

A Study of Ontology Based Recommendation Systems

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Abstract – The Recommendation systems are information retrieval and filtering software tools which analyze user data and strive to deliver relevant and effective item or product suggestions to the user. Similarities between users are discovered through the analysis of obtained consumer information, and products that the consumer is likely to purchase are then recommended by the system. These types of systems are being explored in a variety of disciplines such as crop yield productivity in agriculture sector, location-based services, social robots, online transactions and learning management systems. Traditional recommendation systems can be integrated with multiple methods to overcome several limitations such as cold-start issues, rating sparsity issues, overspecialization, new item drawback and scalability problems. This paper provides a study of various techniques and ontological approaches employed in recommendation systems to provide better performance.

Key Words: Recommendation System(RS), Collaborative Filtering(CF), Knowledge based RS, Ontology, Semantic Web, Personalization, Web Ontology Language (OWL)

1. INTRODUCTION

Recommendation systems (RSs) have become a significant research topic since the mid-1990s. Users are often overwhelmed by the vast amount of data and variety of information available on the Internet, as well as the rapid development of new E-business services which lead them to make to poor selections. Therefore, there is a necessity for systems to offer suggestions to the user based on their need and assist them in making informed decisions or retrieving content. Recommendation system (RS) is an information retrieval and filtering software tool which analyzes user data and strives to deliver relevant and effective product or service recommendations to the user. These systems provide emphasis on mapping the items and users based on their past ratings or preferences. There are two types of recommendations: personalized and non-personalized. Personalization is the process of giving products or services to users based on their characteristics and preferences without asking them explicitly. Various users and user-groups receive different suggestions in personalized recommendations whereas all users receive the same suggestions in non-personalized recommendations. The paper is structured as follows. Section 2 consists of the overview of various techniques and approaches applicable for RSs. In section 3, the current work and discussion on the technologies are carried out. Section 4 of the paper includes the conclusion of the study. The last section lists the references used for this study.

2. OVERVIEW OF DIFFERENT TECHNIQUES POTENTIAL FOR RECOMMENDATION SYSTEMS

This section consists of different technologies and approaches used to develop RS.

2.1 Knowledge-based Technique

The knowledge-based recommendation techniques are used in situations where the item contents include intricate domain knowledge and the user-ratings are insufficient. Knowledge-based recommendation has the advantage of not having a data sparsity issue or a cold start problem, but it does rely significantly on predefined knowledge structures like ontology. Because of the complicated pedagogical link between objects in E-learning, they are excellent for use in recommender systems meant for online learning platforms. Users are categorized into groups based on their profiles and interactions, and the sequential pattern mining approach is applied to identify the highly similar users, obtain the items they visited and produce suggestions or recommendations.

2.2 Ontology Approach

The formal knowledge representation that includes entities, concepts and their connections in a particular area/domain is known as Ontology. It is encoded by the language called as OWL i.e., web ontology language. To improve the user and item description, ontology based recommendation systems utilize ontological keywords and interpretations. For the creation of practical RS, user requests are modelled and presented as fresh concepts if they were unavailable earlier in the ontology with the help of enrichment. Ontology also captures contextual information, and OWL rules are utilized to classify and recommend resources.

2.3 Hybrid Technique

A wide range of techniques are used for producing recommendations and these methods are combined in hybrid recommenders for the purpose of increasing performance of the system. There are several hybridization approaches such as weighted-approach, mixed-approach, switching, feature combination and augmentation. Hybrid techniques may be implemented in a variety of ways including the incorporation of pro-characteristics of one method into another, individual implementation of different approaches and aggregating their predictions to produce suggestions.

3. STUDY OF ONTOLOGY BASED SYSTEMS FOR RECOMMENDATION

3.1 Rule Filtering and Ontology Based RS for E-Learning

In [1], the authors propose an ontology based semantic recommendation system for the purpose of e-learning which allows users to identify and select appropriate learning materials based on their desired field. Ontology and OWL rules are used in this web-based system and Rule filtering has been employed as the technique for recommendation. Semantic systems differ from traditional recommendation systems in that they use semantic web elements to suggest products to users. The architecture of this system mainly comprises of subsystems namely Semantic-Based and Rule-Based System. Semantic-based subsystem consists of the ontology and it is the paramount component in the system as it contains semantic knowledge about all the object contents. The Rule-based subsystem comprises of two elements where one is for identifying rules and the other for the reasoning engine. Along with this it includes additional modules such as Observer module, Recommendation storage, User interface and Learner' profile which consists of previous data, characteristics and level of knowledge. The system offers the possibility of evaluation and monitoring of users throughout the learning process. The authors state that the RS will assess the performance, knowledge level and profile of the users to provide list of recommendations.

In [2], the authors present an ontology based architecture and discuss the benefits of semantic web technologies. They propose to include a semantic layer to a three-tiered traditional web application architecture to make RSs more relevant in the field of e-learning and mobile learning. Ontology has been utilized as a domain knowledge for the purpose of obtaining the learning factor information and Rule filtering based on OWL has been used as the technique for providing recommendation. Current e-learning platforms have layered architecture and the employed RSs are not adequately aware of user context. Context-awareness is highly suggested for delivering learning content that is relevant to the learner's current conditions. Ontological approach is adopted to build a model for representing and managing context data. The authors suggest incorporating a Semantic Layer between the data and application layer. The proposed Semantic layer comprises of two components namely LMS ontology and semantic rules. The ontology of the entire Learning Management System is the LMS ontology and it is divided into Learning Content, Learning Context and Learning Design Ontology for the purpose of making modelling a manageable task. A context model is developed based on ontology of e-learning and strategies for enhancement and adaptation of the learning objectives is applied to it in order to deliver to the user the learning object which is relevant to their context.

3.2 Ontology Based Personalized RS

In [3], the authors present an ontology based personalized recommender system which provides an autonomous mechanism to the users for reducing repeated and time consuming information retrieval. The framework of the system comprises of domain ontology and user interest ontology. Domain ontology is developed by incorporating multiple-resource heterogeneous or diverse information whereas user's interest ontology is constructed by exploring the demographic attributes such as age, gender, education etc., and travel history data and individual preferences of users. To classify the information that the user requested, an automated information retrieval specification and expansion technique is employed. The RS suggests appropriate materials/items to a user who is potentially interested in relevant topics based on the similarity in the results of the domain ontology, user requests and interest ontology. As a final step, a qualitative valuation has been conducted to demonstrate the suggested system's performance and through the process of experimentation, it has been established that the ontology based approach led to an improvement in the recommendation accuracy.

In [4], the authors have proposed an adaptive ontology based personalized recommendation system which utilizes a hybrid recommendation strategy. They have employed knowledge-based technique to deal with new-item problem, data mining technique to manage the new-user problem and they have designed the proposed system to offer recommendation diversity. In order to define concepts and form semantic relationships between them, a domain ontology was an essential part. Background knowledge of users such as user rating records and category preferences were utilized by the system. A core concept called multi agent personalization approach was introduced. Agents were in charge of sub-processes in particular random selection, data mining and semantic discovery processes to solve problems of traditional RSs namely new-item, new-user, sparsity in rating and the issues of exhausting suggestions and static suggestion abilities. Their proposed strategy and RS is portable and convenient to be applied in different areas provided the searching space is substantial and domain knowledge is offered.

3.3 Ontological Approach in Knowledge Based RS for E-Learning

In [5], the authors have taken an ontology approach to create a knowledge based personalized recommendation system for e-learning purposes. Ontology is created in order to store the knowledge required by the system during the process of suggestion using Protégé 3.4.3 and a semantic relationship is formed between learning resources. In this paper, pattern of pedagogy refers to teaching style. The common ontology for learners and learner materials is the first key feature considered. The second feature pertains to the teaching pattern that has been designed for this proposition. The pedagogy structure consists of sub processes such as obtaining the requirements, checking the users' knowledge background and the learning styles of the user. The user's requests lead to the execution of pre-defined query which is specified by SPARQL. The learning resources are filtered

based on the user's knowledge and the preference of the user. Users can learn the topic of their choice, perform modifications to their respective profiles and request for particular learning exercises by using this system.

In [6], the authors have presented a hybrid recommendation system established on knowledge based technique centered on ontology and sequential pattern mining (SPM) for the suggestion of e-learning resources. Ontology is utilized to form and convey the domain knowledge regarding learning resources and the user. The users' sequential learning patterns is unearthed by the SPM algorithm. The approach comprises of different stages such as, developing an ontology to portray knowledge about the learning resources and the user, calculating similarity in ratings on the basis of ontology domain knowledge and predicting outcomes for the target user, using CF recommendation system/engine to produce top N learning items and applying SPM algorithm to these top items to produce final suggestions for the target user. The proposed system was tested in numerous ways and the findings showed improved performance. By utilizing ontological domain knowledge and the sequential access patterns of the user prior to availability of preliminary data in the RS, the suggested hybrid strategy can mitigate the data sparsity as well as cold start issues.

3.4 Merged Ontology and SVM Based RS

In [7], the authors have presented a combined ontology and support vector machine (SVM) based information retrieval and recommender system. The latest technology has enabled social robots to transmit information and deliver suggestions. The proposed intelligent model was designed by using Java and the merged ontology was designed by employing Protégé OWL software. When the robot receives a request orally from a disabled user, the system translates the request into a full-text request and then mines the full-text query to obtain the user's demands, and finally converts the request into the proper format for a search engine. The suggested system collects a set of item-specific information and utilizes SVM to extract the important information on the item and discards the rest. The combined ontology based sentiment analysis is utilized to get the item's polarity for the purpose of recommendation. The items possessing a positive polarity value is suggested by the system to the user. According to the results of the experiments conducted, the developed system is extremely productive while evaluating the retrieved information and the system delivers accurate recommendations.

4. RESULTS

After the study of numerous papers related to recommendation systems and different techniques employed in these systems, the following observations can be made.

1. Knowledge based RS make suggestions by utilizing the knowledge about items and users. Ontology is required to facilitate reasoning about which items match the user requirements. These systems are ideal for usage in e-

learning platforms because of the intricate academic link between elements in E-learning.

2. Utilization of ontological domain knowledge in RS can improve user profiling, mitigate the rating sparsity as well as cold start issues.
3. Ontology based approach leads to an improvement in the recommendation accuracy and also improves the overall recommendation quality.
4. It was found that ontology based hybrid recommendation technique is portable and can be integrated to several application areas provided the searching space was substantial and domain knowledge was provided.

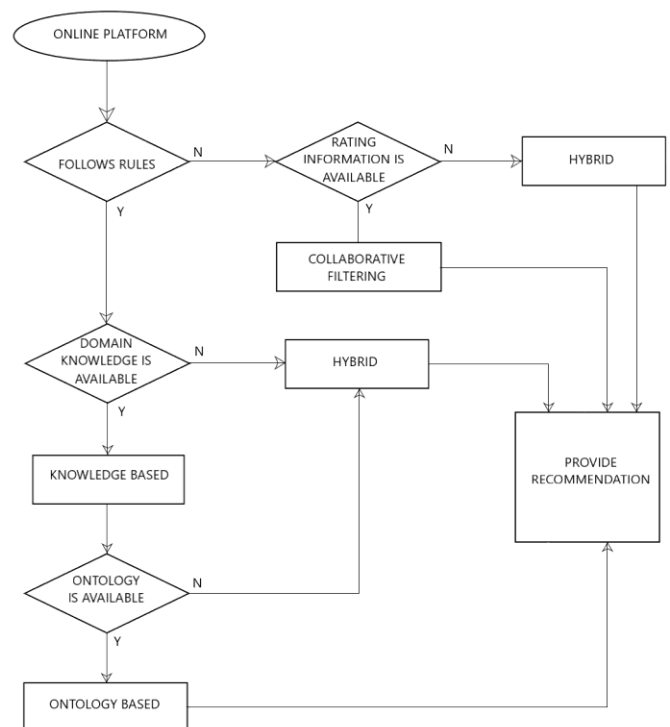


Fig-1: Suitable technique of recommendation

Fig-1 shows the diagrammatic representation of suitable technique of recommendation that can be obtained. This can be applicable to various domains, but especially to the e-learning domain. Formal ways of obtaining information is structured and follows certain rules when compared to informal ways of obtaining information. Ontology is beneficial for the domains which consist of structural information as items can be classified.

5. CONCLUSION

This paper provides a study of various techniques and ontological approaches employed in recommendation systems. It was observed that the implementation of ontology increased the quality of suggestions and services offered by recommender systems, thereby boosting the recommendation accuracy. According to the research of various systems that used an ontology-based approach for

recommendation, it can be inferred that the main purpose of employing ontological approaches in RS is produce suggestions without the well-known issues that surround conventional approaches. The limitations such as cold-start issues, rating sparsity issues, scalability problems, overspecialization, new item drawback in traditional systems that utilize a single approach could be solved using a recommendation strategy that incorporates the combination of various techniques.

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