Dynamic recommendations to support ‘all’ in open standard-based adaptive learning environments

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Abstract. The paper presents the theoretical framework for the research work undertaken in the Ph.D, which is based on a pervasive use of standards and specifications. Next, it introduces the research approach that is being followed on top of the Accessible and Adaptive Module (A2M) that I am developing. This module is based on a multi-agent system which combines user modeling and machine learning techniques in order to provide dynamic recommendations to the learners. To clarify the work, a sample scenario is used to describe how the A2M can be utilized to support it. Finally, the main research question is addressed and discussed at certain level of detail.

Keywords: Artificial Intelligence, Recommending systems, Multi-Agent architectures, Adaptive systems, User modeling, Machine learning, Educational standards, Metadata, Learning design, Accessibility, Open source.

1. Theoretical Framework

Personalization is a key issue to make eLearning equalize and even overcome the effectiveness of the face-to-face education. For instance, the eLearning Program [1] states that ‘it is important to ensure that e-learning products and methods are able to take into account individual needs and learning-styles, and that they are not based on a "one size fits all" philosophy, in which learners are seen as standardized "units"’. However, the current student-centred approach is inappropriate for an increasing number of students who, oddly are supposed to be benefited from the personalized training inherent to the eLearning paradigm, but in fact have to face social, physical and cognitive barriers because of their functional diversity.

The current approaches to remove the access barriers of learners with disabilities focus on the universal design. This approach promotes thinking in advance the possible needs of the users to produce a design that copes with the functional diversity (e.g. the WAI Web Content Accessibility Guidelines [2] to design the content of web interfaces or the IMS Learning Design and IMS Access For All specifications [3] to describe the learning routes for different learning needs and pedagogical models taking into account the interaction preferences and the contents metadata). However this approach has several drawbacks. First, from the experience in aLFanet project [4] regarding the
usage of the several IMS specifications, not everything can be foreseen in the design process (in spite of the huge workload and the complexity perceived by the people dealing with designing for all). Second, even making a universally accessible design that considers the interaction needs does not yet fully fulfill the accessibility needs. Users often have specific information needs that are not shared by other users [5]. In this case, adaptation of the information to the individual information needs is desired. Furthermore, both types of needs, interaction and information, may vary over time and depend on the context at hand. When learners have disabilities that affect their interaction with the learning management system (LMS), not only the learning styles and preferences, background knowledge, interest level, course structure and material metadata have to be taken into account, but also the preferred access strategy for each user, the context the user is accessing and the interaction capabilities of the device used for the communication with the system.

2. The research approach

This Ph.D focuses on dynamically identifying blocking points that occur in learning situations that have been designed in advance with the support of existing specifications (e.g. IMS family [3]), and offer recommendations to learners that help them go through these impasses. In this process, accessibility requirements are considered. In particular, pedagogical and psychological criteria, the context in which the user is accessing the information and the device used for that purpose should be considered when providing information to the learners. Within this framework, in my PhD work I am designing and implementing an Accessible and Adaptive Module (A2M) based on a multi-agent architecture with a twofold objective. On the one hand, to build user models from the learner interactions with educational data mining and machine learning techniques. On the other hand, generate dynamic contextual recommendations during the course execution based on these user models. The focus is put on the people side. It wants to be proven that the combination of these techniques makes a difference in human computer interaction for the disable. More specifically, the techniques are applied on open learning environments where learning scenarios are described in terms of standards.

The A2M follows the same approach as the Adaptation Module I designed in aLFanet [4], and includes a two level hierarchy of multi-agent systems that work autonomously to solve the adaptation tasks. The high level consists of a set of agents that interact to select the appropriate contents and services and provide recommendations to learners so that their needs and preferences are satisfied. In turn, the low level is used to learn the attributes of the models from the interaction data. A multi-agent architecture has been selected due to its flexibility, which allows for the combination of different machine learning techniques via autonomous agents that 1) provide their own solution to each learning task (it is well known that there is no single technique to be applied to a wide range of problems), and 2) support a user modeling system which updates the user model according to the users’ interactions (from those interactions, datasets are built to feed machine learning tasks defined in the user model).

The usage of open software solutions and standard-based service architectures to facilitate the reusability of models and architectures underpins this approach [6]. They provide the framework to integrate the A2M in production standard based LMS. However, in the scope of my Ph.D, I will implement an instance of these principles and
integrate it into dotLRN opensource standard based LMS [7]. Moreover, in order to
guarantee the domain independence of this approach, as well as to have access to
learners with a diverse variety of disabilities for the validation of this research, the
A2M is going to be utilized in the research projects I am currently involved, EU4ALL
(EC IST-2005-034778), ALPE (EC eTen-2005-029328) and ADAPTAPlan (Spain
TIN-2005-08945-C06-01), which are built on top or dotLRN. In this way, typical LMS
services (forums, file storage, calendar, assessment, etc.) will coexist with a new added
service to show the available recommendations, which are to be contextually and
dynamically generated by the A2M.

3. The A2M in a sample scenario

In order to clarify this approach, next I present a sample scenario and how I foresaw it
can be managed from the A2M point of view:

**Step 1.** Linda is a hearing impaired student with attention problem. She is enrolled
in an on-line course on an open source accessible standard based adaptive LMS.

**Step 2.** The course is designed using IMS-LD level B specification and includes
properties to select the appropriate learning route according to Linda’s user model.
In particular, her user model (based on IMS-AccLIP) shows that her learning style
is sensitive and that she cannot understand sign language. She prefers plain text
descriptions rather that subtitles for auditory contents.

**Step 3.** Moreover, to cope with the attention problem, a timer is set on the platform
to measure idle times and present an alert to get her attention back. Since she is
hearing impaired (but has not reported epilepsies problems) the alert is presented
as a blinking pop-up on the screen.

**Step 4.** At a certain moment in the course, Linda is blocked in the activity 3 of the
course design and cannot progress.

**Step 5.** She looks at the recommendations area on her course interface and finds
three recommendations suggested. The second one offers her the link to a learning
content that another student uploaded last week into the course file storage area
when doing his part of the course. This content has also been accessed by other
students when doing activity 3. This content fits with her format preferences.

**Step 6.** After reading the content, Linda feels confident and selects the next
activity, which consists on the assessment of the module specified in IMS-QTI. An
assessment is presented, which is adapted to Linda’s knowledge, learning style,
interaction preferences and the course objectives.

**Step 7.** However, Linda fails the test. She gets disappointed and closes the session.

**Step 8.** Later, the tutor logs in and asks for an audit of the course with the students’
progress. This audit highlights that Linda had problems with activity 3 and
suggests the tutor to email her in order to support and encourage her.

This particular scenario is framed in current learning situations where existing learning
design specifications are insufficient to cope with the learners’ needs. It can be partially
supported by the foreseen functionality of A2M, mainly by 1) modeling users’ features
from the interaction data by applying educational data mining and machine techniques,
2) generating dynamic recommendations with collaborative filtering techniques, taking
into account the user model attributes and the specifications information and 3)
providing other modules of the LMS the users’ attributes to support their functionality.
The first one is an off-line process, while the other two take place at runtime.
4. Discussion

There are several research issues to solve in this Ph.D. For the discussion here, I will focus on the recommendations that are to be dynamically provided to the learners. These recommendations may consist on offering new materials to learners which are not considered in the course design done in IMS-LD, promoting collaboration among fellows, provide motivational support in critical situations, etc. The recommendations are to be built with the information provided by the user model. Using educational standards to describe the learning scenario at design time provides helpful information for the modeling tasks to be done and can improve the construction and dynamic update of user models from user and usage data worked in [8]. Moreover, for the selection of the best algorithms for each particular machine learning task and input data, the multi-agent system allows to combine alternatives to machine learning tasks (i.e. ensembles of classifiers) as done in [9].

In order to select when to provide a recommendation, the measures defined in [10] are quite sensible, since they rely on the tutor to determine the utility of the recommendation. This allows to verify that the progress of the learners is due to the recommendation itself, and not to a external cause. Nevertheless, a first impression can be obtained when detecting that the learner moves forward the impasse and thus, infer that it improves the learning efficiency.

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