previously by the pilot study. To measure the familiarity, the scale of each landmark is scored by subjects. The ranked scale is divided into five degree scale, which depends on whether they can go there by themselves or not.

To acquire structural relationship between community members and their familiar places, social network analysis is applied. To implement social network analysis, the objects were limited to 30 places to save the cost of analysis and presentation. The matrix for social network between landmarks and community members were generated from the first survey data. The affiliation matrix is generated from survey results and it is converted as place-by-place matrix to visualize and categorize the structure of familiar places (Borgatti et al., 2002). This analysis allows us to examine the inter-relationships between actors and the result is shown to have structural characteristics.

TABLE 3. Conversion from affiliation matrix to place by place matrix

P = A x A'
P: place-by-place matrix,
A: place-by-person matrix,
A': person-by-place matrix

For the second study, the survey question was adopted from reference point theory (Sadalla, 1980). In this theory, the asymmetric relationships between landmarks were used to quantify the degree of connectedness of landmarks and the reference relationship was demonstrated with the quantified degree. They measured the degree, using the statements "___ is close to ___". The statement was composed of the pairs with each landmark and subjects mark Yes/No, according to whether the statement was reasonable or not. The degree that was the positively answered number was marked when a landmark was located at the position of reference spot was scored. The statement was rephrased as "which place is the most helpful for getting at ______?" For each question, the five candidate's places, which was the closest one from previous studies, were given to choose. The candidate places were selected from the list that was collected from the first survey, with the order of the closest criteria. The statements were composed of top 30 list of spatial familiarity from the first survey. The survey question explained which landmarks were generally agreed as a spatial reference. Additionally, the asymmetric relationship generated the clues to make the link or connection among landmarks and their scale to cover. In this way we hoped to see how the various elements in the subject's mental structure of study area were held together.

To represent class relationships and connection between classes, Protégé OWL is employed as a composer to build the informational structure. Using Protégé OWL that is one of the ontology composers, ontology of city image is formalized and instantiated. As Protégé OWL provides facilities to impose constraints to concepts and relations, the connection between landmarks and other locations can be under the inference rules.

3. Results and Discussion

The first survey is used to collect the geographical terms and classes that were regarded as the common understanding for direction guide in UB community. The average degree of familiarity of 60 places was 3.77 and these landmarks are generally the functional places such as major intersections, shopping malls, grocery markets or famous restaurants. In this study, top 30 landmarks in familiarity measure are reselected for further analysis and second survey. The anchor and distant type of landmarks were classified, according to their functional characteristic and familiarity. The result is shown in TABLE 4.

TABLE 4. List of landmarks for social network analysis

ID	Name	Type	Function
L01	UB North Campus	Anchor	School
L02	UB South Campus	Anchor	School
L03	Wegmans	Anchor	Grocery
L04	Maple Rd & Niagara Falls Blvd	Distant	Intersection
L05	Boulevard Mall	Anchor	Shopping Mall
L06	Bailey Ave & Main St	Distant	Intersection
L07	I-90 & I-290	Distant	Intersection
L08	Bailey Ave & Maple Rd	Distant	Intersection
L09	I-290 & Niagara Falls Blvd	Distant	Intersection
L10	Buffalo Niagara International Airport	Anchor	Airport
L11	Niagara Falls	Distant	Falls
L12	I-290 & Millersport Hwy	Distant	Intersection
L13	Maple Rd & Sweet Home Rd	Distant	Intersection
L14	Walden Galleria Mall	Anchor	Shopping Mall
L15	Bailey Ave & Sheridan Dr	Distant	Intersection
L16	I-290 & Main St	Distant	Intersection
L17	I-290 & Sheridan Dr	Distant	Intersection
L18	Niagara Falls Blvd & Main St	Distant	Intersection
L19	I-290 & I-190	Distant	Intersection
L20	Marriot Hotel	Anchor	Hotel
L21	Target	Anchor	Shopping Mall
L22	Bailey Ave & Millersport Hwy	Distant	Intersection
L23	Maple Rd & Millersport Hwy	Distant	Intersection

ID	Name	Type	Function
L24	Main St & Transit Rd	Distant	Intersection
L25	Sweet Home Rd & Sheridan Dr	Distant	Intersection
L26	Wal-Mart	Anchor	Shopping Mall
L27	Pepsi Center	Anchor	Recreation Center
L28	I-990 & SweetHome Rd	Distant	Intersection
L29	Maple Rd & Transit Rd	Distant	Intersection
L30	HSBC Arena	Anchor	Arena

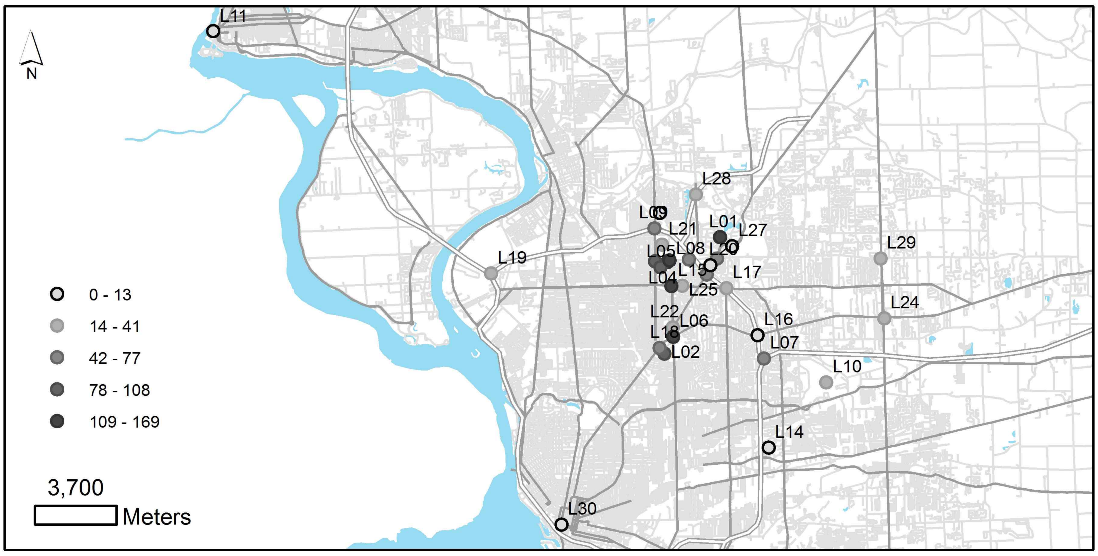

FIGURE 5. Mapping the selected places using centrality measure

For social network analysis, person-by-place affiliation matrix which is output from the first survey is converted place-by-place matrix. The affiliation matrix is converted as place by place matrix for network analysis and the centrality measure of each node is acquired. FIGURE 5 visualizes the locations of high centrality landmarks on map. Considering central measures, UB North Campus is the most central location to this community. The measures of centrality had been associated with their potential network impacts, activity, control, and diversity. The top list of the places with the highest degree of centrality was also the most well-known landmarks that were known to the most of community members. Of course, it made intuitive sense because degree centrality simply measures the total number of connections.

With the result of the second survey, the hierarchical structure is constructed. FIGURE 6 was constructed according to the following steps. Firstly, the central and starting location was decided according to the results of centrality measure that showed the highest centrality and familiarity measures. The list of landmarks that had high spatial familiarity measures were regarded as distant landmarks. The anchor type landmarks were reselected from distant landmarks, which were the places that invoked periodic interactions the UB community members. The reference relationship was constructed according to the one that had the highest proportion from the subjects. The final structure shows the well-known nodes and links as a graph style network. In addition, the component of networks had the hierarchical order according to their class. In short, the place name that structured the figure was network that had links between nodes hierarchically. The network links imply what node can be reference to the others and the hierarchy means what the effective node as a reference in this structure is. In this study, the network drawing was limited with 30 place names, because of the limit of space and time. However, this study presents the possible way of connecting places and it can be extended to the other low level of familiar landmarks and the other unknown places, using referential relationships.

FIGURE 7 shows the visualized graph which is composed by ontology editor Protégé OWL. The second survey result was used to figure out the clues to link the landmarks in order to generate the taxonomic structures. Protégé OWL is used as the tool that represents the conceptual model as a computational physical structure. In practical terms, developing an ontology includes; defining classes in the ontology, arranging the classes in a taxonomic (subclass-super class) hierarchy, defining slots, and describing allowed values for these slots (Knublauch, 2004). As Protégé OWL does not allow the topological reasoning, the spatial relationships between geographical objects can not be inferred. Instead, Protégé OWL identifies the various terms of properties as a subclass. The hierarchical network structure of regional landmarks does not allow cyclic relationships, but it can be solved by object properties with many terms about the properties.

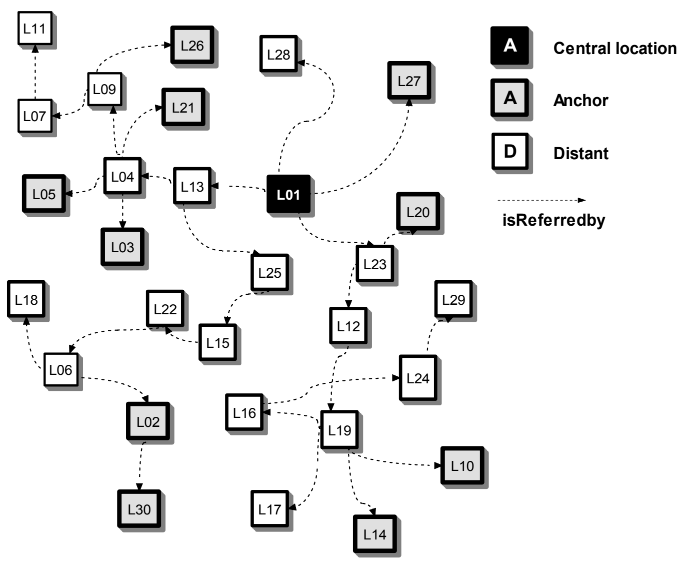

FIGURE 6. Landmarks and their referential links of the UB community

To build the hierarchical structure and the relationships, the survey result from previous study is used. In general, the taxonomy between classes is built on the basis of is–a relation. "A is a subclass of B" means that B inherits all kinds of properties of A and all instances that belong to B can also be the individuals of super-class A. In other words, super-class A has more generic characteristics than sub-class B and B is more easily recognized by A. In this context, the relationship 'is reference to' can be interpreted like is a, so the sub ordinate location B might be easily recognized, through the super-ordinate location A. The hierarchical structure of landmarks, which is built from the results of the second survey, is used as the relative reference frame that can be connected to the other unknown locations. In other words, community members who might have similar interests can infer unknown locations that are close to a well-known location, with the help of landmarks which reflects the social network of regional community.

Currently, ontology modeling allows description logic to infer the integration of objects. However, it does not allow the spatial reasoning, such as a topological relationship, between spatial objects. In this study, the hierarchy of landmarks for a community is going to consider only the possible reasoning that is originated from cognitive links or connections which is based on the degree of referentiality measured from the second survey. With the Ontology language such as Protégé OWL, the spatial logic is not implemented and is not expected to be. One way to embed the spatial relationship among the object at its current situation is to use diverse terms which define the spatial relationship.

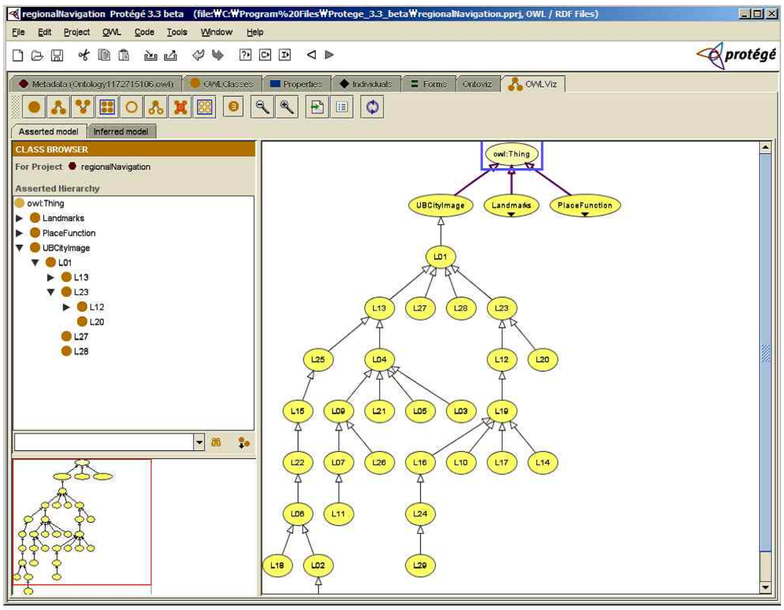

FIGURE 7. Visual representation of OWL ontology, using Protégé OWL.

CONCLUSION

This research focused on finding an alternative way to provide a semantic solution for regional navigation in the mobile age. This approach differs from the usual computational approach which currently dominates in GIS routing services. It enables place recognition based on the semantic relationships among places. Several methodologies were combined for acquiring measurements and representing the formal structure. Therefore, this took a new approach to urban navigation, in the context of ontology modeling. The question of how to extract, measure, and represent the shared common understanding of geographical places was examined.

The conceptual framework of this study promotes assisting urban navigation through semantically related places that act as a guide to the destination for users, starting from more familiar landmarks. With the help of the experiential study that was a practical implementation of the conceptual model, the possibility of ontology-based modeling was examined. While proposing the conceptual framework, this study also pointed out that the geographical places can be connected like a semantic network and the city image can be represented by meta-information of geographical knowledge about a region.

In this study, the following facts are lefts as the limitation and future work. Firstly, the data collection is limited as the survey with the limited persons. However, if we can have various sources of datasets such as GPS waypoints or credit card transactions of individuals, these locations reveal a certain social network and what is the social group that the actor belongs. Additionally, the case study limits the level of landmarks to anchor and distant type, and the building procedure is done by manually. To cover the whole locations of regional community, the automated procedure is needed to be developed to handle the large dataset. Lastly, at preset, there exist web-based semantic web systems such as Jena, Sesame and RDF-suite. The linking these systems to the current Internet Map Services will be another challengeable future work to enhance GIS service. KAGIS

REFERENCES

Allen, G. L. 1999. Cognitive Abilities in the Service of Wayfinding: A Functional Approach. The Professional Geographer 51(4):555−561.

Allen, G. L. 1997. From knowledge to words to wayfinding: Issues in the production and comprehension of route directions. In: Hirtle, S.C., Frank, A.U. (eds.): Spatial Information Theory: A Theoretical Basis for GIS. Springer−Verlag, Berlin. pp.363−372.

Berners−Lee, T., J. Hendler and O. Lassila. 2001. The semantic web− A new form of web content that is meaningful to computers will unleash a revolution of new possibilities. Scientific American 284:34−43.

Borgatti, S., M. Everett and L. Freeman.

2002. Ucinet 6 for Windows: Software for Social Network Analysis. Harvard, Analytic Technologies.

Casey, M. and M. Austin. 2002. Semantic web methologies for spatial decision support. International Conference, On Decision Making and Decision Support in the Internet Age, University College Cork, Ireland.

Couclelis, H., R. Golledge, N. Gale and W. Tobler. 1987. Exploring the anchor-point hypothesis of spatial cognition. Journal of Environmental Psychology 7(2):99-122.

Couclelis, H. 1996. Verbal directions for way-finding: Space, cognition and language. In: Portugai, J. (ed): The Construction of Cognitive Maps Dordrecht Kluwer. pp.133-153.

Cui, Y., H. Hwang, S. Shin, S. Suh and C. Kim. 2008. Ontology Modeling and Its Application for Managing Control Points. The Korean Association of Geographic Information Studies 11(3):34-42.

Deakin, A. 1996. Landmarks as Navigational Aids on Street Maps. Cartography and Geographic Information Systems 23(1): 21-36.

Downs, R. M. and D. Stea. 1977. Maps in Minds: Reflections on Cognitive Mapping. Harper and Row, New York.

Egenhofer, M. and D. M. Mark. 1995. Naive Geography. In: A.U. Frank & W Kuhn. (eds): Spatial Information Theory-A Theoretical Basis for GIS. Lecture Notes in Computer Science 998, Springer, Berlin Heidelberg New York. pp.1-15.

Egenhofer, M. 2002. Toward the semantic geospatial web, in Proceedings of the tenth ACM international symposium on Advances in geographic information systems, Virginia McLean.

Freundschuh, S. M. and R. Kitchin. 1999. Contemporary Thought and Practice in Cognitive Mapping Research: An Introduction, The Professional Geographer 51(4):507-510.

Gale, N., R.G. Golledge, W.C. Halperin and H. Couclelis. 1990. Exploring spatial familiarity, The Professional Geographer 42:299-313.

Garling, T. 1995. Introduction: How do urban residents acquire, mentally represent, and use knowledge of spatial layout?. In: Garling, T.(ed): Urban cognition. Academic Press, London San Diego.

Golledge, R., I. Rayner and V. Rivizzigno. 1982. Comparing objective and cognitive representations of environmental cues, in: Golledge, R., Rayner, I (eds): Proximity and preference: Problems in the multidimensional and analysis of large data sets, Minneapolis, University of Minnesota Press, pp.233-266.

Golledge, R. 1992. Place Recognition and Wayfinding: Make Sense of Space. Geoforum 23:199-214.

Golledge, R. 1999. Wayfinding behavior: cognitive mapping and other spatial processes, Baltimore, Johns Hopkins University Press.

Gould, P. and R. White. 1974. Mental maps. Penguin, Baltimore.

Hiramatsu, K. and F. Reitsma. 2004. GeoReferencing the Semantic Web: ontology based markup of geographically referenced information, in Joint EuroSDR/EuroGeographics workshop on Ontology and Schema Translation Services, Paris, France.

Hirtle, S. and J. Jonides. 1985. Evidence of Hierarchies in Cognitive Maps. Memory and Cognition 13(3):208-217.

Holdings, C. S. 1994. Further evidence for the hierarchical representation of spatial information. Journal of Environmental Psychology 14:137-147.

Jones, C.B., H. Alani and D. Tudhoe. 2001. Geographical information retrieval with ontology of place. in Montello, D. (ed.): Proceedings of International Conference on Spatial Information Theory: Foundations of Geographic Information Science Morro Bay Springer, pp.322-335.

Knublauch, H., R.W. Fergerson, N.F. Noy and M.A. Musen. 2004. The Protege OWL plugin: an open development environment for semantic web applications, Semantic Web - 2004. Proceedings Lecture Notes in Computer Science 3298, pp.229-243.

Kuipers, B. J. 1978. Modeling spatial knowledge. Cognitive Science, 2:129-153.

Lee H. 2009. Implementation of Information Retrieval and Management System Based on Ontology Using Object Oriented Design Pattern The Korean Association of Geographic Information Studies 12(4):146-157.

Lopez, M., A. Gomez-perez, J. Sierra and A. Sierra. 1999. Building a Chemical Ontology Using Methontology and the Ontology Design Environment. IEEE Intelligent Systems & Their Applications 14:37-46.

Lynch, K. 1960. The Image of the City. Cambridge.

Mark, D. M. 1999. Spatial Representation: A Cognitive View. In: Maquire, D.J. Goodchild, M.F. Rhind, D.W. Longley, P. (eds): Geographical Information System: Principles and Applications second edition. 1:81-89.

Mcnamara, T.P. 1986. Mental representations of spatial relations. Cognitive Psychology 18:87-121.

Mika, P. 2004. Bootstrapping the FOAF-Web: an experiment in social network mining. Proc. 1st Workshop Friend of a Friend, Social Networking and the Semantic Web.

Milgram, S. and D. Jodelet. 1976. Psychological maps of Paris. In: Proshansky, H. Ittlelson, W. Rivlin, L. (eds): Environmental Psychology. Holt, Rinehart and Winston, New York.

Noy, N. F. and D. L. Mcguinness. 2001. Ontology development 101: a guide to creating your first ontology, Standford University.

Raubal, M. M. Egenhofer, D. Pfoser and N. Tryfona. 1997. Structuring Space with Image Schemata: Wayfinding in Airports as a Case Study. In: S.C.

Hirtle, A.U. Frank. (eds.): Spatial Information Theory: A Theoretical Basis for GIS, Springer−Verlag, Berlin.

Raubal, M. and S. Winter. : Enriching wayfinding instructions with local landmarks. In : Egenhofer. M. and Mark, D. (eds.): Geographic Information Science, Lecture Notes in Computer Science No. 2478, Berlin, Springer, pp.243−259.

Sadalla, E., W. Burroughs and L. Staplin. 1980. Reference points in spatial cognition. Journal of Experimental Psychology pp.516−528.

Siegel, A. and S. White. 1975. The development of spatial representations of large scale environments. In: Reese, H. (ed): Advances in child development and behavior Academic Press New York. pp.9−35.

Stevens, A. and P. Coupe. 1978. Distortions in judged spatial relations. Cognitive Psychology 10:422−437.

Uschold, M., and M. Gruninger. 1996. Ontology: principles, methods and applications. Knowledge Engineering Review 11:93-155. KAGIS