ADAPTIVE CONCEPT MAPS: ISSUES ON DESIGN AND NAVIGATION

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Abstract. This paper presents some issues on design and navigation in concept maps. It shows a set of visual features based on proposals from information visualization and it describes the navigation tasks a user could perform on a concept map. As a result of this, the article provides the first step in the construction of a visual aids language for concept map exploration.

1   Introduction

Concept mapping has its origins in 1972, when Novak tried to represent the student's knowledge based on personal interviews. In the late 1990's a team mainly composed by Novak and Cañas developed the well known *CmapTools*, a software application for concept mapping. Since that date, many similar applications have been developed in order to ease the creation of concept maps. However, due to most these tools for concept mapping focus on the creation process to the detriment of the exploration process, they lack of aids for navigating the concept map.

On the other hand, a set of concept maps has been defined as a *knowledge map* (Crampes, Ranwez et al., 2006) or as a *knowledge model* (Cañas et al., 2005). Thus, knowledge map navigation is the process of exploring and/or modifying a set of concept maps. Since most of the concept mapping software tools don't deal with the dynamic appearance of nodes, links and resources, it is difficult to explore a concept map with thousands of nodes and links. The dilemma mentioned by (Waterworth, 1994) commenting Norman's book: "*How can artifacts created to serve the function of reducing mental effort be designed to encourage that very effort?*", it serves as an starting point and it poses some questions about concept mapping design and navigation: how to facilitate navigation once a knowledge map has been created and how do visualization and interaction influence in the learning process?. Collin Ware stresses the importance of navigation and the effectiveness of a particular interactive visual display (Ware C., 1994): "*the cognitive cost of navigation in visual data spaces well be critical in determining the effectiveness of a particular interactive visual display.*"

Next, we mention examples of software tools that deal with navigation aids. These systems do not explicitly take in consideration the proposals from information visualization, but somehow it presents visual artifacts that help the user in the navigation process:

- (Coffey, 2005) proposes a system called LEO, which adds some features to the exploration of a concept map. The main visual techniques presented in the system are: the use of the gray color in nodes for diminishing importance, the possibility of visualizing the content of a node by means of an expanded node and the floating window that presents a reduced view of the entire organizer map.

- (Crampes et al., 2006) defines a knowledge map as a map that may contain not only concepts and relations, but also thousands of instantiated propositions. They propose a *Domain-View-Controller* for adapting contents: the *Controller* takes charge of the user's interactions coming from the mouse and the keyboard, the *Model* is the part of the code that transforms the internal state of the data according to the events sent by the *Controller* and the *View* manages different graphical objects that present the data on the interface.

- (Brusilowsky & Peylo, 2003) proposed the *adaptive and intelligent web-based educational systems* as systems that combine resources from the web for further adapting the content and presentation to the end user, making easier the exploration of contents and thus enhancing user navigation.

2   Issues on Designing Concept Maps

In spite of many visual design guidelines, a central principle in information visualization might be summarized in the Shneiderman's Visual Information Seeking *Mantra* (Shneiderman, B., 1996): "*Overview first, zoom and filter, then details on demand*". If we wish to follow this principle in order to visualize a large combination of concept maps, we firstly need to show a clear overview of the entire structure of the concepts and arcs. We propose to show initially the knowledge map with the labeled nodes replaced by circles, getting the labeled text

associated by means of clicking it or just placing the mouse over the node. In this way, the user is encouraged to use the mouse as a pointer of his/her thought.

In order to show a description of the general way in which entities and relationships can be expressed using node-link diagrams, next, in Table 1, the visual artifacts and their semantic are presented. The first three rows of the table are taken from the book (Ware C., 1994). As it is claimed there, these are conjectured to be good display mappings, although none has been proved through scientific study to be the best; the elements in the list has a perceptual, rather than conventional, basis for the way in conveys meaning. The last two rows and the last to columns show our proposal for knowledge map visualization and navigation.
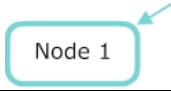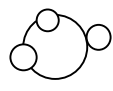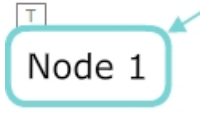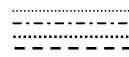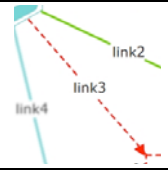
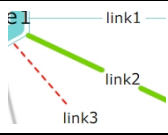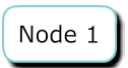| Graphical Code	Visual Instantiation	Semantics	Our Proposal	Our Semantics´ Proposal
1. Closed contour		Entity, Object, Node.		Node
2. Shape of closed region		Entity type.		Node before clicked
3. Color of enclosed region		Entity type		Number of clicks
4. Size of enclosed region.		Entity value. Larger = more.		Letter and contour size depends on the number of clicks and child nodes
6. Attached shapes		Attached entities, Part-of relations		Type of resource contained in a node: Text, Sound, Image, Video, Nested concept map
10. Linking line quality		Type of relationship between entities		Type of relationship between nodes
11. Linking line thickness		Strength of relationship between entities		Number of times the nodes connected by the link have been clicked
14. Blur				Lost of focus during a session
15. Shadow				The user accesses the node or it has been accessed
16. Transparency				Lost of global focus

Table 1. The visual artifacts and their semantic.

2.1   Concept Map Navigation

A common problem that knowledge and information visualization systems share is that the visualization on very large data sets is still difficult. The difficulty relies on the computer display and its size. Due to this limitation, it is complex to visualize a large data set in such a manner that the user can perceive all data elements and can understand the data structure. For easing this limitation, interactive visualizations play a key role in supporting navigation tasks.

In (Shneiderman, 1996), it is enumerated seven tasks that users could perform on the data. Complex tasks e.g. focus & context, can be described as a combination of tasks presented, in this case overview, relate and zoom. Next, in Table 2 we show how these tasks can be performed when users navigate over a knowledge map.

Tasks	Definition	Applied to knowledge map navigation
1. Overview	Gain an overview of the entire collection	Initially, nodes without labels displayed as circles. Zoom transition by means of mouse
2. Zoom	Enlarge items of interest	Click to enlarge node. Zoom transitions. Nested nodes visualization
3. Filter	Filter out uninteresting items	Contract node branch, blur and transparency
4. Details on demand	Select an item or group and get details when needed	Content and relations display
5. Relate	View relationships among items	Type of links (arcs)
6. History	Keep a history of actions to support undo, replay, and progressive refinement.	This tasks is performed through the adaptive feature
7. Extract	Take out sub-collections of data or history to save and communicate.	Selection of a set of nodes. Collaborative web environment

Table 2. A list of navigation task and its application on knowledge map navigation

From this point we start to build a conventional basis of a visual aids language for concept mapping, where the visual artifacts offer complementary information of the meaning of nodes and links and the interaction allows to navigate a knowledge map in a user-friendly way.

Next, in Figure 1, we show an example of a simple concept map design follow the suggestions mentioned above.
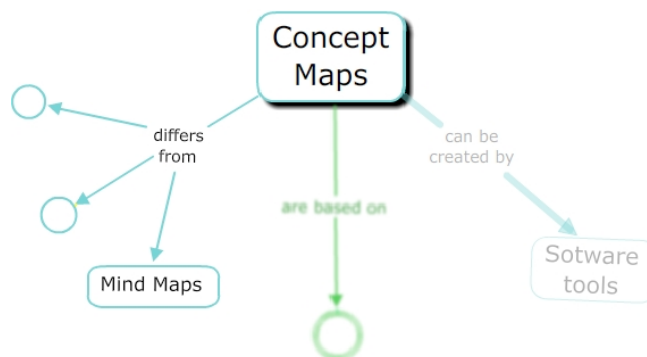
Figure 1: an example of a concept map containing nodes in its initial state, a blur node, a modified transparency node and a node with shadow.

3   Conclusions and Trends

When a user creates a concept map with a software tool like CmapTools, she/he has a set of options for the appearance of nodes and links. These visual options are basically the next: font type, font size, font color, and the properties related to the aspect of the node, as the thickness of the line, line type and line color. In this way the user chooses the design options regarding to his/her preferences. This design is static and it will be modified only by the user during the creation phase. However, once the map is finished, it might be used for personal purposes or for sharing with other people. In the latter case, the learning process of the concept map differs from the author of the map.

The above justification is the reason we propose to distinguish between an interface for the author and an interface for the end user that facilitates the exploration tasks. Moreover, it would be convenient an interface that takes into consideration the paths a user follows when she/he is exploring the knowledge map, in order to

adapt the presentation and the contents with visual artifacts. These artifacts would allow to register the paths and to suggest new ones through color, movement, transparency, shadowing techniques and/or blurring techniques.

4   Acknowledgements

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