Competency Graphs for Intelligent Tutoring System

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Abstract: Throughout the later part of the twentieth century, significant research efforts have been devoted into the area of intelligent tutoring system. While small-scale implementations of various systems have achieved successes, no system to-date has been able to achieve large-scale deployment. While the advance of networking and hypertext technologies in recent decades have seemingly introduced new hopes and promises, developments and advances in computer assisted learning have been weighted heavily on content management, organization and standardization. This paper attempts to propose a number of possible research directions related to a graph-based knowledge representation model call Conceptual Prerequisite Map that will be applicable for modeling knowledge, content, students as well as organizational knowledge needs.

Keywords: Intelligent Tutoring System, Adaptive Hypermedia, Knowledge Modeling

Introduction

This paper attempts to propose a number of possible research directions related to a graph-based knowledge representation model call *Conceptual Prerequisite Map* that will be applicable for modeling knowledge, content, students as well as organizational knowledge needs. Instead of focusing on the algorithms behind the user profiling or adaptivity, studies will be conduct to utilize existing or new graph analysis techniques to answer some of the challenges encountered by developers of intelligence tutoring systems.

1. Knowledge as Conceptual Prerequisite Maps

As discussed in the previous section, complexity of the knowledge representation models varies in a very large degree. The differences in complexity mainly attribute to the different aims the systems were trying to achieve as well as the underlying pedagogical models adopted.

To allow intuitive creation of concepts by subject matter experts, and to ensure maximum adaptability of the algorithms to be investigated, the author decided to model knowledge base on a basic form as directed acyclic graphs (DAG) named *Conceptual Prerequisite Maps (CPM)*. Only two elements are presented in a CPM. The nodes of the CPM represent knowledge or concepts, while the arcs present “is prerequisite of” relations of one concept to another. The formal definition of a CPM is as follows:

Definition: A Conceptual Prerequisite Map (CPM) is a DAG represented as *G(C,P,f)* where *C* is a set of concepts represented as vertices, *P* a set of "is prerequisite of" relationships represented as edges, and *f* being an ordered mapping *f*: $P \rightarrow C \times C$.

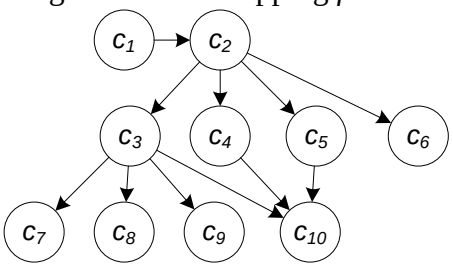

Figure 1. CPM of 10 concepts

CPM can be extended to model student's level of mastery of the concepts in concern. S*killometers*, a set of scalar values, could be associated with individual concepts representing the student's level of mastery. The formal definition of the student model is given below:

Definition: A Conceptual Prerequisite Map based Student Model (CPM-SM) is an extension of a CPM represented as *S(CPM,L)* where the skillometers *L* is a set of scalar values $\{l_1, l_2, \ldots, l_n\}$ exhibiting a one to one relationship with each of the concepts within the set $\{c_1, c_2, \ldots, c_n\}$ in *CPM*.

With the increasing awareness of business intelligence and knowledge management, it is becoming more important to model and to analyze knowledge in an organizational level. The availability of an organizational knowledge model would allow organization to specify organizational needs of knowledge that are related to its essential operations as well as forecasting needs to suit future development. Specifically, organization models could be defined as follows:

Definition: A Conceptual Prerequisite Map based Organizational Model (CPM-OM) is an extension of a CPM represented as *S(CPM,O,W)* where the skillometers *O* and weights *W* are a sets of scalar values $\{o_1, o_2, \ldots, o_n\}$ and $\{w_1, w_2, \ldots, w_n\}$ exhibiting a one to one relationship with each of the concepts within the set $\{c_1, c_2, \ldots, c_n\}$ in *CPM*.

Similar the CPM-SM, skillometers denotes the organization's level of mastery of the concepts. The weights, on the other hand, indicate the amount of human resource required to master such concepts.

2. Conclusion

With the DAG representation of CPM, CPM-SM and CPM-OM, the author believes that future algorithms based on these models could potentially be applicable for other knowledge models with various degrees of complexities. The study of ontology analysis allows better development and dissemination of ontology for promoting wider adoption of ITS as common teaching practices. Determination of learning goals derivation of learning plans could further enhance students' learning experience by determining customized educational goals for students with different needs. Discovery of trends in student models allows teachers to better comprehend the states of students' learning and is particularly important for eLearning courses where there is considerably less face-to-face interaction between teachers and students. Lastly, analysis of organizational needs allows organization to derive better plans for staff developments to align with the organization's present challenges and future developments.