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Visualizing Knowledge Structure for Exploratory Learning in Hyperspace

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1. Introduction

Hypermedia/hypertexts generally provide learners with hyperspace where they can explore domain concepts/knowledge in a self-directed way (Conklin 1988). Exploration often involves making cognitive efforts to construct their knowledge with the contents that they have explored. These cognitive efforts would enhance learning (Carroll et al. 1985; Kashihara et al. 1997). However, learners often fail in knowledge construction since what and why they have explored so far become unclear as the exploration progresses and to what extent learning has been carried out also becomes unclear. This is an essential problem of learning in hyperspace (Thuering, Hannemann, and Haake 1995).

The main issue addressed in this paper is how to help learners reflect on what and why they have learned in hyperspace. Current work on hypermedia/hypertext systems has provided a number of aids to be used as reflection support (Thuering, Hannemann, and Haake 1995). The representative aids are hyperspace maps or concept maps. These maps can visualize learners' exploration history as the partial structure of hyperspace/domain concepts (Gaines and Show 1995; Mukherjea, Foley, and Hudson 1995). This visualization allows them to know where they are, what they explored, and to what extent they explored. However, these maps are not so helpful since the learners do not learn the structure of hyperspace. In addition, they do not always construct the same knowledge structure as concept maps created by the designers. Reflection support consequently needs to make learners pay more attention to knowledge structure shaped in hyperspace.

This paper proposes an effective reflection support that includes visualizing knowledge structure learners would construct during exploration. The knowledge structure visualization needs to consider exploration process deeply

since it has a great influence on how to shape knowledge. In this paper, we accordingly discuss (1) how to model and catch up with exploration process and (2) how to represent knowledge structure according to exploration process.

2. Learning in Hyperspace

2.1 Exploration Process

Let us first consider exploration process in hyperspace. Hyperspace consists of nodes and links that represent the contents to be learned. Learners generally start with a learning purpose, then exploring nodes linked one another. When they explore one node, they would have a local purpose called exploration purpose to search the next node that fulfils it. We call the process of achieving an exploration purpose as primary exploration process. This is represented as a link from starting node where the exploration purpose occurs to terminal node where it is fulfilled. There are sometimes several terminal nodes linked with one starting node. Exploration purpose signifies how to develop/improve domain concepts/knowledge obtained in the starting node. We currently classify exploration purposes as shown in Table 1.

An exploration purpose produced in visiting a node is not always fulfilled in the next node. Learners may then need to keep it until they find the terminal nodes. Another exploration purpose may also occur. They would accordingly keep and achieve several exploration purposes concurrently. Exploration process can be accordingly modeled as a number of primary exploration processes.

Let us give an example where a learner uses a hyperdocument on a WWW server with a learning purpose of learning the occurrence of earthquake. In this example, he/she explores a number of nodes (WWW documents) with exploration purposes. Figure 1 gives the exploration history, which shows the sequence of the nodes visited and primary exploration processes. For example, he/she visited the node of "Animation of the mechanism" in order to rethink the description in the node of "The mechanism of occurrence of earthquake". He/she then visited the node of "Seismic wave" since he/she did not know what seismic wave was in the previous node.

2.2 Knowledge Structure

In the exploration process, learners would relate knowledge in the starting nodes with knowledge in the terminal nodes to construct knowledge structure. The knowledge structure is shaped according to the exploration purposes specifying how to relate. For instance, a learner finds the next node for supplementing an unknown term or elaborating on the description in the current node. Each exploration purpose would provide its own way of knowledge construction.

In this paper, we currently represent knowledge structure as the relationships among the starting and terminal nodes of exploration purposes. This representation provides learners not with the detailed contents of nodes that learners have explored but with the overview. In this sense, it can be viewed as map of knowledge they have constructed.

Table 1: Exploration Purposes and Visual Representations.

Exploration Purposes	Visual Representation
Supplement	Inclusion
Elaborate	Set or Part-of tree
Compare	Bidirection arrow
Justify	Vertical arrow
Rethink	Node superposition
Apply	Arrow

Starting node Terminal node

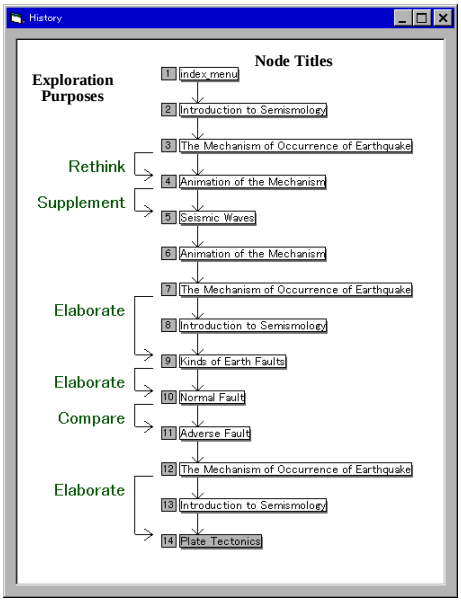

Figure 1: An Exploration History.

3. Knowledge Structure Visualization

Demonstrating a learning assistant system that is currently implemented, we next discuss the following problems to be addressed towards the knowledge structure visualization: (a) how to catch up with exploration process performed by learners and (b) how to visualize knowledge structure.

3.1 How to Catch Up with Exploration Process

It is too hard for a learning assistant system to infer exploration purposes learners set up in mind. We accordingly provide learners with a menu of exploration purposes, and require them to select one from the menu when an exploration purpose occurs. The learners are also asked when they find the terminal nodes.

Our learning assistant system provides a user interface in Figure 2. In the left window, learners can explore a hyperdocument on a WWW server with one learning purpose. When they produce an exploration purpose in visiting a node, they are required to click one corresponding to the purpose in the _Exploration Purpose Menu_ of the right window. The current node is recorded as the starting node. The clicked purpose is added to the _Exploration Purpose List_. When they find a terminal node, they are required to mouse-select the exploration purpose in the _Exploration Purpose List_ and to push the _Fulfilled_ button. The current node is then recorded as the terminal node.

Although inputting such information during exploration may be troublesome for learners, it enables them to explore more attentively. In addition, it is not so easy for learners to keep and achieve several exploration purposes. Our system accordingly displays exploration history with the primary exploration processes on demand. Figure 1 shows an example of exploration history displayed. Such history enables learners to forward exploration without cognitive overload.

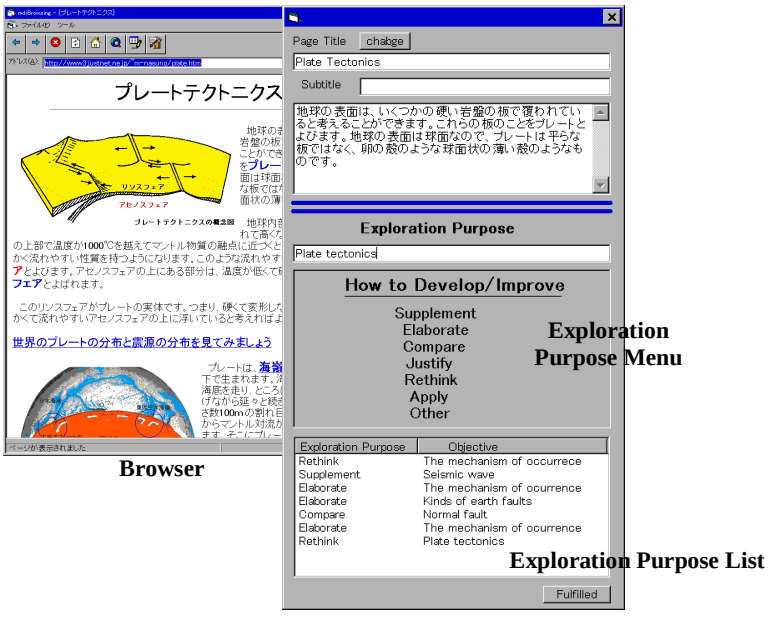

Figure 2: User Interface.

3.2 How to Visualize Knowledge Structure

In order to represent knowledge structure understandably, we provide a table shown in Table 1 that describes the correspondence of exploration purpose to

visual representation of relationship between the starting node and terminal node. Figure 3 shows an example of visualizing the knowledge structure that is transformed with the table from the exploration process in Figure 1. For example, the primary exploration process whose exploration purpose is 'Elaborate' is visualized as a set where the starting node is regarded as a total set and the terminal node is also regarded as the subset.

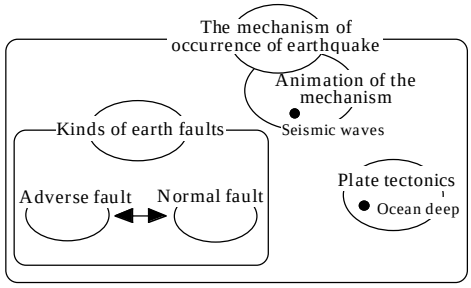

Figure 3: An Example of Knowledge Structure Visualization.

4. Conclusions

This paper has proposed an effective reflection support for exploratory learning in hyperspace. The essential point presented here is to visualize knowledge structure that learners would construct during exploration. The knowledge structure visualization would be more informative than current hyperspace maps/concept maps. This can be viewed as a challenging work on learning support in hyperspace. In the future, we need to evaluate and refine the knowledge structure visualization with the learning assistant system.

5. References

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