A comprehensive study on Ontological Modeling and Semantic Rule Based Reasoning in Pervasive Environments

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Abstract

Web characterizes an information space where the information growth is exponential. This pave the way for personalized interaction between users and web based information systems providing information. Context-aware applications exhibit limitation in supporting user personalization. Ontology serves as a pertinent tool for knowledge representation and semantic visualization. Ontological user modeling is promising technology for personalization in pervasive environments. Moreover, knowledge reuse is made possible through similarity measure estimation between two ontologies, threshold estimation and use of simple if-then rules for checking relevancy and irrelevancy measures. Knowledge driven approaches such as ontology reasoning provide a series of advantages over data-driven classical approaches. This paper presents a comprehensive study on ontological modeling.

Keywords: Ontology, pervasive environment, on demand services, information retrieval, reasoning, Recommendation System, Knowledge Management System

Introduction

The information stored in the web is growing rapidly. Hence, Information Retrieval (IR) has become an active area of research in recent years to handle with the dynamic environment by establishing intelligent systems which can offer effective web content in real time to various wired or wireless devices. In a typical cloud environment, the task of identification and selection of required services solely depend upon the service specification furnished by the cloud user. The experienced users can specify their service requirements in precise terms by using numerical representations. On the other end, the task of service specification is always a challenging one for an inexperienced cloud user who seems to be new to the environment. In such a kind of requirement, vagueness arises in the preliminary phase of cloud service life cycle results service mismatches and affects both the cloud providers and user significantly. Hence, identifying and offering suitable services in responses to the imprecise service requirement have been emerged as an important research issue.
Ontological modeling is one of the promising technologies to support personalization. Ontology structure, a core of semantic web is an excellent tool for knowledge representation and semantic visualization. Ontology represents the relationship between concepts, data and entities in all the domains. Ontology enables the users to limit the complexity and transform information into data and knowledge. Ontology can be classified into domain, upper and hybrid ontology. Domain ontology is domain specific i.e. the context will vary for the same word in two different domains whereas in upper ontology, common relations and objects based model could be applied across different domains. Further, the combination of upper and domain ontology is termed as hybrid ontology. Furthermore ontology modelling is a set of tasks related to development of ontology for specific domain. Ontological modeling is applicable in providing travel assistance, document retrieval, hotel, hospital education services etc. The ontological modeling for education services is portrayed in Figure 1.

![Ontological Modeling for Education Services](image)

**Figure 1. Ontological Modeling for Education Services**

Common components of ontologies include individuals, classes, attributes, relations, function terms, restrictions, rules, axioms and events. Individuals are instances or objects whereas classes are sets, collections or concepts. Attributes define the properties, characteristics, features or parameters of that object while relations represent the way in which the classes and individuals are related. Function refers to complex structures formed from certain relations that can be used in place of an individual term in a statement. Input rules are in the form of if-then, that a sequence can be derived based on certain assertions.

Ontological modeling for personal services support adaptive user interface design, electronic guides and customized libraries. However, the models lack in developing...
personalization of assistive services for mobile users. On demand service can be provided conveniently in pervasive environments through context aware mobile interfaces. Therefore, context aware on demand services are mandate. The system architecture of ontological modeling for context aware on demand service is depicted in Figure 2.

![Figure 2. System Architecture for Ontological Modeling based Personalization](image)

The service oriented system architecture shown in Figure 2 involves distributed computing environment. Case based reasoning, rule based reasoning and collaborative filtering are the techniques adopted for ontological modeling. Rule based reasoning infers the information about the user context based on the specific rules. Hence, rule based reasoning enables more expressive inference since it is preferable in situations where user preferences are changing. Collaborative filtering and case based reasoning utilize the feedback of the users to improve future personalized services.

Further, ontological user models are developed for personalized web information retrieval systems along with adaptive user interface. In addition, these interfaces are developed to suit user friendly mobile applications. Context aware applications are meant or case based reasoning whereas for situation inference rule based reasoning is adopted. In rule based reasoning approaches, the specific rules which infer the context or the area of activity monitoring and recognition. Though, collaborative filtering and case based reasoning considers past experiences in arriving solution, it fails to provide a complete and consistent model. Therefore, rule based ontological modeling is preferred to represent additional attributes which is not possible with traditional methods.
To address the growing demand for personalization, Help-on-Demand (HoD) services proposed is portrayed in Figure 3. In this approach, the user modeling and reasoning is represented through semantic web technologies for personalization. The need for the service and behavior of the user are analyzed to arrive at a more precise context aware service. This is achieved by framing powerful rules to satisfy the user needs and behavior. The following section reveals the literature related to ontological modeling.

![Figure 3. Illustration of Help-on-Demand (HoD) Services](image)

User semantic navigation discovered through web log preparation system is presented [1]. The ontology based user models are constructed using these semantic sessions. The user model construction is based on user activity representation using semantic representation. The user model built without user interaction construct the ontology based on automatic monitoring of browsing habits of the user. The history of user behavior is recorded in user ontology. After the building up of initial model through the visited web pages, the model convergence ought to be arrived. Early detection and diagnosis of lung cancer is possible through Computer Aided Diagnosis (CAD) [2]. The proposed system involves four stages namely image acquisition, lesion detection, texture feature extraction and tumor characterization using a classifier. The texture feature extraction is carried out through ontological modeling.

The automated framework for constructing ontology structure and storing in the repository is discussed [3]. Dyadic demotic logic based graph derivation is used to construct the semantically rich ontologies. In order to acquire more relevant documents from cloud, the similarity between two ontological models are compared with cosine similarity measure. The if-then rules are used to determine the level of relevance. This model is fruitful for fetching relevant documents in cloud environment especially for e-health applications. User modeling for recent web development is attempted by combining modern technologies and web ontology [4]. By employing modern technologies, user adaptive systems for knowledge acquisition, domain and user model visualization are possible. Ontology based user modeling framework is proposed [5]. The behavior of the users is modeled by the framework and classification is performed based on the behavior. Here, ontology acts as a backbone for Information Management System and also the model is able to define the characteristics of the interacting users. However, none of the works deal with personalization to enhance user convenience.
Personalization of the user through enhanced modeling to provide necessary information for the user is attempted [6]. Through this model, the user requirement can be reflected in a better manner. The web based ontology for accessing web information to acquire job is proposed [7]. In addition, the reusability of the approach to suit variety of applications is discussed. The combination of portal and mashup technology is used to access the information distributed across the enterprise. The mashup tools enable integration of independent applications to suit variety of applications. A combination of semantic and rule based reasoning using web rule mark-up language for personalization is proposed [8]. The proposal is implemented with a prototype which includes help on Demand services, user models and personalization along with the application of specific rules.

To achieve better information retrieval system, fuzzy logic based ontology model is developed [9]. The fuzzy model learns the user behavior from the knowledge base and user local instance. The proposed model is evaluated with the benchmark web information gathering model. Fuzzy based conceptual representation for information or document retrieval is proposed [10]. The method utilizes the documents and user interests to arrive at learning user interests thereby improving the relevance of response to user queries. Fuzzy logic based cloud broker to facilitate enhanced user interaction for inexperienced cloud users [11]. The broker acts between the cloud service provider and consumers through suitable fuzzification and defuzzification process. Further, service integration is also accomplished by means of Sugeno integral and the decision making is through fuzzy decision tree. Web service discovery is another issue raised due to rapid development of web services [12]. However, there is lack of matching web services with different ontologies. Further, the subjectivity in designing ontological models also results in difficulty to match with concepts. Hence, fuzzy based framework is proposed that applies fuzzy logic to discover web services for either the model with same ontology or with different ontologies.

Human activity representation using fuzzy logic based ontological modeling is proposed [13]. The model is suitable for vague, incomplete and uncertain environment. The relevant sub-domains that are missing in the previous proposed models are also included in this model. The resulting fuzzy model is able to represent temporal relationship between activities using fuzzy state machine representation. The proposed method is compared with crisp ontologies for work scenarios in office domain and fuzzy based approach proves to be suitable and posses better recognition. Knowledge driven approaches are found to be advantageous when compared to data driven approaches with respect to human activity recognition [14]. The model is adaptable to different scenarios and also supports context aware information retrieval system. The human behavior based ontology allows imprecise knowledge representation due to vagueness and uncertainties. Hence, a fuzzy base ontology modeling for human activity recognition is proposed. The proposed model is suitable for work environments such as domain and public buildings.
Conclusion

Web resources are growing exponentially and therefore information retrieval is a major issue that ought to be addressed. Information retrieval is possible through ontological modeling. Efficient modeling enhances the relevance of response to user query. Further, the interactive models are to be built to suit user friendly and context aware approaches. Therefore, an extensive survey on existing methods that addresses information retrieval through ontological modeling is discussed. The pros and cons of data and knowledge driven approaches are dealt in detail. From the discussion, it is inferred that the fuzzy based ontological modeling suits better for interactive user environments where there may exist vagueness, uncertaininty and imprecise data.

References


