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An Ontological Framework for Research Paper Recommendation

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Abstract: Research are increasing in an exponential quantity daily which wasted alot of time and effort in finding interesting and relevant publications over the internet. In this study, we proposed a conceptual framework that can likely extract data from researcher profiles, synthesize the data and provide personalized recommendations. The conceptual framework can also learned from the researcher's response after recommendation in order to systematically adjust the result of the recommendations. This alternative approach is expected to provide more accurate and relevant research studys to the researchers more than the previous methods. This in turn may solve the problem of information overload. Future research directions are provided in the study.

Key words: Ontology, semantics, spreading activation, recommendation, research study, user profile

INTRODUCTION

Research is the process of searching through what other people may have searched with the aim of uncovering what is yet to be discovered. Internet as a great resource to everyone, help researchers to gain direct access to the most current and promising studys in their area of interest. However, the overwhelming amount of information that is available on the internet leads to the problem of information overload where researchers can easily get lost in the seemingly infinite amount of information which may be associated with their interest (Hawalah and Fasli, 2014).

Recommender systems emerged over the last decade to remediate the problem of information overload. Most work in the literature utilize the richness of user profiles to model the preferences and interests of users for better recommendations (Hawalah and Fasli, 2014; Adomavicius *et al*., 2005; Luna *et al*., 2015). As pointed out in Bouneffouf the representation of user profile includes the background (all the information related to his past experience), goals (what he wants to achieve when he search for information) and interest (the documents that he consulted directly or indirectly through its feedback by indicators of interests) of the user.

Identifying and acquiring information that helps in the construction of user profile in the field of recommender system remains a challenge. However, three ways are identified; explicit or simplistic approach (Yuan *et al*., 2010), implicit or dynamic approach (Yao *et al*., 2015) and machine learning approach (Baeza-Yates and Ribeiro-Neto, 1999).

Many techniques of modelling user profiles were presented in the literature; vector representation (Chan *et al*., 2011), connection representation (Mezghani *et al*., 2012), (ontological representation Middleton *et al*., 2004) and multidimensional representation (Lakiotaki *et al*., 2011).

Most previous works in the literature proposed using ontology to model user profile (Yu *et al*., 2007). However, the approaches typically create an instance of domain ontology and assign it to each user, thereby inevitably treating all users the same while in reality user's interests and views are inherently different.

In this study, we proposed a conceptual framework that uses ontology to model user profile, extracts both implicit and explicit data from the user, calculate the semantic relatedness between concepts and apply spreading activation technique to explore and infer more useful knowledge and finally recommend appropriate and relevant studys. This approach could likely treat each user based on the user's personal interests and views. As such, time and effort required for searching relevant publications will be reduced.

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LITERATURE REVIEW

Research study recommender systems are increasingly been developed over the last decade to solve the problem of information overload. Due to the proliferation of information over the internet, researchers not only find it difficult in keeping track of the most promising studys but also spend much of their time in extracting the relevant ones. One of the solution to this particular problem is to personalize retrieved information according to the need of the researchers.

As defined by Adomavicius *et al.* (2005) "personalization is the ability to provide content and services tailored to individuals based on knowledge about their preferences and behaviour."

In trying to improve the quality and effectiveness of the learning process (Yu *et al.*, 2007) proposed an ontology-based approach for semantic content recommendation. The framework considers knowledge about the learner, the content and the domain being learned. However, the study only considers the context of user learning goal in making recommendation. We argue that the more the contextual information is utilized in the user profile the better the recommendation. Moreover, friends seems to play significant influence in making user choices.

Blanco-Fernandez utilizes the richness of spreading activation in content based recommendations to fights the problem of overspecialization without considering the preferences of other individuals as proposed in most of the literature. Spreading activation has also been employed by Liang *et al.* (2008) to expand the scope of user profile analysis and based on the experimental result, the approach shows an improvement over the traditional keyword-based approach.

Using a three stage approach (Luna *et al.*, 2015) proposed a methodology based on ontologies for processing user profiles and representing the interaction process between the user profiles and the different context that surround him in collaborative learning environment in order to personalize learning process according to characteristics of the users.

Let research is more related to the research by Hawalah and Fasli (2014) in which they provide a model that builds contextual and personalized ontological user profiles based on the user's interest and context information. However, their research is non-specific to any domain and it does not evaluate the response of users after the recommendation. In this research, we concentrate on research study domain in order to provide an easy way of gathering related studys to the researchers.

PROPOSED CONCEPTUAL FRAMEWORK

The quality of ontology lies in its capability to produce a clearly and well defined conceptual description of the relationships between concepts in a particular domain. In our proposed conceptual framework, we used three ontologies: researcher ontology, reference ontology and research study ontology.

The framework illustrated in Fig. 1 utilizes the researcher and research study ontologies to recommend relevant research studys to the researcher after synthesizing the extracted information. The following sections provide the details of each modules in the proposed conceptual framework.

Information extraction: In this phase data is extracted both explicitly through the user interface and implicitly through the researcher ontology. This ontology utilizes the richness of past logs (which may contain the contextual information that motivate the user) and user profiles (usually the basic information that do not change over a short period of time such aslong-term interest) to infer the actual taste and state of the user.

Data is also extracted from the researcher's friends in the social network, we try to analyze how strong or how weak their association is, in order to examine and search for researchers who have similar research interest or backgrounds. The final output of this phase is a set of ontological concepts that represent state of the researcher.

Information synthetization: At the end of extraction phase we will have a set of researcher's view of how different contextual interests are linked together with respect to our reference ontology. Using such views, we can capture the hidden semantic information and relationships between all researcher interests. The hidden semantic relatedness between concepts will not only help us to discover the studys that a researcher may be interested in but also why he is interested, we then apply the spreading activation technique to infer more concepts that a researcher might probably be interested in.

Semantic analysis: We select the node in the reference ontology that is more related to the researcher interests to infer the semantic associations between related concepts based on the strategies presented in (Hawalah and Fasli, 2014). The main purpose is to exploit the richness of the ontology in providing a more accurate relatedness measure between two concepts. We then calculate the semantic relatedness between any two concepts based on the following rules.

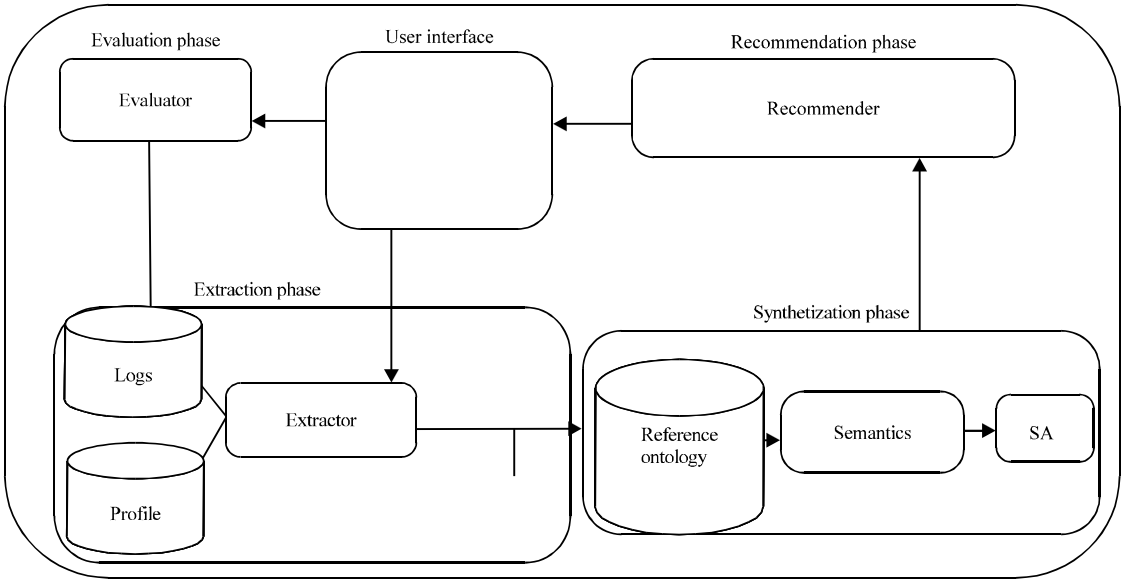

Fig. 1: Proposed conceptual framework

Identity rule (rule 1): The relatedness between two identical concepts where the distance between them is zero has the highest possible value of relations.

Non-negative rule (rule 2): The relatedness between two concepts Px and Py is non-negative and range between [0, 1] (Maguitman *et al*., 2005; Sussna, 1993).

Minimal distance rule (rule 3): The lower the distance between two concepts Px and Py the better the relations. i.e their associative relatedness is higher if they are closer and lower if they are further (Sussna, 1993).

Depth rule (rule 4): The deeper the concepts in an ontology the more closely related and the higher the concepts in an ontology the less related (Sussna, 1993).

Transitivity rule (rule 5): The transitivity rule states that if a concept Px has sub-concepts, then Px is to some extent related to all of its descendants (Maguitman *et al*., 2005).

Based on the above rules, we then compute the semantic relatedness between any two concepts as presented by Hawalah and Fasli (2014).

Spreading activation: Spreading activation technique is a computational mechanism that is used to explore and infer the useful knowledge in a network. As presented in most of the literature such as by Crestani (1997), the technique cannot explore and infer the hidden knowledge in complex ontologies because it only recognize the direct and not the semantic relationship between concepts. Also, the weight that represent relationship between the concepts is usually static and therefore might not represent the dynamicity of user preferences.

In this conceptual framework, we proposed a way in which the assigned weights between concepts can learn the researcher dynamic preferences automatically from his feedback after recommendation and dynamically adapt the spreading process.

Evaluation: We hope to evaluate the interest of the researcher by critically detecting his performed actions after the recommendation result. This detection will be done implicitly using the indicators appeared in Bouneffouf. Based on the outcomes of the detection, we update the researcher logs and then adjust the subsequent recommendations.

Precision, recall and F1 are the three most commonly accepted evaluation measures for evaluating the effectiveness of recommendation model (Bobadilla *et al*., 2013).

For evaluation purpose, these metrics will be applied to measure the ability of the proposed conceptual framework to predict and recommend personalized research studys to the researchers.

CONCLUSION

In this study, we propose a framework that will extract data from researcher profiles, perform semantic analysis on the data, applies spreading activation technique and

provides personalized recommendations. This novel approach if implemented is hoped to provide a better, more accurate and relevant research studys to the researchers and in turn solve the problem of information overload. In future we hope to develop an application that will implement the proposed conceptual framework. We decide to use the work by Hawalah and Fasli (2014) as our benchmark for evaluation purpose because our work is an enhancement to it.

RECOMMENDATIONS

After spreading activationis applied over the reference ontology, all the relevant studies with their interest values will be obtained and finally the recommender will then recommend the top N concepts with the highest activation values to the researcher through the user interface.

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