

Knowledge Based New POI Recommendation Method in LBS Using Geo-Ontology and Multi-Criteria Decision Analysis

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要 旨

위치 기반 서비스는 사용자 중심의 위치를 기반으로 한 정보 서비스이며 유비쿼터스 시대에 있어서 핵심적인 엔진으로서 논의되어져오고 있다. 본 연구의 목적은 다중 의사 결정 기법을 통해 이동 단말 사용자의 위치 정보와 공간적 선호도를 반영한 새로운 온톨로지 추론 시스템을 개발하는 것이다. 이를 위해 POI 검색을 위한 온톨로지 기반의 LBS 추론시스템을 개발하고 사용자의 상황인식정보와 개인적 특성 및 공간선호도에 따른 온톨로지로 구축을 하여 그 구현 결과를 보였다. 또한 사용자의 의사결정시 결정기준요소에 가중치 부여를 위한 Cost Value Ontology를 구축하여, 다 기준 의사추론을 통해 사용자에게 적절한 추천 결과가 도출되는 위치 기반 서비스 방법을 제안하였다.

핵심용어 : 모바일 웹 서비스, 위치기반서비스, 온톨로지, 경로 안내 시스템, 다기준의사결정

Abstract

LBS services is a user-centric location based information service, where its importance has been discussed as an essential engine in an Ubiquitous Age. We aimed to develop an ontology reasoning system that enables users to derive recommended results suitable through selection standard reasoning according to various users' preferences. In order to achieve this goal, we designed the Geo-ontology system which enabled the construction of personal characteristics of users, knowledge on personal preference and knowledge on spatial and geographical preference. We also integrated a function of reasoning relevant information through the construction of Cost Value ontology using multi-criteria decision making by giving weight according to users' preference.

Keywords : Mobile Web Service, LBS(Locational Based Services), Ontology, Route Guidance System, Multi-criteria decision making

1. Introduction

Context awareness refers to the recognition of individual's location, time, weather, schedule and personal preference. Current location based services(LBS) provides information and services simply with users' context based on the users' current location including map, weather, and traffic situation (Spiekermann, S., 2004; Tilson, D,2004). Semantic technology was recently adapted in the LBS area while trying to get out of providing merely simple information. Semantic technology is an intellectual technology which understands the meaning in the system by giving meanings to the information (YoungHoon Yu., 2009). In order to apply semantic

technology, we need the formation of systematic mechanism for knowledge interface and the concept of the ontology. Using ontology, it is possible to support the decision making through the communication between users and system, and provide intelligent and flexible services which recommend the most suitable services to the users(U. Visser, 2002; Abolghasem, 2007).

Recent researches provide users with the information through the inference of single criteria using information of users and preference. This has a limit which can not reflect the users' decision making with various criteria. In order to overcome the limit, we architected ontology according to location, basic information, preference and spatial preference by interpreting and context awareness of users. After ar-

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chitecting the cost value ontology to give weight on the factors of the decision making criteria, we suggest the service measures based on location can provide the users with the recommended suitable result through multi-criteria decision inference.

In this research, we designed ontology according to location, basic information, preference and spatial preference by interpreting and context awareness of users. After architecting the cost value ontology to give weights on the elements of the decision making criteria, we architect a GIS inference system which shows the suitable recommended results for the users' current location and context through multi-criteria decision inference. Therefore, we aimed to develop a knowledge base POI recommendation LBS that can support user participation as collective intelligence.

To make this goal come true, we firstly analyzed the previous context aware – location based systems, and investigate the possibility of unification with the geographic data system after studying previous researches which are based on the theories related to ontology. Next, in order to architect ontology, we defined using the Ontology Web Language (OWL) which is the standard of the World Wide Web Consortium (W3C). Then, since the experimental GIS inference system has spatial question functions, we architected the ontology for users' context awareness, individual characteristics, spatial preference and the search results come from the corresponding spatial questions. And then, we architected the cost value ontology which is to consider the weight of the factors for various decision making criteria as well. And last but not least, we applied the LBS inference system which is embodied in the area for the experiment. After analyzing actual inferenced result, we tried to seek the practical application possibility in LBS inference system through using ontology.

2. Considerations in Applying Semantic LBS

2.1 Related Works

Costa-Requena, Haitao, and Espigares (2002) proposed a novel mechanism to create a common LBS

universally understood by different terminals or systems. The LBS protocol works in wired and wireless IP networks for providing LBS and reuses existing network elements and protocols. Kim et al. (2005) focused on how LBS applications obtain integrated, dynamic, and sensitive content on different domains. They applied Semantic Web technologies to resolve these issues and designed an architecture to combine Semantic Web technologies with LBS and implemented a prototype to describe the Semantic LBS. Tilson, Lyytinen, and Baxter(2004) presented a framework to help design and assess the potential of LBS and identify a viable strategy for service positioning. Individual service concepts are passed through two stage filters to simplify later analysis. These filters incorporate our growing knowledge of social and behavioral characteristics of location-aware services along with technical and commercial considerations. They also proposed a scenario analysis and other techniques for mitigating risks in decision making under the uncertainty that surrounds these services. McDiarmid and Irvine(2004) presented a protocol that allows users to anonymously receive location-based information, within certain restrictions. The protocol can be used to guarantee user anonymity for user-pulled location-based services with a handset-based location measurement system. Alexander (2005) presented several novel realizations of adaptive GI services for mobile applications by using dynamic personalization as well as context factors.

2.2 Context Awareness for LBS

For the most part, LBS have provided information on the database. the database is designed through the reference of various information and search patterns according to the users and location information. After inputting the information suitable for the criteria, the information match to the condition is provided through query. In the case of database based on search method, there could be difficulties when searching complex questions related to users' function of saving information contexts due to the databases' particular function of saving information according to the forecasted criteria. In order to provide more intelligent LBS, studies of context aware LBS

which provide LBS matches for the users' demand and considers user's situations, were recently introduced. After architecting ontology with consideration for users' location information, schedule, information of service, service operating hours and costs, these researches provide users with suitable services through inference of information matching the meaning. However, these researches did not consider users' preference and spatial preference, and cannot support analytic decision making according to the importance of various factors for decision making.

3. Design of Context awareness based Ontology in LBS System

3.1 System Architecture in Sematic LBS

The architecture of the total system which was suggested in this research is comprised of three different parts : ontology design, user interface and space database. Figure 1 shows the detailed system architecture.

When modeling the real world according to a specific subject, ontology does not only clearly define the concepts which resulted after the agreement from relevant individuals and groups, but also to a logical group of terms which are expressed as a formation that computers can understand and process (World Wide Web Consortium, 2004). Ontology defines the terms that are used in the domain and their relations

and needed to share the knowledge information and the common semantic understanding of its architecture. It is also used for efficient reusing of domain knowledge. The characteristics of ontology are the plentiful expressions of relations and causal relationship, connection and expansion of the real information and the concept system, expansion of knowledge, providing reuse, mutual application and connecting different information and knowledge base which is possible for logical inference. For ontology language, there are RDF (Resource Description Framework) and OWL (Web Ontology Language). RDF is a standard language for technology exchanges of meta-data which was presented by W3C. For mutual application among various meta-data, RDF provides common rules about semantics, architecture and syntax.

3.2 Ontology Structure for Personalized Information

In this research, ontology is composed of class, relations, instances, axioms and cost value ontology. Class is a concept of the domain or tasks, which are usually organized in taxonomies. Class in this research is composed of user profile and spatial data. Relations are a type of interaction between concepts of the domain. Instances are used to represent specific elements of class. Axioms are model sentences that are always true. This research uses a semantic technique and applies for context-aware. Through the users' profile, space, constraint design, cost value ontology, instance and axiom, the final ontology like below was designed. Figure 2 shows ontology where is constructed in the last.

3.2.1 User Profile

In order to use users' context awareness, users' basic information is inputted in the system users use. In the user profile ontology, information about users' age, gender, possessing card, location, preference and preferred location is architected.

3.2.2 Spatial Preference

It is a part about important spatial preference among users' context awareness. That is, spatial pref-

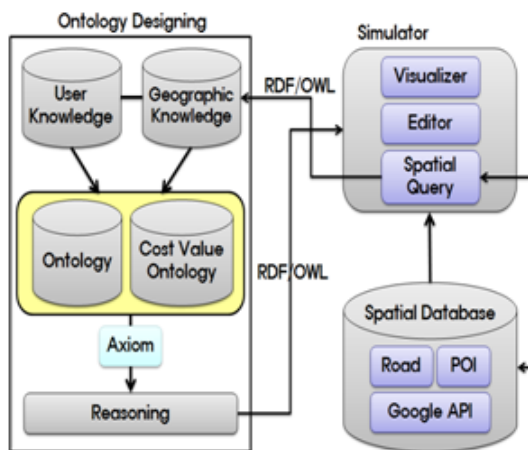


Figure 1. The Detailed Architecture of Ontology Inference System

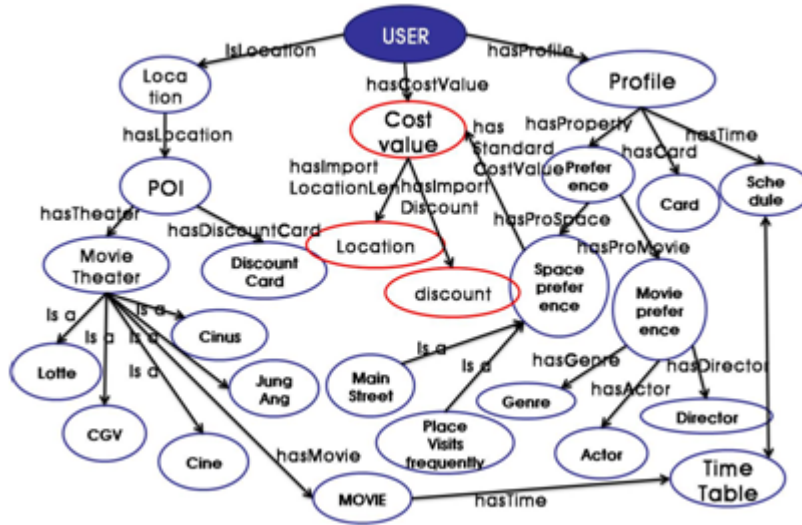


Figure 2. Design of Ontology Structure

erence is able to determine travel mode choice (walking, bike, and public transportation). In accordance with selected travel mode, range of radius search in order to choose final destination POI can be changed into walking coverage (400-500m), bike coverage (2-3km), public transportation coverage (10km). Therefore, in case users set up walking as a travel mode, they can use the services from corresponding POI when the walking approach distance is within 400-500 m and the walking hours is within maximum 6 minutes, users get the spatial database they want within the maximum 500m.

3.2.3 Relation

In context awareness, time is the most important variable for users' context interpretation and an important attribute for the users' selection and the system. It is because providing the most suitable schedule for users is the subject should be preferentially considered when choosing the operating hours of service location or movies from theater. For example, the user's flexible hours is from 13 to 17 o'clock. In case of movie 1, the starting time of the movie does not match user's flexible time. In case of movie 3, it is not recommended to the user because the finishing time of the movie does not match user's flexible time. However, in case of movie 2, the movie starts and finishes in the range of user's flexible time. For

Time Table										
Time	11	12	13	14	15	16	17	18	19	20
USER	User flexible hours									
Movie 1	Case 1									
Movie 2			Watching Possibility							
Movie 3					Case 2					

Figure 3. Time Table

this reason, movie 2 is recommended to the users under the condition of time constraint.

3.2.4 Cost Value Ontology and Axiom based on AHP

In order to give weight on the selection criteria when deciding POI and service, cost value ontology was architected. In this study, distance rate and discount rate were presented as selection criteria for POI and service. In order to calculate weight, AHP method was used. Discount rate and distance rate were selected as criteria factor of selection. We decided the semantic scale and figure, and then organized them in a matrix according to the decision criteria. Through the pair wise comparison between the criteria factor of selection and POI, we compare according to the number of cases of every criteria factor of

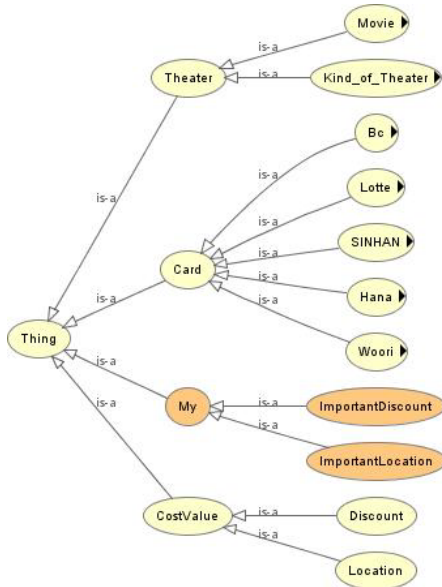


Figure 4. OWL-VIZ Model

selection and POI. Through the sum total of weight selection criteria about for POI, the maximum price is used for decision making, and this maximum price is applied to ontology. As shown in figure 4, Using AHP method, we can give the different service result depending on user preference in terms of location of POI and kind of Card.

As knowledge which is expressed strictly, axiom is something we have to accept without any proof if it is right. In logic, public interest has an essential meaning to show the knowledge which is the premise of inference. When constructing ontology, axiom strictly expresses the definition of vocabulary and concept. Axiom also has a function of inference about the questions of ontology ability which is described using vocabulary and concept that are contained in ontology. As shown in formula, axiom suggests the most appropriate theater and movie by com-

```

<Class IRI="#My"/>
  <ObjectIntersectionOf>
    <ObjectSomeValuesFrom>
      <ObjectProperty IRI="#hasActor"/>
      <Class IRI="#DongWonKang"/>
    </ObjectSomeValuesFrom>
    <ObjectSomeValuesFrom>
      <ObjectProperty IRI="#hasGenre"/>
      <Class IRI="#Action"/>
    </ObjectSomeValuesFrom>
    <DataSomeValuesFrom>
      <DataProperty IRI="#hasDiscountVal"/>
      <DatatypeRestriction>
        <Datatype abbreviatedIRI="xsd:integer"/>
        <FacetRestriction facet="&xsd:maxInclusive">
          <Literal datatypeIRI="&xsd;integer">7</Literal>
        </FacetRestriction>
      </DatatypeRestriction>
    </DataSomeValuesFrom>
    <DataSomeValuesFrom>
      <DataProperty IRI="#hasLocationLen"/>
      <DatatypeRestriction>
        <Datatype abbreviatedIRI="xsd:integer"/>
        <FacetRestriction facet="&xsd:maxInclusive">
          <Literal datatypeIRI="&xsd;integer">3</Literal>
        </FacetRestriction>
      </DatatypeRestriction>
    </DataSomeValuesFrom>
    <DataSomeValuesFrom>
      omit
    </DataSomeValuesFrom>
  </ObjectIntersectionOf>
</EquivalentClasses>

```

Figure 5. Owl/XML Rendering

paring user's preference, schedule and movie time among nearby movie theater through giving weights to decision criteria factors which user consider more importantly. In other words, axiom indicates that user has LotteCard as a discount card and favorite movie genre is an action-film. In addition, favorite actor is DongWon Kang and time that user can see a movie on schedule is from 13~17. Lastly, current user regards discount rate highly than distance rate, which were defined by AHP.

$$\begin{aligned}
 & \textit{RecommendedPOI} \\
 \equiv & \textit{MyLocation} \exists (\textit{Theater} \cap \textit{hasCardLotteCard}) \quad (1) \\
 & \cap (\textit{Movie} \cap (\textit{hasActorDongWonKang} \\
 & \cap \textit{hasGenreAction} \cap \textit{hasTimes} (\geq 13 \textit{and} \leq 17)) \\
 & \cap ((\textit{hasLocationLensesome} = 0.3) \\
 & \textit{and} (\textit{hasDiscountValsome} = 0.7)))
 \end{aligned}$$

4. Case Study : Ontology-Based POI Search in LBS

4.1 Prototype Implementation

In this chapter, we describe LBS inference system which unified the architected ontology. We used several programs in order to perform the research. To architect the ontology we used Protege4.1-alpha, Google Map API for spatial database and the system was developed by Apple iOS 4.01. Before materialization, we selected Myung-dong, downtown area with various business complexes. Figure 6 is a material-

ized system image. It was materialized basic map view, map control, spatial query, geo-tagging and route finding.

In LBS inference system, there is a condition that users have to be in 400-500m of walking approach distance and maximum 6 minutes of walking time in order to access the services from the corresponding POI according to users' spatial preference. According to this condition, users can contact space search for movie theaters which are within 500m from the centered users, and search total POI which comes from the corresponding space search. We architected ontology using Protégé 4.1 - alpha for searched POI information and users' context awareness. Normally, suitable service operators and services are inferred to the users from the architected ontology, this time it was inferred by using constraint conditions like users' basic information, preference, schedule service hours.

4.2 Simulation Result of Experiments

In the Figure 7, the result of the multi criteria decision is inferred through the ontology design system which is comprised of Protégé 4.1 - alpha of the server. Information used in reasoning process is user's personal preference regarding genre of movie, director, actor as well as time for the movie, user's schedule, location and credit card. The decision

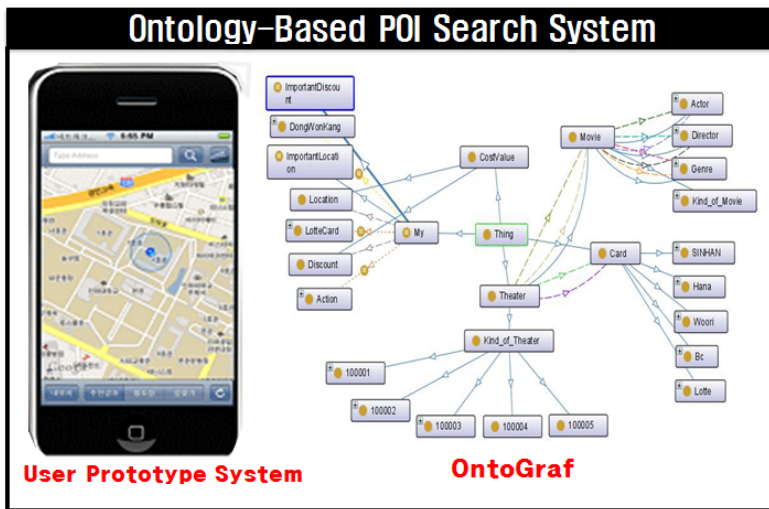


Figure 6. User Interface of Implemented Prototype System and designed OntoGraf

making criteria; distance rate and discount rate, movie theater IDs, The movie ID (10003) was the result from when user consider distance rate higher then discount rate. On the other hand, the movie ID (10001) was the recommendation result of that user think of discount rate then distance rate.

As an inference result of ID 10001, as shown in the figure 8, ‘Swon Brother’ was recommended based on the personal preference such as genre of movie, director, and actor etc, giving the information about the optimal time for the movie through comparing user’s schedule. the inference result is visualized through the map display and information expression by the LBS inference system. It shows the names of the corresponding movie theaters and recommended movies, genre and movie hours through the inferred result as movie theater IDs. Finally, it seeks the routes to the recommended locations from the users’ current location. Like the above materialization and experiment result, this system proved that it

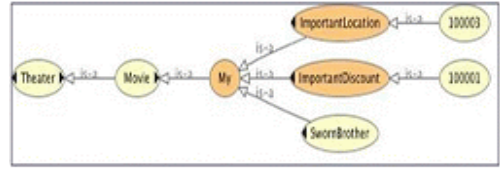


Figure 7. Inference Result

could perform multi criteria decision making inference based on the users’profile, location information and spatial preference. The inference result could bring accurate result while performing location based personalized services to users.

5. Conclusion

We suggested LBS inference system which is capable of recommending suitable location-based services to users through the users’ context awareness and interpretation. In this research, we designed ontology

The figure is divided into two main sections: **Ontology Building** and **The Result of Recommendation**.

- Ontology Building:**
 - Searching Range Based on Users' location:** A map showing a red circle around a 'User' location.
 - Create User Profile:** A 'My Profile' screen with fields for Gender (Male), Age (24), and Interests (Supreme Team).
 - Card Information:** A list of loyalty cards including kt SHOW 멤버십카드, BC TOP카드, DC Supreme카드, New. 오픈 V 카드, 하나 VIVA 체크카드, and Platinum SKYPASS카드.
 - Schedule available:** A calendar view for the week of 2010. 7. 27.
- The Result of Recommendation:**
 - The Result of Distance Rate:** A list of recommendations for 'CGV광동' and 'SwornBrother'.
 - The Result of Discount rate:** A list of recommendations for '롯데시네마에버뉴영' and 'SwornBrother'.
 - Route Guidance on the basis of Users' Location and POI:** A map showing a red route from the user's location to a recommended POI.

Figure 8. The Result of Recommendation in LBS

which can give weight on users' individual characteristics, spatial geographic preference, service hours of POI and criteria factors of decision making. After unifying inference functions and space analysis functions, the new location based service which can bring the result by interfacing suitable POI according to the users' context awareness were shown. In order to verify the recommendation suitable for the individual users' context, it inferred the movie schedule, current time, schedule according to the users' flexible hours, constraint conditions with the alliance cards of users', recommended movie theaters, movies and movie hours from the public interest after assuming the scenario of watching movie in the theater. As a consequence, we presented a new LBS which brings out the result by interfacing the suitable POI and service according to the users' current context, basic information, preference and spatial preference.

In the future researches, the study of tight coupling of ontology design and GIS system and inference engine is needed to be processed. Moreover more automatic and intelligent functions are needed to be developed for the improvement of usefulness for the suggested model.

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