Information Seeking Support System for E-Learning

Lawrence Y. Deng[1], Yung-Hui Chen[2] and Yi-Jen Liu[3]

[1] *Department Computer Science and Information Engineering, St. John's University*

[2] *Department of Computer Information and Network Engineering, Lunghwa University of Science and Technology*

[3] *Department of Computer Science and Information Engineering, Tamkang University*

Lawrence@mail.sju.edu.tw

***Abstract*—How to provide a multimedia Information Seeking Support System (ISSS) is becoming more and more imperative. In this paper, we provide a multimedia ISSS for e-learning. This system requires flexible support for the modeling of multimedia content models and also supports possible interactivity, transfer of streams multimedia data such as audio, video, text and annotations using network facilities. However, we investigated the existing standards and applications for multimedia documents models such as HTML, MHEG, SMIL, and HyTime etc. We propose a new approach for the modeling of reusable and adaptable multimedia content. We also developed a comprehensive system for advanced multimedia content production: support for recording the presentation, retrieving the content, summarizing the presentation, weaving the presentation and customizing the representation. This approach significantly impacts and supports the multimedia presentation authoring processes in terms of methodology and commercial aspects.**

***Keywords*— ISSS, E-Learning, Ontology, Content Model, Multimedia Presentation**

I. Introduction

Web-based application system must consider the user's various demands, such as the different cultural context, the learning environment as well as the professional field; the video-based multimedia ISSS for e-learning must also consider them. [1] depicted two exciting opportunities that await science and engineering in information seeking support systems. The first moves us from pre-scientific conceptual framework about information seeking to the concern of human-information interaction. The second opportunity expands the media seeking tools. [2] proposed that the following guidelines can be recommended for designing web-based asynchronous learning systems for procedural tasks. (1) When a learning system was designed for simple procedural tasks, then use of a particular multimedia combination should not affect learning performance. (2) For complex procedural tasks when learning performance was the criterion, then a combination of both audio and synchronized text or audio, video and synchronized text was the best alternative. (3) When resource utilization was the issue for a learning system for complex procedural tasks, a combination of audio, video and synchronized text was the best alternative in terms of the time spent on the learning modules and the frequency of access of the modules. (4) For simple procedural tasks, the choice of multimedia combination should not affect the system resource in terms of the amount of time spent viewing the modules or the module accessing frequency. Therefore, multimedia ISSS should not be irrevocable, and should defer to each user's special characteristic conditions and special demands. For example, the different knowledge degrees, the different network facilities as well as the time demand should give different personalization multimedia with different content that explores the effect of using different adaptive presentation strategies and the impact on learning performance when material is matched and mismatched with learning preferences. [3]. These different user's demands can be seen as adaptability for the multimedia ISSS.

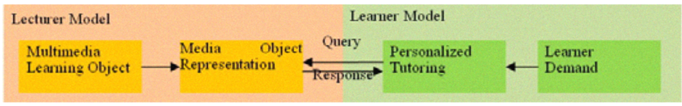

Figure 1: Multimedia ISSS model for e-learning.

Figure 1 depicts a conceptual framework for media retrieval for learning. This conceptual framework for information seeking prompts a learner with an information need to reconfigure it as a query to a media course content management system, that in turn seeks multimedia learning objects whose media object representation best match the query [1]. In our experience, a normal procedure for developing the multimedia information seeking support system usually follows the framework shown in figure 1. After deciding to develop the multimedia information seeking support system, one has to consider the requirements during presentation both in the authoring or presenting process. Usually, when one adopts these operational requirements, some presentation properties have to be defined and modeled. Once the authoring tools and presentation tools are demanded; the adaptive multimedia content model should be designed to satisfy both of them.

There were five sections in this paper. First the above section introduced the video-based multimedia ISSS. Learner's different preferences in information retrieval were unexceptional for learning. The E-learning system provided a video-based information seeking support system for people, which was natural and correct. Section 2 discussed the related fundamental theories. Related fundamental theories included ontology, adaptive learning, and the operations of multimedia ISSS model for course content. Ontology technology is a well-defined content representation methodology. An Ontology-based content representation can provide the conceptual

978-1-4244-5228-6/09/$26.00 c2009 IEEE

knowledge to describe the course content objective. Section 3 gives the formal framework and the related adaptation operation for a detailed understanding of the multimedia content model. In Section 4, some significant concepts presented our approaches and discussed the adaptation operation evaluations, this paragraph discuss our approach that try to work steadily and make solid progress. Section 5 summarizes our work and gives an outlook of ongoing and future work.

II. Ontology-based Information Representation

An easy way to comply with the conference paper formatting requirements is to use this document as a template and simply type your text into it.

An ontology is a specification of a conceptualization [10]. Ontology is a collection of key concepts and their interrelationships collectively providing an abstract view of an application domain. Ontologies play a key role in the semantic description. With the support of ontology, both user and system can communicate with each other by the shared and common understanding of a domain [11]. Protégé 3.3.1 is an ontology construction tool that is open-use, free of charge, and has well-defined features and was developed by SMI (Stanford Medical Informatics). Protégé is not only was one of the most important platforms to construct ontology but is also the most frequently adapted one [12][13]. The most special feature is that its framework is constructed by ontology concepts. It uses multi components to edit and make ontology and lead knowledge workers to construct a knowledge management system based on ontology; furthermore, users can transfer to different formats of ontology such as RDF(S), OWL, XML or directly inherit into databases like MySQL and MS SQL Server, which have better supported functions than other tools [14]. The superiorities were described by [12], [13].

Ontology is a method of conceptualization on a specific domain [15]. Protégé-3.1.1[16] was developed by SMI (Stanford Medical informatics) for construction ontology. This software has some advantages for developers: (1) Open-source software. (2) Multiple knowledge ontology support. (3) Multiple storage formats support. (4) Multiple data types support. (5) Integrated Application GUI. (6) Plug-in service support.

Based on the above features, we know that the Protégé-3.1.1 not only has a friendly GUI for developers but also supports multiple storage formats for databases. We could use the database to construct the entities or the XML description to represent the semantic facilities. In this paper, we used Protégé-3.1.1 to develop our multimedia course object ontology. There are two main methods to construct the ontology in Protégé: Open Knowledge Base Connectivity protocol (OKBC) and Web Ontology Language (OWL). Open Knowledge Base Connectivity protocol (OKBC) defines the knowledge ontology: class describes the domain concept; slot describes the abstraction of properties and relationships; facet is the restriction of the properties. Inheritance relationship existed between two classes. Subclass inherited super-class's slot and their relationship. Web Ontology Language (OWL)[17] is designed for the application to process the messages that the documentation contains. This feature is the only form presenting the content for people. OWL can represent the terminologies of the specified vocabulary and the relationship between two terminologies more clearly and definitely. In domain semantic representation, OWL provides more categories than XML, RDF or RDF-S. OWL adds many lexicons to describe the properties and classes: among them, relations between classes, cardinality, equality, richer typing of properties, characteristics of properties, and enumerated classes. On the other hand, OWL designed three extensible sub-languages for special purposes communities of implementer and users [17]:

Ontology is one theory in philosophy and is used primarily to explore knowledge characteristics of life and real objects; in artificial intelligence fields it is used to define the content of domain knowledge, express knowledge, solve communication, and commonly share problems; in information technology field it offers much assistance for research and development of E-commerce and Knowledge Management [18]. Ontology provides complete semantic models, which mean in specified domain all related entities, attributes and base knowledge among entities have sharing and reuse characteristics which could be used for solving the problems of common sharing and communication. To describe the structure of the knowledge content through ontology can accomplish the knowledge core in a specified domain and automatically learn related information, communication, accessing and even induce new knowledge, therefore, ontology is a powerful tool to construct and maintain an information system.

The Adaptive Learning System is the system that performs the regulation/adaptation for learners, and to conform the student preferences for learning. Adaptive Learning System is derived from Intelligent Tutoring Systems (ITSs) and contains: learning material, characteristic of learner, and teaching strategy to support the adaptive learning approach [19]. There are many research issues in ALS, for example: course planning, intelligent Q &A analysis, interactive problem solving support, collaborative learning support, adaptive presentation, and adaptive navigation support [20].

TABLE 1: LEARNING FEATURES ANALYSIS ABOUT ADAPTIVE/DYNAMIC/ TIME LIMITATION FOR RELATED RESEARCH AND OUR APPROACH

	Adaptive	Dynamic	Time Limitation
[22]	Yes	Yes	No
[23]	Yes	No	No
[24]	Yes	No	No
Our approach	Yes	Yes	Yes

[22] address the adaptive learning object sequencing problem in intelligent learning management systems proposing a concrete methodology based on the use of ontologies and learning object metadata. The result is a generic instructional planner capable of serving for both Adaptive and Dynamic Courseware Generation. The main advantage of this method is that it is fully automatic and can be applied independently of the knowledge domain.

[23] proposed a distinct constructivist learning framework that is distinguished from other counterparts in the following aspects: the domain learning concepts and concrete learning objects associated with it are separated; how to teach depends on the learner preference and learning status and how to learn lies on the learner's control on his/her own. Based on the domain model, they put forward an efficient searching algorithm for the presentation generation based on the proposed domain ontology model.

[24] proposes an approach that can automatically composite and recommend courses to learners with different presentation order and in accord with their intentions. First, a course MAP is constructed according to the contents of related domain ontology and web pages collected from the Internet. Then, a learner's intention is analyzed for compositing automatically suitable orders of the learning objects to form a personalized course. This proposed approach can also recommend learning objects according to a learner's preferences and others' feedback.

Table 1 presents the compare results of learning features analysis about Adaptive/Dynamic/Time Limitation for Related Researches with our approach.

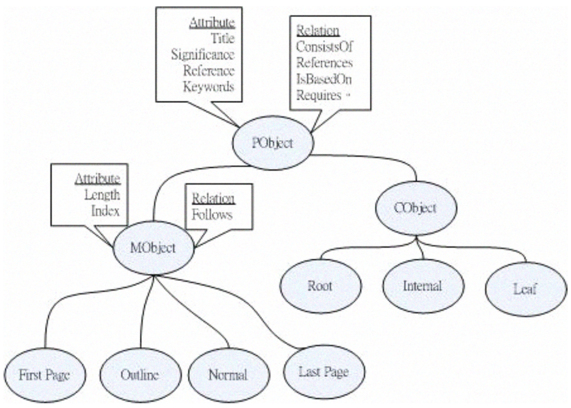

Figure 2 : Ontology for multimedia ISSS

III. ONTOLOGY-BASED ADAPTIVE MULTIMEDIA ISSS

We propose an ontology that describes the multimedia-learning object as shown in figure 2. PObject Class is employed to describe a presentation object. The presentation object is the fundamental unit to construct a learning course. PObject contains four attributes: Title, Significance, References and Keywords.

- Title – the title of the object.
- Significance – the significant weight for the object.
- References – Related References, a set of Reference entities.
- Keywords – The keywords of the Learning Object, a set of Keyword entities.

There are four relationships between PObject entities: ConsistsOf, References, IsBasedOn and Requires.

- ConsistsOf(x,y) represents that y is one of the components in PObject x.
- References(x,y) represents that x refers the content of y.
- IsBasedOn(x,y) represents that x is based on the content of y.
- Requires(x,y) represents that x exists if and only if y exists.

There are two subclasses of PObject: CObject (Concept Object) and MObject (Multimedia Object). CObject and MObject both inherit the attributes and relationships of PObject. CObject subclass describes Concept Object. Concept Object depicts table of content for learning course. MObject subclass describes Multimedia Object. Multimedia Object depicts the physical media being performed as learning material. A segment of video can be taken as a unit of multimedia object that is reformulated/ expanded as a transparency slide. MObject owns two other attributes: Length (the period of time) and Index (the ordered anchor). MObject owns another relationship: Follows. Follows(x,y) represents that x must be performed after y committed.

As shown in figure 3, Keyword Ontology describes the related keywords of presentation object. Keyword includes three attributes: Value, Significance and Appearance.

- Value - a context of the keyword.
- Significance - the significant weight for the keyword.
- Appearance – the frequency of the keyword.

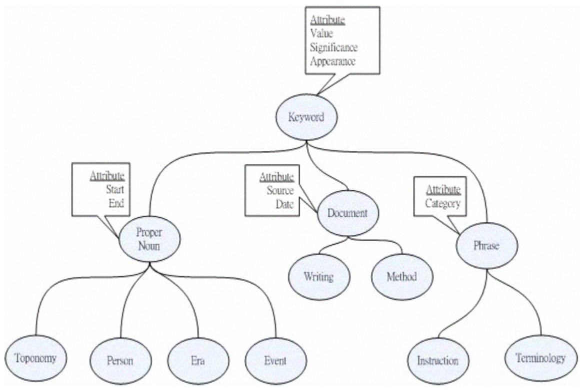

Figure 3：Keyword Ontology

Keyword contains three subclasses: Proper Noun, Document, Phrase, Proper Noun contains Toponym, Person, Era, Event,… etc.. Proper Noun owns two attributes: Start and End (valid period from start to end). Document contains two subclasses: Writing (refer to publication) and Method (refer to methodology or algorithm). Document owns two attributes: Source (such as authors), Date (Release Date). Phrase contains two subclasses: Instruction (a set of instructions) and Terminology (a set of terminologies). Phrase owns an attribute: Category (denotes the specific domain).

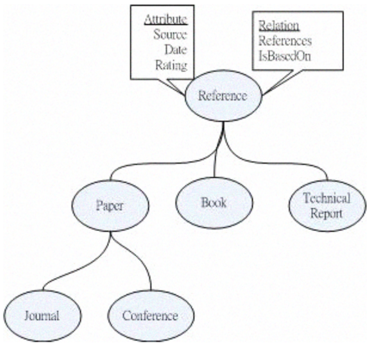

Figure 4 : Reference Ontology

As shown in Figure 4, Reference Ontology describes the related references of presentation object. Reference owns three attributes: Source (such as authors), Date (Release Date) and Rating (Impact Factor). There are two relationships between Reference entities: References and IsBasedOn.

- References(x,y) represents that x refers the content of y.
- IsBasedOn(x,y) represents that x is based on the content of y.

Reference contains three subclasses: Paper (refer to the other paper)、Book (refer to the other book) and Technical Report (refer to the other technical report).

For the most part, a multimedia presentation must be produced with a great quantity of data capacity. In most existing presentation systems, the user didn't have to be endowed with retrieving, abstracting, additional adapting (e.g. select channels, time specified), weaving or customizing facilities during the presentation. These above-mentioned presentation system facilities are user-concerned in the available system resources. In the section, we assume that multimedia content model must offer the possibility to represent alternatives and categorically to conform to the dynamic user-context.

TABLE 2: AN EXAMPLE OF LABELED CONCEPT AND KEYWORDS FOR SLIDE ITEM.

.Slide Item	S1		S3	S4	S5	S6	S7	S8	S9	S10
Concept	first	Outline	Ch1	1-1	1-2	1-2	Ch2	2-1	2-1	2-2
K1					◎					◎
K2								◎	◎	
K3								◎		◎
K4			◎	◎		◎				

Table 2 is an example of labeled concept and keywords for a slide item. As row of Concept shows, S1 and S2 are the first and outline slide respectively, and from S3 to S10 represent the subchapters' slides. As row of K1 shows, Keyword K1 appears in S5 and S10, Keyword K2 appears in S8 and S9, Keyword K3 appears in S8 and S10, and Keyword K4 appears in S3, S4 and S6. As given the above information in table 2 that represents the respective hierarchical relationship among learning objects as well as figure 5 shows. Concept Ontology represents Hierarchical Relationship among Concepts Objects. Hierarchical Relationship among Concepts Objects consists of concept objects (labeled as table of content) and arcs (relationships:1.ConsistsOf, 2.References, 3.IsBasedOn and 4.Requires).

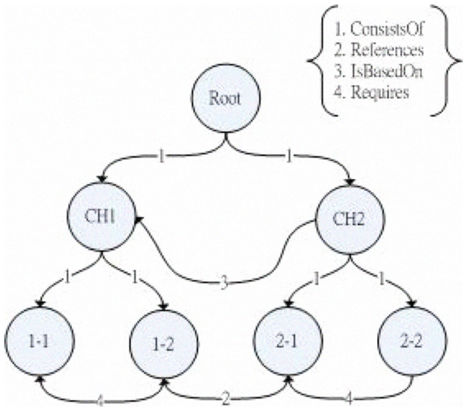

Figure 5 : Hierarchical Relationship among Concepts Objects

According to the hierarchical relationship among learning objects, we can derive a Multimedia Presentation Map, as shown in Figure 6. Multimedia Presentation Map consists of multimedia objects (slides:s1~s10), concept objects(labeled as table of contents) and arcs (relationships:1.ConsistsOf, 2.References, 3.IsBasedOn, 4.Requires and 5.Follows).

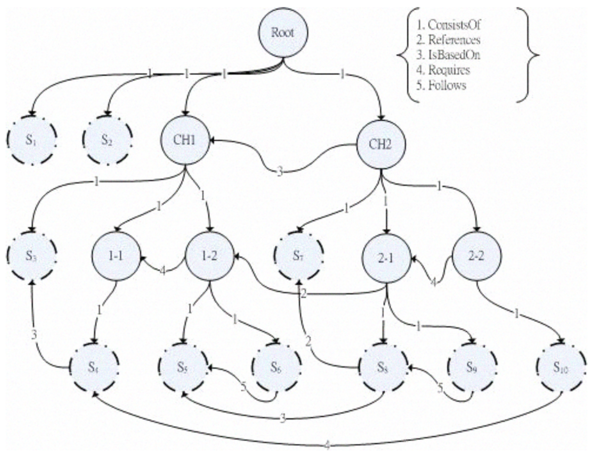

Figure 6 : Multimedia Presentation Map

According to Multimedia Presentation Map and the keywords assigned by the user, each presentation object will be equipped with a reasonable weight value. First, all presentation objects' weight values are initialized on the basis of Multimedia Presentation Map, as shown in Algorithm 1 and Figure 7. The concept objects, which have no parent node, are taken as root nodes. The weight values of root nodes are initialized as initialValue (The weight value that represents highest priority). Function setWeightValueOfChild is used to initialize the weight values of root nodes' descendant nodes recursively. The rule of initialization is as follow:

Weight_value_of_child = weight_value_of_parent + 1.(The bigger weight value represents the higher priority.)

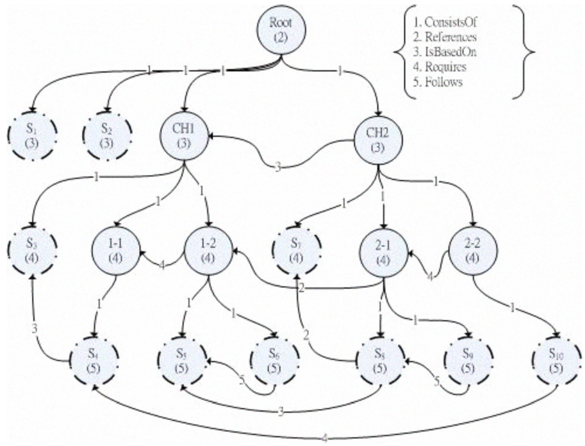

Figure 7: Initialize Weight Value

As soon as one's weight value is modified, the weight values of its children need to be modified, too. If the child's weight value is smaller than the weight value of the parent, the weight value of the child won't be modified. If the child's weight value is bigger than the weight value of the parent, the weight value of the child would rate as the weight value of the parent.

According to the various learning needs, the content of the lecture would be adapted dynamically. While a user is taking lessons in a lecture, his progress would be observed. If his performance did not meet the expectations, the system would generate the keywords that user needs most and re-build the content tree. The Content Tree provided the adaptive representation dynamically.

IV. Conclusion

In this article, we not only proposed an ontology-based well-defined description multimedia content model for adaptive multimedia content but also offered a framework of web-based multimedia ISSS for e-learning. In order to model the fundamental multimedia course content requirements clearly, we began to use ontology technology to describe the multimedia learning objects and formalized definitions for user-concerned adaptive adaptation operation. Building metadata for learning object (video-based) representation matched classic information-retrieval model that crested with the searching engine technologies now pervasive on the web.

Thus, the configuration and the operation steps of the multimedia information seeking support system are clear and definite. Finally, we considered the generated presentation with different operations for learning context. The final goal of our approach was to provide a feasible multimedia content model and the unequivocal framework to developer as guiding principle or policy. We hope that our approach can be used to the general purposed multimedia information seeking support system for distance learning, enterprise training, commercial advertisement, and others.

In this dissertation, a multimedia information seeking support system was introduced and the ways of constructing the multimedia information seeking support system for distance learning was addressed. The main contributions of this research can be summarized as follows:

- Ontology-Based Adaptive Multimedia ISSS.
- Ontology definition for video-based multimedia ISSS is presented.
- Procedures of automated Presentation map construction were illustrated.
- Multimedia Object Weighting was defined.
- Multimedia Content Tree Generation was performed.
- Adaptive presentation weaving that can satisfy the user dynamic and unpredictable context.
- Dynamic Presentation Weaving was addressed.
- System implementation

The multimedia ISSS for learning was represented as a web-based system, which integrates the different medium object (e.g. text, video, slices/images…) and encodes into the browser-based hypermedia format.

References

[1] Peter Pirolli, "Powers of 10: modeling complex ISSSs at multiple scales", IEEE Computer (March 2009), vol. 42 no 3, 33-41

[2] Arindam Bhowmicka, Mohammad T. Khasawnehb, Shannon R. Bowlingc, and K. Gramopadhyea, Brian J. Melloy, "Evaluation of alternate multimedia for web-based asynchronous learning", International Journal of Industrial Ergonomics 37 (2007) 615–629

[3] Declan Kelly, & Brendan Tangney, "Adapting to intelligence profile in an adaptive educational system", Interacting with Computers 18 (2006) 385–409

[4] Lawrence Y. Deng, Yung-Hui Chen, Yi-Jen Liu, and Yu-Chi Chang, "Ontology-Oriented SCJP Learning and Assessing System Design," in the Journal of Software (JSW2009), Vol. 4, No. 2, pp. --, , 2009. (ISSN:1796-217X) (NSC 96 - 2520 - S - 262 - 001 -)

[5] Liao, W., and LI, V. O. K., "Synchronization of Distributed Multimedia System with User Interactions", ACM Journal of Multimedia System, Vol. 6, No. 3, pp. 196-205, 1998.

[6] Prabhakaran, B. and Raghavan, S. V.,"Synchronization of distributed Models for MultimediaISSS with User Participate", ACM Journal of Multimedia System, Vol. 2, No. 2, pp.53-62, 1994.

[7] H.-C. Wang, C.-W. Hsu, Teaching-Material Design Center: An ontology-based system for customizing reusable e-materials, journal of Computers & Education 46 (2006) 458–470.

[8] Advanced Distributed Learning (2001). SCORM version 1.2 – the SCORM content aggregation model.<http:// www.adlnet.org /ADLDOCS/ Documents/ SCORM_1.2_CAM.pdf >2001 Retrieved October 1, 2003.

[9] Ing-Chau Chang & Sheng-Wen Hsieh, "ATF: an Adaptive Three-layer Framework for inter-stream synchronization of SMIL multimedia information seeking system", The Journal of Systems and Software 75 (2005) 283–303.

[10] T.R.Gruber. "A translation approach to portable ontologies". Knowledge acquisition, 5（2）:199-220, 1993.

[11] Soo, V.W., Lin, C.Y., (2001). Ontology-based information retrieval in a multi-agent system for digital library. Proceedings of the Sixth Conference on Artificial Intelligence and Applications (TAAI 2001), 241–246, Taiwan.

[12] W.E. Grosso, H. Eriksson, R.W. Fergerson, J.H. Gennari, S.W. Tu, and M.A. Musen, "Knowledge Modeling at the Millennium: the Design and Evolution of Protege-2000," SMI Technical Report, SMI-1999-0801, 1999.

[13] L.Y. Hsu, M.Y. Wu, and I.C. Chang, "Construction an Ontology-based Freeware Knowledge Sharing Web Platform with OWL," Proc. of 2005 International Conference on Open Source, Taipei Taiwan, 2005.

[14] H.C. Chien and T.H. Su, "Study and Implementation of a Learning Content Management System Search Engine for Special Education Based on Semantic Web", Master Thesis, MingHsin University of Science and Technology, HsinChu, Taiwan, 2006.

[15] Deborah L. McGuinness. Question Answering on the Semantic Web, In IEEE Intelligent Systems, 19(1):82-85, 2004.

[16] N.F. Noy and D.L. McGuinness, "Ontology Development 101:A Guide to Creating Your First Ontology," Available at http://www.ksl.stanford.edu/people/dlm/papers/ontology-tutorial-noy-mcguinness.pdf, 2000.

[17] OWL web Ontology Language Overview, http://www.w3.org/TR/2004/ REC-owl-features-20040210/

[18] S.Y. Yang, C.W. Wu, and C.S. Ho, "Using Rule Mining and Behavior Prediction Techniques in Web Information Query Processing," Proc. of the 6th Conference on Artificial Intelligence and Applications, Kaohsiung, Taiwan, 2001, pp. 574-579.

[19] Burns, H. L. and Capps, C. G. (1988) Foundations of intelligent tutoring systems: An introduction. In: M. C. Polson and J. J. Richardson (eds.): Foundations of intelligent tutoring systems. Hillsdale: Lawrence Erlbaum Associates, pp. 1-19.

[20] Brusilovsky, P. (1996) Methods and techniques of adaptive hypermedia. In P. Brusilovsky and J. Vassileva (eds.), Spec. Iss. on Adaptive Hypertext and Hypermedia, User Modeling and User-Adapted Interaction 6 (2-3), 87-129.

[21] Zhiwen Yu, Yuichi Nakamura, Daqing Zhang, Shoji Kajita and Kenji Mase, "Content Provisioning for Ubiquitous Learning", journal of PERVASIVE computing, October–December 2008 pp. 62-70.

[22] Karampiperis, P. and Sampson, D., "Adaptive Instructional Planning using Ontologies," In: Proceedings of The 4th IEEE International Conference on Advanced Learning Technologies, Joensuu, Finland, 2004, pp. 126 -130.

[23] Peng Chen, Anbo Meng, Chunhua Zhao, "Constructing Adaptive Individual Learning Environment Based on Multi-agent System," Computational Intelligence and Security Workshops, International Conference on 15-19 Dec. 2007 pp. 374-377, 2007 International Conference on Computational Intelligence and Security Workshops (CISW 2007), 2007.

[24] Kun Hua Tsai, Ti Kai Chiu, Ming Che Lee, Tzone I Wang, "Automated Course Composition and Recommendation based on a Learner Intention", The 7th IEEE International Conference on Advanced Learning Technologies (ICALT2007), Niigata, Japan.

[25] J. Ayers et al., "Synchronized Multimedia Integration Language (SMIL) 2.0, World Wide Web consortium Recommendation, Aug. 2001, http://www.w3.org/tr/2001/rec-smile20-20010807/.

[26] Dick C. A. Bulterman, "Standards SMIL 2.0", Journal of IEEE Multimedia, pp. 82-88, 2001.

[27] Ch. F. Goldfarb, "The SGML Handbook", Claredadon Press,Oxford,1991.

[28] ISO/IEC JTC1/SC29/WG12, Information Technology-Coding of Multimedia and Hypermedia Information -Part 5: Support for Base-Level Interactive Applications, ISO/IEC IS 13522-5, ISO/IEC, 1995.

[29] ISO/IEC JTC1/SC29/WG12, Information Technology -Coding of Multimedia and Hypermedia Information-Part 6: Support for Enhanced Interactive Applications, ISO/IEC IS 13522-6, ISO/IEC, 1996.

[30] ISO/IEC JTC1/SC29, Information Technology-Coding of Multimedia and Hypermedia Information-Part 1: MHEG Object Representation ISO/IEC 13522-1, ISO/IEC IS, 1997.

[31] S.R. Newcomb, N.A. Kipp, and V.T. Newcomb, ªHyTime-The Hypermedia/Time-Based Document Structuring Language, Comm. ACM, vol. 34, no. 11, Nov. 1991.

[32] ISO/IEC, Information Technology-Hypermedia/Time-Based Structuring Language (HyTime), ISO/IEC IS 10744, 1992.

[33] Dynamic HTML in Netscape Communicator, Netscape Corp., http://developer.netscape.com/docs/manuals/communicator/dynhtml, 1997.

[34] D. Raggett, A. Le Hors, and I. Jacobs, HTML 4.0 Specification W3C Recommendation, revised on 24-April-1998, W3C, URL: http://www.w3.org/TR/1998/REC-html40-19980424, Apr. 1998.

[35] B.Bos et al., Cascading Style Sheets, Level2, W3C Recommendation, W3C, May 1998, URL: http://www.w3.org/TR/REC-CSS2

[36] Microsoft® Dynamic HTML Editing Component (DHTML Editing Component) SDK, Microsoft® Inc., URL: http://www.microsoft.com/

[37] S. Boll, W. Klas, and U. Westermann, "ZYX - A Multimedia Document Model for Reuse and Adaptation of Multimedia Content", IEEE Transactions on Knowledge and Data Engineering, Vol.13, NO.3, MAY/JUNE, pp. 361-382, 2001.

[38] Herman, N. Correia, D.A. Duce, D.J. Duke, G.J. Reynolds, and J. Van Loo, "A Standard Model for Multimedia Synchronization: PREMO Synchronization Objects", in: Multimedia Systems, 6, 1998.