The Review of Adaptive Educational Hypermedia System Based on Learning Style

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***Abstract*—Accommodating learning style in adaptive educational hypermedia system (AEHS) may lead to an increased effectiveness and efficiency of the learning processes as well as teacher and learner satisfaction. The premise is that a fact that learning in classroom is less efficient, when teachers will not be able to get insight of each of the student's learning style hence, they wont be able to adapt their teaching strategies to match with the student's learning style. In order to get insight of the student's learning style in AEHS, the system must be able to recognize the learning style of the students. Current methods for recognizing learning styles are less efficient, where questionnaires or surveys were used to the students, which lead to tedium and disturbance at learning processes. By using proposed approaches which are multilayer feed forward artificial neural network (MLFF), fragment sorting, and adaptive annotation technique, this study will design and develop an AEHS.**

***Keywords*—adaptive educational hypermedia system, multi layer feed forward artificial neural network, fragment sorting,adaptive annotation.**

I. Introduction

Adaptive Hypermedia is relatively interesting research area where it is a crossroad of hypermedia and user modeling. Adaptive hypermedia consists of model of goals, preferences, and knowledge of each of the user and then uses this model to adaptively interacts with the user to match with the user needs. Educational hypermedia or can be called as adaptive educational hypermedia system (AEHS) was one of the first application of the hypermedia area and it is still becoming the most popular study in the area [1].

AEHS consists of user model and adaptation model. The user model holds informations of the student's goal, learning preference, knowledge, interest, needs and background while the adaptation model consists of method of inferencing on how to adaptively interact with the students in order to fulfill their requirements, needs and goals.

However, less attention has been paid in AEHS to the fact that people have different approaches in learning, namely that individual perceives and processes information in very different ways. Besides, individual does not only learns differently but he or she also learns different content in different learning strategy [2]. Those differences can be defined as learning styles or learning strategies. For example, a student may become an auditory learner on history but when he or she learns about mathematics subject, he or she may become a kinesthetic learner.

Moreover, between 1995 to 1996 the first intelligent and adaptive web-based educational system (AI-WBES) were developed [3]. Since then, both the advanced and intelligent features in the area have evolved and expanded. A relatively recent characteristic that has started to be taken into account is the learning style of the student [4].

According to Keefe, learning style is a combination of characteristic cognitive, affective and psychological factors that serves as relatively stable indicators of how a learner perceives, interacts with and responds to the learning environment [5].

For instance, some learners like to study by seeing (visual learning style) and they remember best what they see. Others like to study by listening (aural learning style), and so they remember best what they hear. And others prefer doing some experiments (kinesthetic learning style) rather than merely reading chemistry books and they remember best what they do. while others like to study by reading (read/write learning style), and so they remember best what they read [6].

This paper will review existing systems that are related in the area of AEHS based on learning style, elaborate the drawbacks and the advantages of those system as well as propose a new system that is expected to fill the gaps found in the existing system.

It will start in section I which is the introduction of the paper. Then it will be continued to section II with a spacious review of the existing and related works, previewing the existing methods used by those works. Next we continue to section III which is the discussion of the existing systems including the drawbacks and advantages of the techniques used. The next chapter is a future works section that contains the proposed system that is expected to be able to fill the gaps that have been found in the related works section. At last the conclusion section will conclude and summarized this paper.

II. Related Works

We will present the summary of related work in this section which is focused on the user model, domain model and adaptation model. The systems that have the most similarity with this paper are also elaborated and explained. The overall related works in this paper will be illustrated on table I.

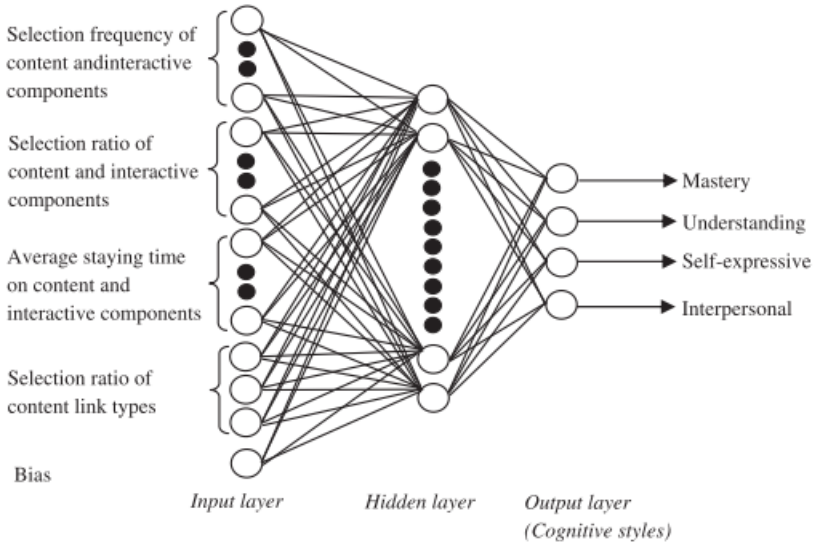

Fig. 1: the neural network architecture in student model

$$\text{Selection frequency of component } i = \text{Frequency of student's click on component } i, i = 1, n \tag{1}$$

$$\text{Selection ratio of component } i = \frac{\text{Frequency of student's click on component } i}{\text{Frequency of student's click on all components}, i} = 1, n \tag{2}$$

$$\text{Average staying time of component } i = \frac{\text{Total staying time of component } i}{\text{Frequency of student's click on component } i, i} = n \tag{3}$$

$$\text{Selection ratio of content link type } j = \frac{\text{Frequency of student's click on content link type } j}{\text{Frequency of student's click on all content link types}, j} = 1, m \tag{4}$$

The first system is a system that collects the student's browsing behavior to update the user model through a multi layer feed-forward neural network (MLFF) and then adapts the web interface based on the student's cognitive style [7]. This system uses a multi layer feed-forward neural network to recognizes the student's learning style by analyzing the student behavior and then adapts towards the user interface (which is in this case is the user interface layout) based on the corresponding student's cognitive style. While for the cognitive style model, this system applies Myers-Brings type indicator which is based on jungs theory of cognitive style (mastery, interpersonal, understanding, self-expressive) [8].

The models which are entangled are user model and adaptation model. In the user model, a MLFF is included and it consists of three layer : input layer, hidden layer and output layer. The MLFF uses five input factors in total, those are; Type one input factor represents the browsing behavior of the students by recording their selection frequencies of content and interactive component as illustrated in equation 1. In this equation, n is the number of content and interactive components used. The second input nodes represent a student's behavior for the selection ratio of one content and interactive component as illustrated in equation 2. Type three of input nodes reflect the temporal effect, which is defined as the average staying time on content and interactive components as illustrated in equation 3. Type four of input nodes represent the browsing behavior of the students in selecting course content link types as illustrated in equation 4. The last input node uses bias node in order to modify the threshold level of activation required to stimulate the output node. this neural network model is illustrated in figure 1.

The adaptation method in this system is the adaptive presentation which is in this case, is a web interface for students with different cognitive styles. For instance, the web interface or web layout for a student who has mastery cognitive style is located on a sidebar, while the graphic is located at the center of the web page. Whereas students with self-expressive cognitive style will have pretest and discussion forum located on a sidebar, while the the center of the page is filled by introduction and glossary [7]. The domain modeling in this system is not mentioned and highlighted.

The second system is developed by Elvira, named WELSA (Web-based Educational System with Learning Style Adaptation). WELSA includes the user model, domain model and adaptation model. Three main modules are included in WELSA; authoring tool, data analysis tool and a course player. WELSA logs and analyzes the student's actions in order to create an accurate learner models. Based on that model, the adaptation rule (in this case is using a rule base technique), provides individualized courses [9].

The first main modules of WELSA is WELSA authoring tool. The WELSA authoring tool uses a LAG-XLS adaptation language which is inspired from three layer model called LAG

System / Author Name	Developed	Learning Style	User Model	Adaptive Model
Jia-Jiunn et al	2012	Myers-Briggs Type Indicator	MLFF	Adaptive User Interface
WELSA	2010	Unified Learning Style Model	Rule Base	Fragment Sorting & Adaptive Annotation
INSPIRE	2003	Honey & Mumford Learning Style Model	Questionnaire	Link Ordering & Link Hiding
CS383	1999	FSLSM	Questionnaire	Fragment Sorting

TABLE I: Adaptive Educational Hypermedia System Based on Learning Style

[10]. LAG-XLS takes the advantages of dynamic reuse of LAG model and add a new research results which alleviate some problem found in LAG and simplify parts of it. The intention of developing LAG-XLS adaptation language is to create a reusable, flexible, and high level semantics of a course-ware development and fully compatible with AHA! platform [11]. Besides the adaptation language, WELSA applies Learning Object as the authored content. The learning Object is annotated by the teacher with the set of weights corresponding to its suitability of the ULSM (Unified Learning Style Model).

The second main module is the analysis tool. In this module, the system applies the ULSM model (Unified Learning Style Model), which is the integration of several learning styles (e.g., visual / verbal, abstract / concrete, serial / holistic, active experimentation / reflective observation, Individual work / team work, Intrinsic motivation / extrinsic motivation). For the identification of the ULSM preferences, WELSA uses implicit user modeling technique by analyzing the interaction between the student and the system in the form of behavioral patterns [4]. Then the analysis tool computes the ULSM preferences values by using modeling rule based on pattern values, reliability levels and learning object's weight.

The third main module is the course player (adaptation component) which is where the WELSA's adaptation model takes place. The adaptive sorting and adaptive annotation technique are used. The learning object is sorted based on its approachability to each learner. The other thing is that the system also uses adaptive annotation techniques where traffic light metaphor is used to differentiate between recommended learning objects (with highlighted green title), standard (with a black title), and not recommended(dimmed light grey title).

The third system is called CS383 [12]. CS838 uses Felder-Silverman model (FSLSM) as a learning style model, while for the learning resources, the system divided them into categories such as hypertext, audio files, graphic files, digital movies, instructor sideshows, lesson objectives, note-taking guides, quizzes , etc. The author has to give a rate for each of the learning style that correspond to the category of the learning resources (rate scale is from 0 to 100). when a student use the system, a Common Gateway Interface (CGI) loads the student profile (student's learning style which was known by issuing dedicated questionnaire) then it generates an unique ranking of each of the learning resources category by combining the information in the student's profile with the learning resource ratings. Next the CGI dynamically generates HTML page with the ordered list of the learning resources from the most to the least suitable learning resource for each of the student according to their learning style.

The fourth System is called INSPIRE [13]. It uses Honey and Mumford model which is Activist, Pragmatist, Reflector and Theorist [14]. In this system, each of the students will get the same learning resources, but their order and appearance (embedded in page or represented as link) differ for each learning style. For instance, when a theorist student logged in to the system and start learning, the learning resource labeled with Theorist will be available on the top of the page, while the rest will be followed under it. Likewise for activist student, the labeled Activist learning resource will be available on the top of the page followed by other's learning style which is less match with the logged in student's learning style.

III. Discussion

All of the four most similar and related systems in AEHS area have been described and summarized. Each of those system has their own drawbacks and advantages. We will describe those drawbacks and advantages in this section. The first is the system developed by Jia-Jiunn et al on 2012. The advantage of this system is the usage of MLFF that eliminated the drawback of rule base technique which is a mainstream technique used in the AEHS. MLFF can provides the ability on imprecise or incompletely understood data, ability to generalize and learn from specific examples, ability to be quickly updated with extra parameters, and speed in execution making them ideal for real time applications [7].

The second system is WELSA which was developed by Elvira in 2010. The advantage in WELSA system is the reusability of it's authoring tool. As it has been mentioned that WELSA uses LAG-XLS adaptation language which is fully compatible with AHA! and indeed it makes the content more reusable.

However, it is found that exist some drawbacks in WELSA that need to be improved. The first one is in the authoring tool module, WELSA uses the LAG-XLS adaptation language based on XML . even though it is reusable but it has unfriendly user interface. Moreover, the author must be a skilled author who understand the XML language to be able to create a content [15].

At the analysis tool module, WELSA uses a rule base technique to model a user. In fact, rule base technique has it's own limitation. In this case, using the rule base to model a user in AEHS is less appropriate. The reason is because in adaptive educational environment especially in learning style context, dynamics is a point that need to be concerned. Sonwalkar, mentioned that individual does not only learn differently but they also learn different content in different learning styles. For instance, a student may has a visual learning style in mathematics, but he/she may become an auditory student when he/she learns history [2]. Hence, in adaptive educational environment, the adaptation model must be able to accurately model a student's learning style regardless on what subject and

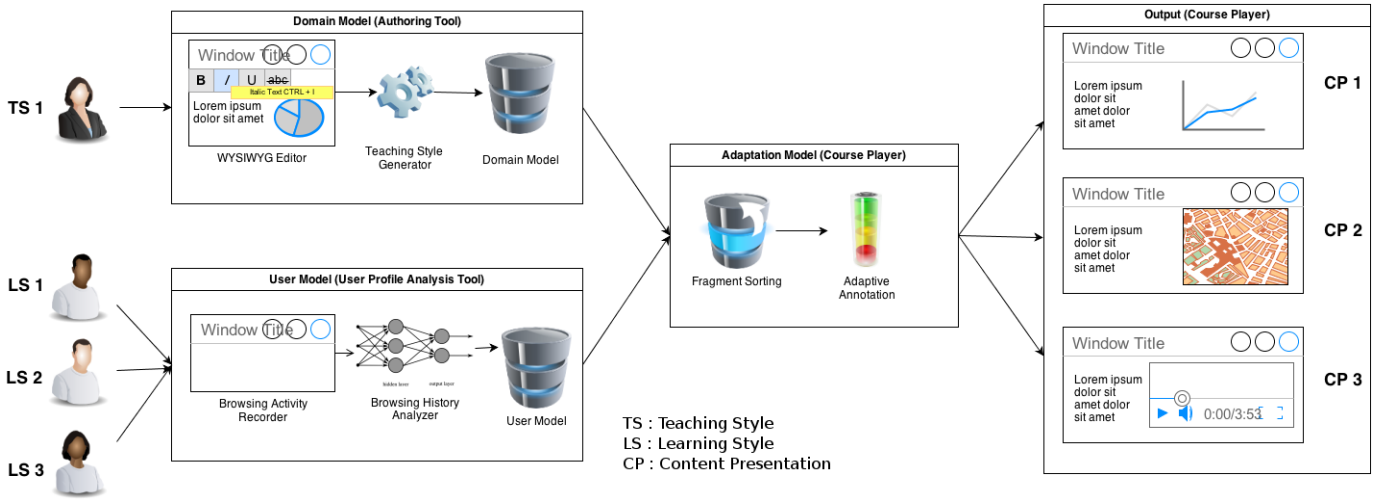

Fig. 2: ULUL-ILM Architecture

what learning object that they are studying. While rule base technique is lack of dynamics and it has an inability to learn and it is not a self updatable [16]. Hence, its a inadequate method to be applied in adaptive educational environment.

The third system is INSPIRE. in INSPIRE, the classic way of acquiring user information is still used that is a questionnaire. It is clear that taking questionnaire is not appropriate in getting the user information since it leads to cumbersome and may interfere the learning process of the student [17]. Besides, the user modeling process by using questionnaire is not so valid, since the user's learning style is keep changing as the topic changes [2].

The last system is CS383. Same as INSPIRE, CS383 uses questionnaire as a way to get the user information. Hence, it has the same drawback as INSPIRE.

IV. Future Works

After the explanation and elaboration of the drawbacks and advantage of the existing system, we will propose a web-based adaptive educational hypermedia system called ULUL-ILM which is expected to fill the gaps found on the existing systems.

ULUL-ILM is an adaptive educational hypermedia system that will consist of three main model, those are; user model, domain model and adaptation model. Each of those models are going to use the technique which is a hybridization from the systems in related works section above. Each of the techniques used on the related works section above will be analyzed and then will be selected by considering the advantages and disadvantages of each of the techniques.

ULUL-ILM will provide an easy way in authoring the content, by using the WYSIWYG rich text editor which will allow the author create, edit or delete the learning object on the fly. The authoring tool of ULUL-ILM also will bring a new approach of pedagogic expert. By using the ULUL-ILM's pedagogic expert, the author will not need to worry about the learning strategy for each of the learning object hence they will be able to concern more on the content.

A. Architecture

The overall ULUL-ILM architecture is illustrated in figure 2. ULUL-ILM is composed of three main modules, those are :

1) The authoring tool that will provide the author a real-time and easy way to create a course content (learning object) and equipped with the teaching style generator.
2) The user profile analysis tool will provide an automatic student's profile generation (implicit user modeling) by analyzing the browsing activities of the students and then automatically will recognize the student's learning style.
3) The course player will provide an automatic generation of the learning object that correspond and match with each of the student's learning style by other means that this module will provide the generation of the individualized content.

As the sake of implementation of the system, the PHP 5.4.6 will be used as a server side scripting language. As the HTTP web server, Apache/2.2.22 will be installed. While jQuery AJAX and JSON technologies are going to be utilized for the client side scripting language that will provide a user friendly interaction and asynchronous processes for the system which is very useful in recording the student's browsing activities. MySQL 5.5.29-0 will be used as a database management system.

V. Conclusion

Four systems have been elaborated in this paper as well as their drawbacks and advantages. The first system is a system developed by Jia-Jiunn et al which use MLFF as an adaptation model to adapt the web interface based on the student's cognitive style. The second one is WELSA, a system that uses rule base as an adaptation model which is lacks of dynamics. It also uses fragment sorting and adaptive annotation. Next is INSPIRE, a system that uses questionnaire as a user modeling technique which has many drawbacks and limitations as it has

explained in the previous section. Same as INSPIRE, CS383 also used a questionnaire in acquiring user informations.

The proposed system in this paper has been mentioned in previous section which is called ULUL-ILM. ULUL-ILM will be expected to fill the gaps found in the existing works such as the problems of questionnaire, rule base and the user-friendliness of the AEHS's authoring tool.

At last, a short description of the design and architecture of ULUL-ILM is also mentioned as a future work of this study.

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