Automatic Construction of Concept Maps

Belinda Ng'asia Wafula

June 20, 2006

1   Introduction

A *concept map* is a graphical tool that allows the user to visualize his/her own knowledge and express it in comprehendible form [2]. In a well constructed map, the concepts and linking phrases can be read as a statement. Concept maps of the same topic, constructed by different users vary as the maps depend on the user's knowledge on the topic concerned [5].

In educational environments, concept maps are used to aid students to understand concepts as the students are encouraged to actively construct concept and relationships based on certain topics. In addition, concept maps can be used in extracting information from text books, laboratory, studio and/or other fields of studies, reading articles in newspapers and journals and planning a paper or exposition [4]. Concept maps facilitate creative thinking, enabling the user to make relationships between concepts. Apart from being use in educational environments, concept maps can be used in businesses. Some of the uses include note taking, summarizing, idea generating and knowledge creation.[4]

Effective concept maps can be deemed as maps that are easily understood by a second party. Constructing effective concept maps is sometimes considered as a complex task as the users may encounter a difficulties in finding the resources that are relevant to the topic at hand. The users may also find it hard to remember some concepts of a certain topic. To reduce these problems, applications have been developed to help users to retrieve relevant information and resources that may be required in the specific topic. Some applications may work in such a way that they display concepts that are closely related to the topic at hand. This helps the user to recall and learn about a topic.

Concept maps in general are usually evaluated to reveal the user's understanding or misunderstanding of concepts by a usera topic. This is done by comparing the user's concept maps to the instructor's (expert's) concept map. To be able to do this, a reference map, either constructed by an expert or automatically from a text, is needed.

Concept maps can be created automatically or semi-automatically. Automatic creation of concept maps aids to reduce biasness. In automatic construction, concept maps are created automatically using information, for instance, a text document or the internet. In automatic construction, the user's assistance is not required as the process learns the concept maps automatically from the resources. On the other hand, in semi-automatic construction of concept maps, some assistance is required from the user. For example, the system retrieves information or suggests concepts or relationships between concepts. The completion of the concept map depends on the user.

This paper is organized as follows: in Section 2, methods and tools used in semi-automatic construction of concept maps will be discussed. A method of constructing concept maps automatically is discussed in Section 3. Section 4 will focus on discussion on problems related to automatic construction of concept maps and suggest a new method. The final conclusions will be drawn in Section 5.

2   Semi-automatic concept map construction

In semi-automatic construction of concept maps, some assistance is required from the user. For instance, the system can retrieve information or suggest concepts or relations between concepts. The user then uses the information provided by the system to complete the concept map.

Self organizing concept maps (SOCOMs) [3] is based on neural network model. SOCOMs can arrange concepts or words in a map space using Kohonens self organizing map algorithm. SOCOMs employ the idea of k-nearest neighbour (k-NN) as they do not require all the detailed information among the concepts or words. There are two kinds of SOCOMs: *metric* and*non-metric* SOCOMs. Metric SOCOMs use the information about the metric data such as similarity while the non-metric SOCOMs use the information about the rank order of similarity among the items.

Cmap [1] is a tool that constructs concept maps semi automatically. Cmap supports generation as well as modification of concepts maps while allowing integration of other media resources. In regard to Cmap, research has been done aimed at developing "intelligent suggestors" for the users to automatically provide information during the process of creating concept maps [1]. One property of the Cmap tool is automatic generation of queries from the concept map. The system should generate short queries while focussing on important terms in the concept map. Cmap also searches the we for relevant information based on the cconcept maps to further substantiate the concept map being generated.

An experiment involving 20 subjects from Indiana University was conducted using concept maps specifically designed to investigate structural influences by varying factors such as the degree of connectivity or the distance to the root node of certain concepts in the map[1]. The concepts and the relationships between the concepts were marked by random letters. This was done to ensure that the structural influences were independent from the map content. The subjects were asked to indicate the most important concepts after being presented with a pair of concepts. If, according to the subject, the concepts were equally important, the subjects were asked to indicate that too. The models were then fitted to the subjects' preferences using a hill-climbing algorithm. The results showed that there was a low trend in the structural effects on concept importance. Firstly, authority nodes i.e, the nodes with incoming connections were considered more important than hub nodes i.e the nodes with outgoing connections. Secondly, nodes close to the root node were considered more important than the nodes more distant from the root node. These results enabled to model structural influences on concept importance when selecting terms from a concept map to include a search engine query, by summing the weights of the concepts in which the term occurs and using terms with the highest weights as query terms.

3   Automatic concept map construction

Two phase concept map construction (TP-CMC) [5] is an algorithm to automatically construct a concept map of a course using past testing records. The first phase of the algorithm involves grade fuzzy association rule mining and the second phase involves concept map construction. TP-CMC contains a table, test-item concept mapping table, which records the related learning concepts of each test item in a quiz. The main idea behind this approach is

to identify pre-requisite relationships among concepts in test items in a quiz and construct a concept map based on these relationships.

Grade fuzzy association rule mining phase
Grade fuzzy association rule mining phase consists of three steps [5]:

1. Grade fuzzification: fuzzy concept is applied to transform numeric grade data into symbolic notation e.g "low", "middle" and "high"

2. Anomaly diagnosis: discrimination of an item is used to set good test items from the bad test items. This phase aims to refine the input data by reducing the redundant data not to be used in the concept map. If the discrimination of the test is too low (most students get high scores or low scores) the item is considered redundant. Fuzzy item analysis for norm-referencing (FIA-NR) is used to remove redundancy in the input data.

3. Fuzzy data mining: in this step, the system checks the existence of a relationship between two test items. Look ahead fuzzy association rule mining algorithm is used to find fuzzy association between the test items

Concept map construction
The concept map construction phase involves the use of association rules to analyze the pre-requisite relationships between learning concepts in quizzes. Concept map construction algorithm is used to find corresponding learning concepts of concept sets to construct concept maps. The proposed algorithm is based on the test-item concept mapping table and pre-requisite relationships. Finally, the cycle detection process is used to detect and delete unwanted pre-requisite relationships that form a cycle between concepts.

4 Discussion

In general, it is difficult for an individual to construct a "correct" concept map as the concept maps vary from one individual to another. The variation of the concept maps of the same subject can be accounted for by the individual's understanding and perspective of the subject concerned. Automatic or semi-automatic construction of concept maps reduced this "biasness" that might be caused by the individual in an attempt to create a "correct" concept map. Methods for constructing concept maps automatically and semi-automatically have been discussed in the previous sections. Both methods

involve a mathematical understanding and might be incomprehensible for one without solid background in mathematic.

Concept maps can be constructed with text as the main resource. A document is often divided into paragraphs, each paragraph representing a slightly different concept from the previous paragraph. Each paragraph is often introduced by the first sentence stating what the paragraph is about. In automatic construction of concept maps, using text as a resource, the application could take one paragraph at a time and examine it. It could then extract the common concepts or words from the paragraph in the document. In creating the relationships between these concepts, the application could extract the words that link the concepts together. The concept could then be linked to form the relationships among the concepts suggested by the application.

5 Conclusions

In this paper, we have considered two approaches for constructing concept maps: automatic and semi-automatic. In addition, we have discussed a way of how to implement automatic construction of concept maps.

Semi-automatic construction of concept maps requires some assistance from the user. Semi-automatic construction of concept maps can involve processes such as retrieving information for the generation of concept maps or suggesting concepts or relations between concepts. The user has to complete the concept map.

In automatic construction of concept maps, the whole map is constructed automatically. The system retrieves information from a source, for example text or the web and constructs the concept map. We have suggested a system that constructs maps from a text as the main source of information. The system could extract concepts and relationships between concepts from the different paragraphs of the text and construct concept maps.The system could create the concept map automatically.

References

[1] A. J. Caas, J. D. Novak, and F. M. Gonzlez. "googling" from a concept map: Towards automatic concept-map-based. In *Concept Maps: Theory, Methodology, Technology. Proceedings of the First Int. Conference on Concept Mapping*, Pamlona, Spain, 2004.

[2] J. Cañas, Carff, Hill, M. Carvalho, Arguedas, C. Eskridge, Lott, and Carvajal. Concept maps: Integrating knowledge and information visualization. In Sigmar-Olaf Tergan and Tanja Keller, editors, *Knowledge and Information Visualization*, volume 3426 of *Lecture Notes in Computer Science*, pages 205–219. Springer, 2005.

[3] M. Hagiwara. Self-organizing concept maps. In *1995 IEEE International Conference on Systems, Man and Cybernetics. Intelligent Systems for the 21st Century*, volume 1, pages 447–51, New York, NY, USA, 1995. IEEE.

[4] D. Novak and Gowin. *Learning how to learn.* Cambridge University Press, Cambridge, 1984.

[5] Pei-Chi Sue, Jui-Feng Weng, Jun-Ming Su, and Shian-Shyong Tseng. A new approach for constructing the concept map. In Kinshuk, Chee-Kit Looi, Erkki Sutinen, Demetrios G. Sampson, Ignacio Aedo, Lorna Uden, and Esko Kähkönen, editors, *ICALT*. IEEE Computer Society, 2004.