www.ijiarec.com

ISSN: 2348-2079

MAR-2015

International Journal of Intellectual Advancements and Research in Engineering Computations

SEMANTIC ENHANCED WEB-PAGE RECOMMENDATION BASED ON ONTOLOGY USING WEB USAGE MINING

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ABSTRACT

Web-page recommendation plays an important role in smart Web systems. It not only reduces the Web traffic, but also gives effective personalized Web-page recommendation for every user. Effective knowledge discovery from Web usage data and attaining exact knowledge representation are typical task. This paper proposes a novel method to provide better Web-page recommendation through semantic enhancement based on knowledge representation model using domain and Web usage knowledge. An ontology based model was proposed to represent the domain knowledge, which is a powerful way of knowledge representation using today in many Websites. Finally, Web usage data founded from Web log file was integrated with the domain knowledge representation model to provide effective Web-page recommendation.

Keywords- Knowledge representation, Ontology, Web usage mining, Web-page recommendation

INTRODUCTION

Web-page recommendation has gain more popularity in today's Web traffic and it is shown as links to related products or Web-pages. When a particular user browses a Website, a flow of Web-pages visited during a session was stored and organized into a Web session S. The value of $S=d_1,d_2,d_3,....$, where $d_i(i=[1...k])$ is the page ID of the i_{th} visited Web-page. The goal of Web recommender system is to effectively predict Web-pages that are visited from the Web-page of a Website.

There are no of issues in getting Web usage and domain knowledge for Web-page recommender system. And how to model and use the discovered knowledge for effective Web-page recommendation based on the discovered knowledge. Previously approaches based on tree structures and probabilistic models can efficiently represent Web access sequence (WAS) [2]. However, these two models mostly depend on size of the training dataset. Bigger the training dataset is, higher the prediction accuracy. Recommendation was mainly depend on Web access sequence which was generated from Web usage data. Therefore, prediction was limited within founded Web access sequence. These approaches will not work well, if founded Web-page was not in the Web access sequence. In this project, this problem is referred as new-page problem.

Some studies have shown that semantic-enhanced approached are effective to overcome the new page problem [2] [3].The use of domain knowledge of Web-pages is better idea and domain ontology is constructed based on it. This domain ontology will represent the semantics of Web-pages. Integrating domain knowledge with Web usage knowledge enhances Web recommender system performance using ontology based Web mining techniques [4] [5].This method achieves higher performance than classic Web usage mining algorithms [5] [9]. However, the biggest challenge is acquisition of semantic knowledge of a Web-page.

The domain ontology can be constructed by both automatically or manually. Automatic construction will be done by using some learning models such as Bayesian network or a collocation map. Manual

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construction is difficult for websites having large scale web usage data. However, automatic construction also needs experts at the beginning to design learning models. But its saves time and discover all possible concepts and links between them. So the resultant ontology is reusable.

This paper presents a new method to provide better Web-page recommendation. New model was proposed. It is an ontology based model which represents domain knowledge of website. The construction of this model is semi automated. Finally, domain knowledge representation model and Web usage data was integrated to provide effective Web-page recommendation. This new method has alleviated new-page problem and it gives better performance compared with existing Web-page recommendation systems.

RELATED WORKS

Research works related to Web-page recommendation was classified into two categories

A. SEQUENCE LEARNING MODELS

In applying sequence learning models, association rules and probabilistic models has been used. Sequence modeling has shown their significant effectiveness in recommendation generation [2]. To model the transitions between different Web-pages in Web sessions, Markov models and tree-based structures are used [2], [11]-[14]. Among all tree based algorithms, Pre Order Linked WAP-Tree mining (PLAP-Mine) proves very efficient in Web-page recommendation compared with other sequence mining algorithms [15], [16].

B. SEMANTIC ENHANCED APPROACHES

The semantic-enhanced approaches integrate semantic information into Web-page recommendation models. By using ontology of the Websites, Web-page recommendations can be improved in systems [18], [19]. Domain ontology in a system is useful for clustering documents, classifying pages etc. Domain ontology can be constructed by either manually or automatically. Ontology can be constructed for any kind of systems like distance learning courses [20], course content [21], personalized e-learning [22], contracts [23], and software [24]. Depending upon the interest in the system can reuse some existing ontology's or new ontology will be created. In this system, ontology was constructed based on the concepts extracted from the documents. Then, usage data is integrated with it to produce semantically enhanced navigational patterns. So that the system can make recommendations, depending on the input patterns semantically matching with the produced navigational patterns. Liang Wei and Song Lei [18] chose ontology to represent Website's domain knowledge by using the concepts and terms extracted from documents. They generate online recommendations by semantically matching with the Web-page sequence generated during the Web usage mining process. On the other hand, by categorizing Web-pages to domain concepts in a semantic model, the recommendation system can find easily about what Web-pages are , and then make more accurate Web-page recommendations [7], [8]. Alternatively, converting Web access sequence into sequence of ontology instances, Web-page recommendation can be made by using ontology [6], [9]. In these approaches, Web usage mining algorithms uses ontology instances instead of normal Web-access sequences for finding frequent navigation paths. Generally, ontology has helped to organize knowledge bases systematically and allows systems to operate effectively.

DOMAIN ONTOLOGY OF A WEBSITE FOR WEB-PAGE RECOMMENDATI-ON

In the situation of Web-page recommendation, the input data is taken from web logs which records user sessions on a daily basis. The user session records include information about users Web-page navigation activities. Each Web-page has a title, which contains the keywords that wrap the semantics of the Web-page. Based on these certainties, we plan to recognize domain knowledge from the titles of visited Web-pages at a Website and represent the detected knowledge in domain ontology to support valid Web-page recommendation.

Domain ontology is defined as a conceptual model that determines the terms and relationships between them absolutely and regularly, which in turn represent the domain knowledge for a specific domain [26]. The three main components are listed as follows [21]:

1) Domain terms (concepts),

2) Relationships between the terms (concepts), and

3) Features of the terms and relationships.

Ontologies are often achieved in a sense-based language, such as OWL/RDF, to become recognizable to software agents or software systems. Therefore, ontology based knowledge representation allows distributing and interchanging semantic information with Web systems over the Internet. It also facilitates the reuse of the domain knowledge, and analyzing the semantics of Web-pages from the existing details

[27]. Furthermore, ontological representation of recognized knowledge from different sources can be easily assimilated to support Web-page recommendation effectively.

Depending on the goal of ontologies, they can be described as domain conceptualizations of various degrees of formality and can be in the form of concept schemes, taxonomies, conceptual data models, or general logical theories [28]. In this section, we will shape a conceptual data model as domain ontology for a given Website. Since this ontology is used to support Web-page recommendation, we take a Web-page as a unit and assume each page title is well defined to represent key information about the content of the page. The rationale behind this assumption can be seen from two aspects. One aspect is that a Web-page contains a collection of objects (represented by HTML tags) documented in metadata, which is data about data. Metadata wraps the core elements of title, meaning, descriptive context, structure, and overall context of a Web-page. By analyzing the metadata, such as Web-page title, the meaning of a Web-page can be understood and conquered. The second aspect is from the professional practice in Web development. In well-designed Web-pages, the

Page	Title	Path
d1	Visual FoxPro	/vfoxpro
d2	MS Word	/msword
d3	MS Excel	/msexcel
d4	MS Education	/mseducation
d5	MS Support	/mssupport
d6	MS Access	/msaccess

Table 1. Sample MS Website Dataset

TITLE tag should contain the meaningful keywords which are relatively short and attractive to support Web search or crawling. In practice, the terms in page titles are usually given higher weights by search engines, such as Google [29], [30]. Consequently, professional Website developers need to define the Web-page titles very seriously because they want their Web-pages to be correctly identified during Web search or crawling and use the Web-page titles to convey accurate information about the Web-page. Because of these facts, we use the Web-page titles as clues to represent the domain knowledge of a Website. It implies that although there are numerous models for extracting topics of Web-pages, making use of Web-page titles is simple and easy to implement. This section now presents a procedure for constructing the domain ontology using the Microsoft (MS) Website (www.microsoft.com) as an example. The dataset was downloaded from http://kdd.ics.uci.edu/databases/msWeb/msWeb.html. The ontology will be constructed based on the titles of visited Web-pages so that it is the domain knowledge perceived by users. Queries are then provided based on this domain ontology.

A. DOMAIN ONTOLOGY DEVELOPMENT

There are three steps for constructing the domain ontology

Step 1: Collect the key terms

In order to collect the key terms, we will: (1) Web log file was collected from the Web server of the Website for a span of time (at least seven days data), (2) run a pre-processing unit for analysing the Web log file to produce a list of URL's that were accessed by users. (3) run a software agent to crawl all the Web-pages in the URL to excerpt the titles, i.e., single tokens are excerpted first by clearing stop words from the titles, some single tokens are then mixed into composite terms if these single terms are regularly takes place at the same time and there is never any token occurs between these tokens, and the remaining single tokens become single word key terms.

Using the MS Web dataset, we gather the Web-page titles and paths. A sampling dataset is shown in Table 1.

Given the dataset, the excerpted terms, for the sampling (Table 1), might be "Fox_pro", "Support", "Education", "Word", "Access" and "MS". Based on the excerpted key terms, we can establish them to domain concepts in Step 2.

STEP 2: DEFINE THE CONCEPTS

It is possible for some excerpted key terms to share the same ideas, so it is finer for them to be instances of a concept, rather than standalone concepts. Domain concepts will be defined for the given Website based on the excepted terms. In this paper, we prompt MS Website as an example. This Website focuses on the application software, such as MS Excel, Windows Operating system, and MS SQL Database. Therefore, the classified domain concepts of Website are *Misc, Support, Category, Application, Manufacturer, News, Product, News, Solution, and SemPage*, where the concept SemPage cites the class of Web-pages, and the other concepts cite the generic terms in the MS Website.

STEP 3: DEFINE TAXONOMIC AND NON-TAXONOMIC RELATIONSHIPS

There are three possible ways to establish taxonomic relationships, such as, (4) a top-down development process starts from the most generic concepts in the domain and then classifies the consequent specialization of the general concepts, (5) a bottom-up development process starts from the most precise concepts as the leave nodes in the concept hierarchical/tree structure, then associate these most precise concepts into most generic concepts, (16) a hybrid development process is the mix of top-down and bottom-up approaches. We describe the core concepts in the domain first and then generalize and specialize them appropriately.

With the MS Website example, we implement a hybrid approach to define taxonomic relationships. We initiate with the concepts *application* and *product*. Considering the *consistsOf* relation, which reveals the concept encompasses a number of components that are also concepts, we especially have an application that may *consist of* some sub-applications. For example, application software of Office has some sub-applications, including OneNote, Outlook, Groove etc. Considering the *belongsTo* relation, we have a *product* that may *belong to* a certain *category*, e.g. *software, hardware, entertainment,* or *service.*

The non-taxonomic relationships can be the link types used in a relational database excluding the links between a super-set and a sub-set, such as self referencing, 1-M and M-N relationships. In the MS Website example, the primary types of non-taxonomic relationships are listed as below.

1. The `provides` relation defines the M:N relationship between concept *Manufacturer* and concepts *Product, Solution, Support,* and *News.* The `isProvided` relation is the inverse of the `provides relation`.
2. The `has` relation defines the M:N relationship between concept *Application* and concepts *Product, Solution, Support,* and *News.* The `isAppliedFor` relation is the inverse of the `has` relation.
3. The `hasPage` relation defines the M:N relationship between a concept, such as *Application* and *Product* and the concept *SemPage,* e.g. the MS Excel *application* has some Web-pages defining its generic information and features. The `isAbout` relation is the inverse of the `hasPage` relation, which means when we define a page about a certain example, that example has the page as its object property value.

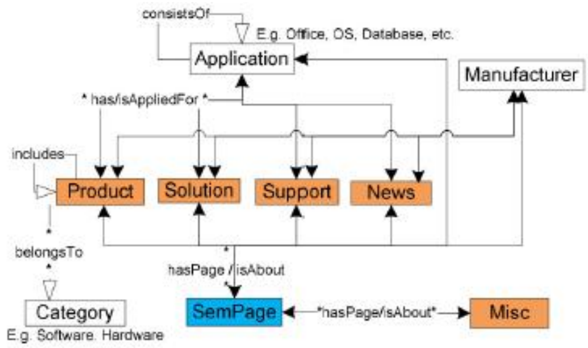

Fig 1. Ontology schema for extracted terms from MS Website

Incorporating the taxonomic and non-taxonomic relationships between the concepts, we have a conceptual data model as the ontology schema as shown in the Fig. 1.

The domain ontology is created at three levels: 1) *General level*, which influences the concepts that present the general domain terms of Web-pages and relationship definition sets; 2) *Specific level,* which influences the specific domain terms corresponding to the domain concepts and the relationship between them, e.g. terms “Office” and “Editor” are the instances of a concept Application; 3) *Web-page level*, which influences all the Web-pages within the Website and relationship between Web-page and terms; The general level is given as ontology schema due to its scalability and reusability at different levels, and the specific level and Web-page level are instances of general level. General level is preferred as schema type because of its stability and needs only little changes at the time of new Web-page evolves. Specific level needs frequent changes while the evolution of new Web-pages. With this ontology structure, new terms and Web-pages are added to specific level and Web-page level easily.

The association relation between the concept *SemPage* and other domain concepts grants the machine to interpret Web-pages or analyze what Web-pages are about. However, the issue is how to nominate huge Web-pages to domain terms properly. Hence, each term instance needs to be specified by relevant keywords. By matching keywords in terms and Web-page titles, the system can automatically assigns the Web-pages with respect to the domain terms.

SEMANTIC KNOWLEDGE REPRESENTATION MODEL OF WEB USAGE OF A WEBSITE FOR WEB-PAGE RECOMMENDTION

In previous section, we had given a model of knowledge representation, DomainOntoWP, to acquire domain knowledge of a Website for supporting Web-page recommendation. Although, they are good for acquiring domain knowledge and semantics of a Website, it is not enough for providing Web-page recommendations. In order to provide efficient Web-page recommendation, we have to integrate domain knowledge model (DomainOntoWP) with the Web usage knowledge which was acquired from Web log file using a Web usage mining technique to obtain semantic Web usage knowledge. In this study, we used an advanced Web usage mining technique namely PLWAP-Mine, to obtain the Web usage knowledge, which is in the form of frequent Web access pattern (FWAP), i.e. patterns of frequently visited Web-pages. We integrate FWAP with the domain knowledge model (DomainOntoWP) to obtain a set of frequently viewed term patterns (FVTP). This is the semantic knowledge of Web usage of a Website.

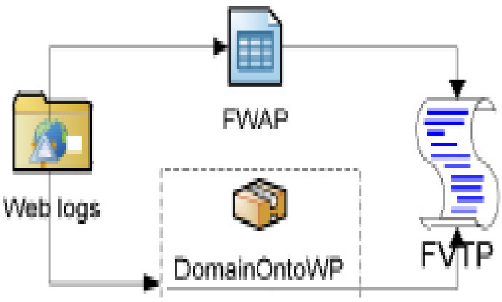

Fig 2. Discovery of Frequently Viewed Term Patterns (FVTP)

Definition 1.

Let D be a set of Web-pages, T be a set of different domain terms in the titles of the Web-Pages, where T ≡ Tman if DomainOntoWP is involved, and T ≡ Tauto if TermNetWP is involved. Let P = {P1, P2,...,Pn} be a set of FWAP, where each pattern Pi (i = [1 . . . n]) contains a sequence of Web-pages, n is the number of the patterns, and Pi = di1di2 ... dim, dik ∈ D, k = [1 . . .m], m is the number of Web-pages in the pattern.

Definition 2.

Based on Definition 6, since each page (dik) ⊆ P i (Pi ∈ P) contains a set of domain terms τ ⊂ T, we can generate a set of **FVTP F** = {ti1ti2 . . . tim : tik ∈ T ∧ i = [1 . . . n] ∧ k = [1 . . .m]}, where each domain term pattern F = ti1ti2 . . . tim is a sequence of domain terms, in which each domain term tik is a domain term of page dik in Pi.

EXPERIMENTAL EVALUATION

In order to evaluate the capability of the proposed models of knowledge representation and the recommendation strategies, we implement these models, algorithms and strategies to test their efficiency of Web-page recommendation using a public dataset. In this section, we firstly list the measures for the performance evaluation of Web-page recommendation strategies, and then design of the experiments, followed by the comparison of experimental results.

Performance Evaluation

The potency of Web-page recommendation procedures is measured in terms of two major performance metrics: *Precision* and *Satisfaction.* The definition for two performance metrics given below

Definition 3 (Precision). Let Rc be the sub-set of R, which consists of all correct recommendation rules. The Web-page recommendation precision is defined as:

$$precision = \frac{|R_c|}{|R|}.$$

Definition 4 (Satisfaction). Let Rs be the sub-set of R, which consists of all satisfied recommendation rules. The satisfaction for Web-page recommendation is defined as:

$$satisfaction = \frac{|R_s|}{|R|}.$$

DESIGN OF EXPERIMENTAL CASES

Experimental cases are designed in the aim of measuring successes of different techniques ranging from traditional Web-page recommendation approach, such as PLWAP-Mine; over the Domain ontology (Domain Onto WP) and Domain Onto WP-based semantic web usage knowledge of a Web-page.

Based on knowledge representation and recommendation strategies, we designed two experimental cases.

Case 1(R.PLWAP). Threshold value was fixed for traditional Web-page recommendation approach using the Web usage mining algorithm, i.e. PLWAP-Mine. The Web-page recommendations are generated based on it.

Case 2(R.DO). Potency of semantic enhanced Web-page recommendation integrated with domain ontology was tested.

Input:
WASD (Web access sequence dataset)
MinSup (the minimum support threshold)
N (the recommendation length)
O_1 (TermNavNet)
O_2 (DomainOntoWP)
Output:
Precision
Satisfaction
Process:
For each sequence S_i **in** *WASD*:
1: $S_i = s_1 s_2 \ldots s_k s_{k+1} \ldots s_n$
2: For each $k \in [1..n\text{-}1]$:
a. Set $curP = s_k$
b. Set $preP = s_{k-1}$
c. Given the parameters ($curP$, $preP$, O_1, O_2), generate the top-N recommended pages $recP = \{r_1, r_2, \ldots, r_M\}$ using one Web-page recommendation strategy with respect to a certain experimental case
d. If $s_{k+1} \in recP$, then increase the number of *correct* recommendation rules $|R_c|$ by 1
e. If $\exists s_i \in recP$ $(k+1 \le i \le n)$, then increase the number of *satisfied* recommendation rules $|R_s|$ by 1
f. Increase the number of recommendation rules $|R|$
Return: the *precision* and *satisfaction*, computed using Equations (5) and (6), respectively

Table 2. Algorithm for measuring Evaluation measures

The experimental cases are implemented in Java paired with Protégé 5.0.0 based on models, algorithms and strategies, and the recommendation approach which is PLWAP-Mine, and run in a Intel core i5, Windows 8.1 machine with 4GB of RAM.

A. TRAINING AND TEST DATASET

The Microsoft website (www.microsoft.com) and other similar websites (Minimum 5) were used for experimental purposes. The sample dataset was down-loaded from [http://kdd.ics.uci.edu/database-s/msweb/msweb.html](http://kdd.ics.uci.edu/databases/msweb/msweb.html). In the sample dataset, users are identified as numbers and number of Web-pages is founded by their titles and URLs. Therefore, this dataset is applicable for the experiments. The sample dataset is divided into two sub-sets, one for training and one for testing. The above two sub-sets are pre-processed in the format of web access sequence. The training and test set has 32710 and 5000 records each respectively.

CALCULATION OF EVALUATION MEASURES

We establish an algorithm to measure the performance evaluation measures for experimental cases as illustrated in table 2.

COMPARISONS OF EXPERIMENTAL RESULTS

The experimental results validate the effectiveness of semantics brought in by the models based on manually constructed domain ontology (DomainOntoWP). Regarding MinSup, The size of discovered FWAP is too big to run the algorithms when MinSup values is less than 0.3%, and it becomes too small when the value is greater than 1.0%. The experimental results are shown in the comparison graph.

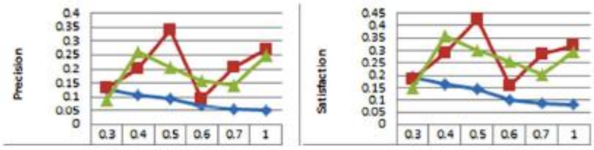

Figure 3. Precision and Satisfaction graph

The experiments were run with different MinSup values, which are 0.3% to 0.7% and the recommendation length was taken as 10. The experimental results are showing better performance when compared with the traditional approach in terms of precision and satisfaction.

CONCLUSIONS

This paper has given a new method to provide better Web-page recommendation through semantic enhancement by knowledge representation model. For knowledge representation of more than one Website, ontology based model is used which can be constructed semi-automatically namely Domain Onto WP. Integrating domain knowledge representation model with the semantic Web usage knowledge provides efficient Web-page recommendation.

Proposed method is very energetic when compared with one of the advanced Web usage mining technique method, i.e. PLWAP-Mine. Because of using Web usage knowledge and semantics of Web-page, this also solves the "new-page" problem as we mentioned in the introduction. It also yields better performance in terms of precision and satisfaction.

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