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An Interactive History as Reflection Support in Hyperspace

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Abstract: The main problem addressed in this paper is how to help learners reflect on knowledge that they have constructed during exploration in hyperspace. In this paper, we describe an interactive history that encourages learners to annotate and reconstruct their exploration history to reflect on what and why they have explored so far. The interactive history also generates a knowledge map proper to the annotated/reconstructed exploration history. It can be viewed as a potential support for constructive learning in hyperspace.

Introduction

Hypermedia/hypertext based learning resources generally provide learners with a hyperspace within which they can explore the domain concepts/knowledge in a self-directed way (Conklin 1988, Kashihara et al. 1997). The exploration often involves making cognitive efforts at constructing the knowledge from the contents that have been explored (Thuering, Hannemann, & Haake 1995). These cognitive efforts would enhance learning (Carroll et al. 1985). However, learners often fail in knowledge construction since what and why they have explored so far become hazy as the exploration progresses. To what extent the learning has been carried out also becomes unclear. This is a frequently experienced problem of learning in hyperspace (Nielsen 1990).

A possible resolution of this problem is to encourage learners to reflect on what they have constructed during exploration in hyperspace (Tauscher & Greenberg 1997, Thuering, Hannemann, & Haake 1995). The reflection also involves rethinking the exploration process that they have carried out since it has a great influence on their knowledge construction. In particular, exploration purposes, which mean the reasons why the learners have searched for the next node in hyperspace, play a crucial role in knowledge construction (Kashihara, Uji'i, & Toyoda 1999, Murray et al. 1999). For instance, a learner may search for the meaning of an unknown term to supplement what is learned at the current node or look for elaboration of the description given at the current node. Each exploration purpose would provide its own way to shape the knowledge structure. The reflection support accordingly needs to adapt to the exploration activities and the knowledge structure being constructed by the learners.

In this paper, we discuss a proper reflection support with a careful consideration of exploration process in hyperspace. This paper also describes an interactive history for learning with hypermedia/hypertext based learning resources on the Web. The interactive history system provides learners with their exploration history annotated with exploration purposes that have arisen during exploration. It also transforms the annotated exploration history into a visual representation called knowledge map. It spatially shows semantic relationships among WWW pages the learners have visited (Kashihara, Uji'i, & Toyoda 1999). Using the interactive history system, the learners can view and reconstruct the exploration history to rethink their exploration process that they have carried out so far. They can also view the knowledge map to reflect on what they have constructed in hyperspace. Before discussing the interactive history, let us first consider exploration process in hyperspace and how we can represent it.

Exploration in Hyperspace

In hyperspace, learners generally start exploring from one node to others by following links among the nodes with a learning purpose. The movement between the nodes is often driven by a local purpose called exploration purpose to search for the node that fulfills it. Such exploration purpose is also regarded as a sub purpose of the learning purpose. We refer to the process of fulfilling an exploration purpose as primary exploration process, which is represented as a link from the starting node where the exploration purpose arises to the terminal node where it is fulfilled.

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

Table 1: Exploration Purposes and Visual Representation.

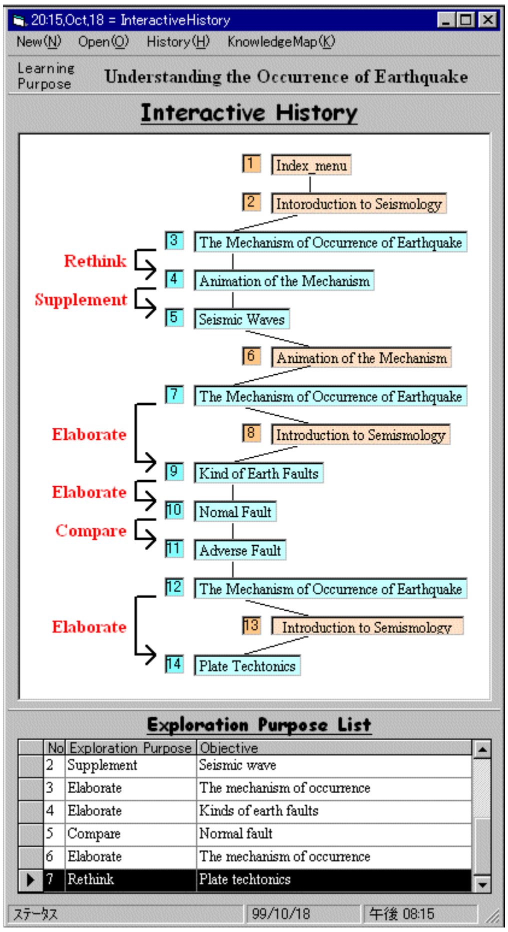

Figure 1: An Exploration History.

An exploration purpose may have several terminal nodes with one starting node. Exploration purpose, represented as verb, signifies how to develop or improve the domain concepts and knowledge learned at the starting node. We currently classify exploration purposes as shown in Table 1, which are not investigated exhaustively.

An exploration purpose arising from visiting a node is not always fulfilled in the immediately following node. In such case, learners need to retain the purpose until they find the appropriate terminal node/s. While searching for the fulfillment of the retained purpose, it is possible for other exploration purposes to arise. The need to retain several exploration purposes concurrently makes the knowledge construction more difficult to achieve.

The exploration process can be modeled as a number of primary exploration processes. Let us give an example where a learner uses a hyperdocument on a WWW server with the learning purpose of understanding the occurrence of earthquake. In this example, he/she explores a number of nodes (WWW documents) with various 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 "Animation of the Mechanism" in order to rethink the description in the node "The Mechanism of Occurrence of Earthquake". He/she then visited the node "Seismic Wave" since he/she did not know the meaning of the term used in the previous node.

Exploring hyperspace in a self-directed way, learners construct a knowledge structure that is often different from the structure of hyperspace (Thuering, Hannemann, & Haake 1995). The knowledge structure is shaped according to primary exploration processes, especially the exploration purposes. Each exploration purpose provides its own way to shape the knowledge structure (Kashihara, Uji'i, & Toyoda 1999).

Interactive History

Problems Addressed

Let us now discuss what kind of reflection support is indicated by the above consideration. There are the following important problems to be addressed towards a proper reflection support. The first issue is how to help learners retain the primary exploration processes that they have carried out. The retention may cause cognitive overload on exploration. It is also hard for computer to infer their exploration purposes, which arise in the learners' mind. These suggest that learners should be encouraged to note down the primary exploration processes.

The second problem is how to assist learners in reconstructing their exploration process. In reflecting on their exploration process, they would not only look at it but also modify/delete the primary exploration processes and add new primary exploration processes. It is accordingly necessary to provide learners with a space where they can reconstruct their exploration process after exploring hyperspace.

The third problem is how to help learners reflect on knowledge constructed during exploration. One way to resolve this is to visually represent semantic relationships among nodes included in primary exploration processes. Such representation does not obviously show the contents included in the explored nodes. However, this would be a useful map for the learners to reflect on what they have learned. We accordingly call it knowledge map.

In order to resolve the above problems, we have developed an interactive history that helps learners reflect on their exploration process and knowledge structure by means of an exploration history annotated with primary exploration processes.

Annotated Exploration History

In order to help learners note down and retain primary exploration processes during exploration, the interactive history system provides them with a user interface as shown in Figure 2. They explore hyperdocuments on a WWW server with one learning purpose in the left window. When they want to set up an exploration purpose in visiting a node, they are required to click one corresponding to the purpose in the "Exploration Purpose Input" section of the right window. The clicked purpose is added to the "Exploration Purpose List" section. The node visited currently is also recorded as the starting node of the exploration purpose.

The learners can also add the object of verb describing an exploration purpose. It means what to develop/improve in the current node whereas the exploration purpose specifies how to develop/improve. When the learners do not add this object, the system adds the title of the current node, which is the title tag in the

HTML file. When the learners find a terminal node of the exploration purpose, they are required to mouse-select the exploration purpose in the "Exploration Purpose List" section, and to push the "Fulfilled" button. The node visited currently is then recorded as the terminal node of the exploration purpose.

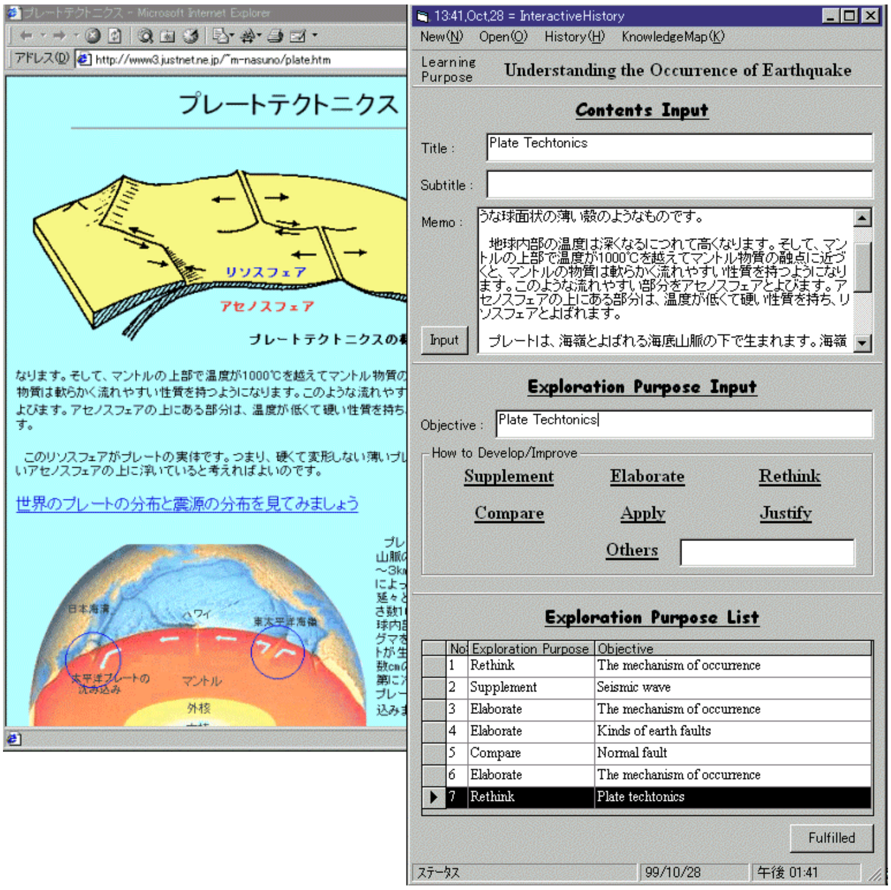

Figure 2. User Interface.

The system also provides another support for helping learners store part of the contents of the node visited currently with Cut&Paste function in the "Contents Input" section although they may not always need this support. In hyperdocuments on WWW, in addition, the title tags of the nodes do not always represent the contents of the nodes. If the learners want to change the node titles, they can input new titles in the "Contents Input" section, which new titles should represent the contents the learners explored in the nodes.

Using the information inputted from the learners, the system generates the annotated exploration history as shown in Figure 1. In the annotated history, the nodes learners visited are sequenced in order of time. The starting node of each purpose is linked with the corresponding terminal node/s. There may be some primary exploration processes without terminal nodes since they have not been found yet. They can also click the nodes in the history to review the contents information, which they have inputted with Cut&Paste function.

Learners are not always required to input the above information whenever they visit nodes. Nevertheless, inputting the information during exploration may be troublesome for learners. On the other hand, it enables the learners to make their exploration more constructive, facilitating their exploratory learning. Without inputting, they may only browse in hyperspace.

History Manipulation

Directly manipulating the annotated exploration history, learners can reconstruct their exploration process without revisiting hyperspace. Each manipulation is done by means of mouse-clicking/dragging parts of the primary exploration processes. There are three basic manipulations: deleting and changing exploration purposes/links between starting and terminal nodes, and adding new primary exploration process.

Knowledge Map

The representation of knowledge map follows the visualization scheme shown in Table 1, which shows the correspondence of an exploration purpose to a visual representation of the relationship between the starting and terminal nodes. For example, an exploration purpose to 'Elaborate' is transformed into a set that visualizes the starting node as a total set and the terminal node as the subset. Following such correspondence, the system generates a knowledge map from the annotated exploration history. The knowledge mapping is executed on learners' demand before/after manipulating the annotated exploration history.

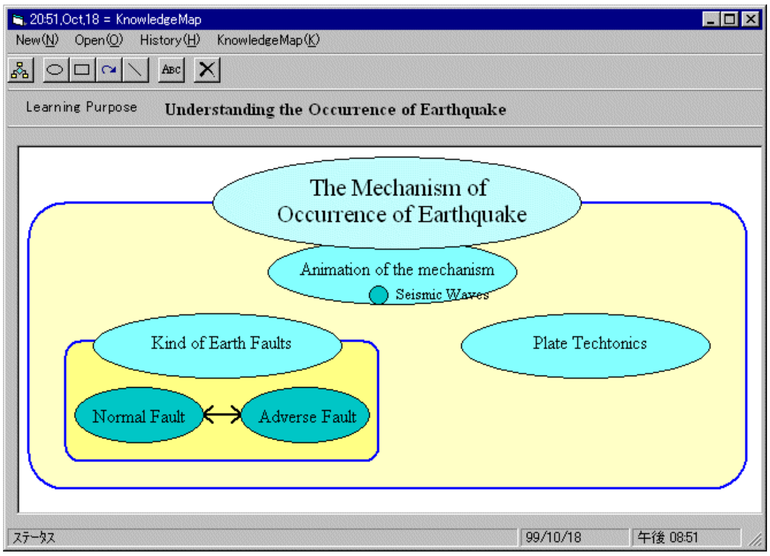

Figure 3. Knowledge Map.

Figure 3 shows an example of the knowledge map that is generated from the annotated exploration history shown in Figure 1. Viewing this map, the learner can reflect on his/her knowledge construction. For example, he/she can recall that he/she rethought the mechanism of earthquake occurrence by looking at the animation of the mechanism. He/She can also recall that he/she compared normal fault and adverse fault to elaborate the description about kind of earth faults.

Related Work

Let us next discuss the usefulness of the interactive history compared with related work on reflection support in hyperspace. As the retention support, there are several kinds of annotation systems that allow learners to take a note (Brusilovsky 1996). However, there is very little discussion of what kind of annotation should be done for the success in exploratory learning. In the interactive history, we claim that the reasons why learners search for the next nodes should be particularly noted down.

Current work on adaptive hypermedia/hypertext systems has often provided spatial maps and concept maps, which are originally used as navigational aid. Spatial maps can inform learners where they are, what they explored, and to what extent they explored (Domel 1994). However, the reasons why they visited the nodes are not clearly shown. In addition, these maps are not very helpful since learners do not need to learn the structure of hyperspace. Concept maps are more helpful for learners who have lower capability of exploring hyperspace since the direction of knowledge construction is presented to them (Gaines & Shaw 1995). However, learners who have higher capability of exploratory learning may not always construct the same knowledge structure as the structure of domain concepts that the designers of concept maps draw. In hyperspace, learners are free to identify relationships among the domain concepts visited in a self-directed exploration, and these relationships may be different to those defined in the concept maps (Thuering, Hannemann, & Haake 1995). The interactive history, on the other hand, provides them with a more proper support since it enables self-directed exploration. In addition, the reflection support can be provided even in ill-structured domains of which concept maps cannot be defined.

Conclusions

This paper has claimed that exploratory learning in hyperspace requires learners to reflect not only what but also why they have explored, and that the reflection support needs to adapt to their exploration process and knowledge structure being constructed by them.

This paper has also demonstrated the interactive history with knowledge mapping as a proper reflection support. The interactive history encourages learners to annotate and manipulate the exploration history to rethink their exploration process. It also generates a knowledge map from the annotated exploration history, which allows the learners to reflect on what they have constructed during exploration.

In the future, we need to evaluate and refine the interactive history. We would also like to classify exploration purposes in more detail and to represent learners' exploration process and knowledge structure more precisely.

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Acknowledgments

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