S. L. Wong et al. (Eds.) (2010). Proceedings of the 18th International Conference on Computers in Education. Putrajaya, Malaysia: Asia-Pacific Society for Computers in Education.

Mining Collective Knowledge for Reconstructing Learning Resource

Koichi OTA, and Akihiro KASHIHARA
Dept. of Information and Communication Engineering,
The University of Electro-Communications, Japan
kou@ice.uec.ac.jp

Abstract: There currently exist a lot of Web resources, which are useful for learning. However, it is hard for learners to learn the Web resources since the hyperspace is not always well-structured. Our approach to this issue is to mine collective knowledge from a group of learners who learned the Web resources to reconstruct the hyperspace including useful pages and links to be learned. This paper proposes a collective knowledge mining method that can extract these pages and links from learning histories gathered from the group of learners.
Keywords: Collective Knowledge, Mining, Hyperspace, Learning Resource Reconstruction

Introduction

There currently exist a lot of hypermedia/hypertext-based resources on the Web, which are useful for learning. Such Web resources generally provide learners with hyperspace, which consists of Web pages and their links. In the hyperspace, the learners can navigate the pages in a self-directed way [1][6]. Such self-directed navigation involves constructing knowledge, in which the learners would integrate the contents learned at the navigated pages [6].

However, there are the following problems with regard to hyperspace provided by a Web resource. First, the hyperspace could be navigated/learned in multiple goals. It might accordingly become difficult for learners to follow their own learning goal to learn. The hyperspace is also too huge to learn, and is not always well-structured.

Our approach to these problems is to reconstruct the hyperspace so that the learners can readily navigate and learn the pages to achieve their learning goal. This paper proposes a method of mining collective knowledge from a group of learners who have learned the same Web resource with the same goal to reconstruct the hyperspace [5]. In order to obtain such collective knowledge, this paper demonstrates a learning history mining, which can extract pages and links useful for learning, with learning histories that could be gathered from the group of learners.

1. Framework

Figure 1 shows the framework for reconstructing a Web resource with learning history mining. The learning history mining method can extract Web pages and links useful for learning from histories that could be gathered from a group of learners who learned the same Web resource with the same learning goal. Such useful pages and links can be viewed as collective knowledge of the group, which could be instructive for other learners to learn the resource with the goal. In this framework, learning histories are generated with Interactive History system (IH for short).

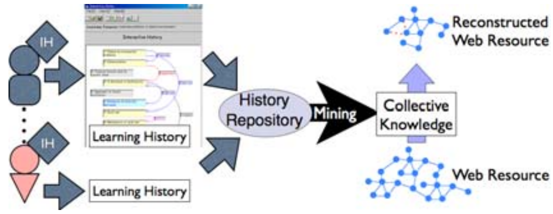


Figure 1.Framework for Web Resource Reconstruction.

The extracted pages and links compose a partial hyperspace of the Web resource as reconstructed resource, which is represented as partial hyperspace map where the partial hyperspace is highlighted on the original hyperspace map. Such representation is informative for learners to achieve their learning goal.
In the following, let us demonstrate IH and learning history mining.

1.1 Interactive History

Learners generally start navigating the Web pages for achieving a learning goal. The movement between the various pages is often driven by a local goal called navigation goal to search for the page that fulfills it. Such navigation goal is also regarded as a sub goal of the learning goal. The navigational learning process includes producing and achieving a number of navigation goals. We refer to the process of fulfilling a navigation goal as primary navigation process (PNP for short) [2]. PNP is represented as a link from the starting page where the navigation goal arises to the terminal page where it is fulfilled.
The knowledge construction process can be modeled as a number of PNPs [4]. In each PNP, learners would integrate the contents learned at the starting and terminal pages. Carrying out several PNPs, learners would construct knowledge from the contents they have integrated in each PNP.

IH monitors learners' navigation in the Web browser to generate the navigation history in the *Annotated Navigation History* window. The learners can make annotations of the PNPs, which they have carried out. (See [3] in more detail.)

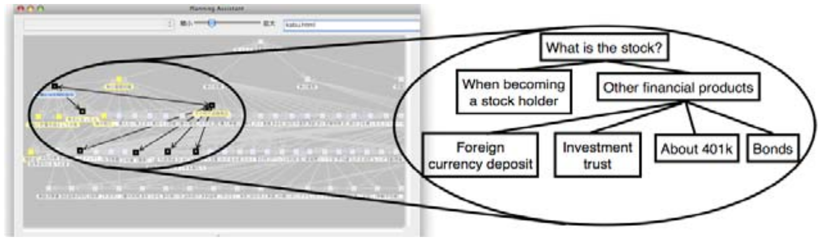
1.2 Learning History Mining and Example

In order to reconstruct a Web resource to help a learner learn, our framework prepares a repository that accumulates annotated navigation histories precedent learners generated with IH. It also generates a set of annotated navigation histories called *focused set* from the repository, which have been generated from the same Web resource as the learner uses and the same learning goal as he/she has. The focused set is inputted into learning history mining.

Each PNP in the focused set is regarded as association rule *Ps->Pt* that represents an association between two learning events in the starting and terminal pages. It means that learning event in the starting page *Ps* is concurrent with learning event in the terminal page *Pt*. In order to extract useful PNPs from the focused set, we introduce the minimum support (*Sth*) as thresholds.

Each annotated navigation history generated from each learner in the focused set is called transaction. The number of the learners in the set becomes the number of transactions. The support value is then calculated as follows:
Support (*Pi->Pj*) = the number of transactions including (*Pi->Pj*)
/ the number of transactions

The higher support value means that more learners carry out the PNP. The learning history mining method basically outputs the PNPs whose support values are higher than *Sth*.



(a) Reconstructed Hyperspace. (b) Highlighted Part of the Hyperspace Map.

Figure 2.An Example of Learning History Mining Result.

The details of the mining are as follows. First, the support value of each PNP included in the focused set is calculated. If the value is less than *Sth*, the PNP is excluded. A set of the first degree PNP is then generated. Second, the support values of the second degree PNPs to be extracted from the set are calculated, and are excluded if the values are less than *Sth*. The second degree PNPs mean the two PNPs connecting via the starting or terminal pages. A set of the second degree PNPs is the generated.

In the same way, a set of (K+1) degree PNPs is generated from a set of K degree PNPs. When the set of (K+1) degree PNPs is not generated, the history mining outputs the set of K degree PNPs as useful pages and links composing a part of the hyperspace.

Figure 2(a) shows an example of the reconstructed Web resource, which was obtained from the focused set that included learning histories generated by 16 graduate and undergraduate students who learned the Web resource (including 85 pages) about stock investment with the goal of learning the basics about the stock investment. *Sth* was 25%. The highlighted part of the hyperspace map in Figure 2(a) shows the sixth degree PNPs (including pages and links) output by the learning history mining, which is represented in detail as shown in Figure 2(b). Such reconstructed hyperspace could facilitate navigational learning process with the same learning goal.

2. Conclusion

This paper has proposed a method of reconstructing Web resources with learning history mining. The important point of this method is to extract useful pages and links from learning histories of a learner group who learned the same learning resource with the same learning goal, which can be viewed as collective knowledge.

In future, we would like to evaluate the effectiveness of the Web resource reconstruction.

Acknowledgements

The work is supported in part by Grant-in-Aid for Scientific Research (B) (No. 20300266) from the Ministry of Education, Science, and Culture of Japan.

References

[1] Hammond, N. (1993) Learning with Hypertext: Problems, Principles and Prospects. In McKnight, C., Dillon, A., and Richardson, J. (eds): *HYPERTEXT A Psychological Perspective*, 51-69.

[2] Kashihara, A., and Hasegawa, S., (2003) LearningBench: A Self-Directed Learning Environment on the Web. Proc. of ED-MEDIA2003, 1032-1039.

[3] Kashihara, A., and Hasegawa, S. (2004) Meta-Learning on the Web. Proc. of ICCE2004, 1963-1972.

[4] Kashihara, A., and Hasegawa, S. (2005) A Model of Meta-Learning for Web-based Navigational Learning. International Journal of Advanced Technology for Learning, 2, 4, ACTA Press, 198-206.

[5] Powers, J.:The Wisdom of Crowds : Why the Many Are Smarter Than the Few and How Collective Wisdom Shapes Business, Economies, Societies and Nations, 2004

[6] Thuering, M., Hannemann, J., and Haake, J. M., (1995) Hypermedia and cognition: Designing for comprehension. Communication of the ACM, 38, 8, 57-66.