ODL EDUCATION ENVIRONMENTS BASED ON ADAPTIVITY AND ADAPTABILITY

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ABSTRACT

In the Information Society of the new millennium, the use of Information and Communication Technology (ICT) is becoming essential for the rapid dissemination of information. In this context, Open and Distance Learning (ODL) will have a growing role in effectively training people to have active roles in society. However, modern learners have a variety of backgrounds, with respect to knowledge, social environment, preferences, etc. Therefore, our main goal is to create the basis of a European platform of standards for user modeling-based adaptability and adaptation, towards individualization of the learning process. This paper reports about the birth of a new European project, ambitiously aiming at going one step further than plain user modeling (UM), by creating a common structure for the ODL systemsí adaptive response to specific user needs, thereby creating a basis for modern European Education. The main goal of this paper is to highlight the importance of the standardization of the adaptive and adaptable techniques to the research community at large, and therefore find more external support for our efforts. Moreover, this paper presents some first background research to establish a starting point for this project.

KEYWORDS

Adaptivity and Adaptability, preferences and profiles, agent technology, web-based navigation, collaboration, ODL for ICT

1. INTRODUCTION

The society of the beginnings of the new millennium is also known as the new Information Society. Information and Communication Technology (ICT) is becoming increasingly essential for the information dissemination, and especially, for knowledge dissemination. With such premises, Open and Distance Learning [6,11,24] (ODL) has a growing role in effectively training people to have active roles in society, as a precondition of fostering a real equality among them. The main problem with ODL, noted by many researchers [4,5,20,27] is that it offers monotonous, uniform education to everybody.

However, with this expansion of the reach of education and creation of equal opportunities, as well as with the need of giving practical expression to the principle of lifelong learning, the need of handling cultural and linguistic differences, gender differences, the analysis of learnersí attitudes and profiles, is increasing.

Our main research objective is to establish a *European platform of standards (guidelines, techniques and tools) for user modeling-based adaptability and adaptation*, in the sense of the new paradigm of intelligent human-computer interaction, based on the new generation of ODL tools, towards individualization of the learning process.

Note that similar standardization efforts exist, for e.g., collaborative learning [25,26], or the Semantic web research, but in the area of adaptivity and adaptability there are no real efforts towards some unification of means and methods. In other words, the semantic web creates the basis on which the adaptivity and adaptability standards can be built.

The 2 year long projectís main contribution will be to go one step further than plain UM [19,29], by creating a common structure for the ODL systemsí adaptive response [34] to specific user needs, thereby creating a basis for modern European Education.

2. MOTIVATION & OBJECTIVES

As previously stated, this projectís main objective is to establish a European platform of standards for UM-based adaptability and adaptation, using methods and techniques of, among others, artificial intelligence [8] and neural networks [7], towards individualization of the learning process.

More concretely, the following objectives will be pursued:

O1. *Identify a set of relevant good practices of (UM based) adaptation techniques for education, based on current technology.*
O2. *Extract a minimal set of relevant and necessary features for adaptation techniques in education and for*

distributed (Internet) and multimedia environments.
O3. *Extract a supplementary set of relevant (but not necessary/ essential) features for adaptation techniques in education; also extract examples of irrelevant features (redundant techniques sets).*
O4. *Based on O1-O3, define guidelines (minimal set of requirements) for an authoring system for adaptive techniques in education.*
O5. *Build a prototype adaptive authoring tool [32] and, separately, one (or more) training system(s) based on the minimal set of relevant features, with possible addition of supplementary features.*
O6. *Evaluate the adaptive prototype system on different target groups.*
O7. *Disseminate and promote the results.*

3. TARGET BENEFICIARIES

The primary beneficiaries of the project and research outputs are:

- *Students* of a large variety of disciplines that can profit from the pursued trans-disciplinarity and knowledge individualization envisaged by the project.
- *Teaching staff* from the institutions *participating in the project*, who can use the researched techniques for their own courses.
- *Researchers* in these disciplines, who will have a unitary basis to work upon.
- The larger *research community*, which can benefit from these results and will be able to integrate them into their own research.
- The *standards community*, which will be able to use our standard proposals.
- *Teaching staff at universities outside the project* that want introduce adaptive methods in their teaching.

4. ADAPTABILITY VS. ADAPTIVITY

4.1 Adaptability

The lowest level of ìintelligenceî for the WWW is to have some adaptable features. I.e., *the user* (learner or teacher/ course designer, in our case) *can make some options that will determine some alterations to the aspect, contents or functionality of the Web material*. The simplest example is to have a button for changing colors. Another, more complex example, is to have alternative courses for students with disabilities: for instance, to read aloud the material for visually impaired students ñ or to simply provide a version with larger characters.

We group these static adaptable features under the name of adaptability.

4.2 Adaptivity

Adaptivity, on the other hand, is what one would expect from this term: *the actual capability of the system to adapt automatically to the new conditions* (usually deduced from a user model). This represents a more advanced step towards artificial intelligence, compared to adaptability.

In the following, some insight into the fundamentals of these techniques will be given. Adaptation and adaptability are approached here from the perspective of the person to whom the web site has to adapt to (or be adaptable for): the user. Both adaptation and adaptability can exist without UM. An example where this sometimes occurs is adaptive hypermedia [5]. For the purpose of the project, all these aspects will be studied. However, the more personalized a website has to become, the more the *user model* and *UM* grows in importance [15].

For the purpose of this paper, we will therefore analyze some fundaments of user modeling. A more sophisticated model has to take into consideration the learnerís cognitive styles ñ in this case, learning styles.

5. LEARNING STYLES

The literature provides various definitions of cognitive styles (proposed initially by Allport in 1937) and learning styles (proposed initially by Herb Thelan in 1954), and often the two terms are used interchangeably. For our purpose, we are focusing on learning style, as the specific individual approach of each student to new knowledge acquisition [10]. According to the student's learning style, the student is able to receive knowledge easier or not via a certain teaching style. The learning style is independent from the other abilities, which have direct sequels (the more, the better [28]), whereas styles are controlling mechanism and define the internal preferences and value system.

Among the different cognitive/ learning styles, we are enumerating some of the more important in the following.

5.1. Hill's cognitive style mapping

Hill has built a cognitive style coefficient as a function of symbols and meanings (i.e., the preferred form in which an individual encodes information), cultural determinants (i.e., family, colleagues, etc.), modalities of inference (reasoning style, i.e., inductive, deductive, etc.) and a memory function.

It is interesting here to note that the cultural determinants, in the form of the influence of the country and cultural background on ones information processing style (learning style) have only recently been proposed for studying in the adaptive hypermedia community.

5.2. Kolb's learning styles

Kolb (1984) defined a 2-dimensional scale to represent learning styles, which leads to 4 extreme cases:

1. *converger* (abstract, active): abstract conceptualization and active experimentation; great advantage in traditional IQ tests, decision making, problem solving, practical applications of theories; knowledge organizing: hypothetical-deductive; question: "How?".
2. *diverger* (concrete, reflective): concrete experience and reflective observation; great advantage in imaginative abilities, awareness of meanings and values, generating alternative hypotheses and ideas; question: "Why?"
3. *assimilator* (abstract, reflective): abstract conceptualization and reflective observation; great advantage in inductive reasoning, creating theoretical models; focus more on logical soundness and preciseness of ideas; question: "What?".
4. *accomodator* (concrete, active): concrete experience and active experimentation; focus on risk taking, opportunity seeking, action; solve problems in trial-and-error manner; question: "What if?".

5.3. Dunn and Dunn's Learning styles

Rita and Kenneth Dunn developed in 1974 a comprehensive learning style model on four axes:

1. *environmental factors* (sound/noise level, light level, temperature, design setting)
2. *emotional factors* (motivation, persistence, responsibility, structure)
3. *sociological factors* (self-orientation, colleague orientation, authority orientation, pair orientation, team orientation)
4. *physical factors* (perception, intake, time, mobility)

Although this model deals very little with the cognitive factor, this model is currently used in schools for pupils of grades 3-12 and a version has been developed for adults.

5.4. Herman brain dominance model

Ned Herman classified in 1976 thinking styles into:

1. *Quadrant A* (left brain, cerebral):
analytical, logical, factual, critical and quantitative
2. *Quadrant B* (left brain, limbic):
sequential, structured, organized, planned, conservative and detailed
3. *Quadrant C* (right brain, limbic):
interpersonal, emotional, sensory, kinesthetic, symbolic and spiritual
4. *Quadrant D* (right brain, cerebral):
visual, holistic, innovative, conceptual, imaginative, artistic

His model classifies people according to their preferences (fig. 1), determining a dominant style (without excluding different preferences degrees for the remaining quadrants).

Figure 1 shows an intuitive example of simple adaptability in a WWW distance learning model for students of different cognitive styles [9].

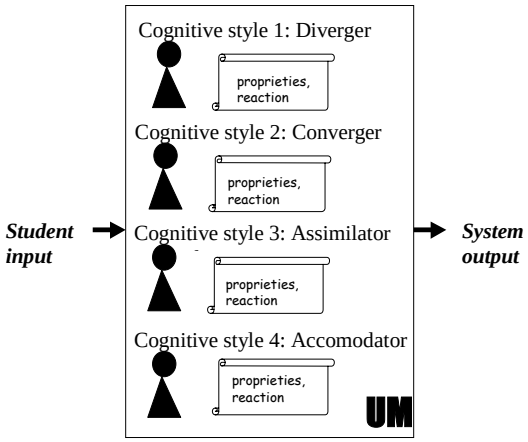

Figure 1. I-O UM white-box of an educational system w. student separation by learning styles based on the Herman brain dominance model

5.5. Other models

There are many other models, but among all those we would like to mention also the classification into:

1. *field dependent*
2. *field independent*

Field independence means the extent to which a person can perceive analytically, and can distinguish the study object from the surroundings. Field dependent people, on the other hand, are dependent on external cues, and can, for instance, learn better if they have graphical support.

6. USER MODELING

However, although very important in learning, the learning style is not the only prerequisite to be modeled

for adaptivity and adaptability in WWW learning. UM implies more layers, as depicted in figure 2 [1].

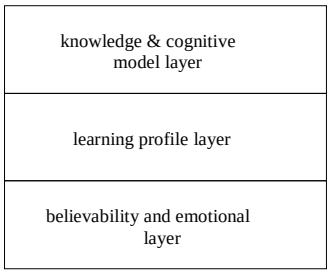

Figure 2. Layers in student modeling

For instance, environmental factors (such as time, location, computing environment, network, physical handicaps, etc.) and the browsing behavior of a user should also be taken into account when generating and updating the information presentation and navigation structure of a hypermedia application.

A different perspective on studying the premises of user-modeling, and thus, the premises of adaptation and adaptability, is given by the MAO model (motivation ñ ability - opportunity) [18], not presented here.

7. CONSIDERATIONS ON UM

Building any model starts with the following:

- *feature definition,*
- *selection* and
- *extraction.*

As well known, this involves an iterative refinement process for achieving an efficiently working model, able to make predictions that meet reality, at least, statistically.

There exists no purely empirical approach to modeling. Even the definition of attributes/features and the selection of the relevant ones in a given context are actually theory driven, explicitly or not.

A prototype model of the learner can be used as a starting point that actually encodes some available general theoretical knowledge in the field of learning. Because of the large variability in human personality and in human behavior, and because the traits that are essential in various contexts are not the same, such a prototype model cannot be used directly in practice, without the penalty of being perceived as being rigid and biased. The model has to be customized by using empirical data ñ sets of examples collected for the given user, while interacting with the system.
If the features used to parameterize the initial model do not allow capturing specific detailed behavior, i.e., if the simple tuning of parameters cannot adapt the model to properly depict the userís profile, new features have to be extracted from the empirical data and added to the model.

The available collection of examples is never large enough to cover all possible classes in an unbiased manner, to avoid spurious correlation when elaborating a model. Small sets of exceptions may be poorly represented, or even ignored.

The combined use of theoretical knowledge and experimental results can offer the sought for solution, by allowing for incomplete and/or incorrect theoretic knowledge and for incomplete or noisy data. Such a system has the inherent capability to recover from errors. This is the reason why very new hybrid approaches emerged, based on AI (artificial intelligence) techniques, in particular NN (neural network) techniques.

8. THE PARTNERSí EXPERTISE

The expertise of the partners is manifold. Here we will summarize only some specific complementary expertise of use in the project:

- Eindhoven University of Technology (TU/e), Dept. of Computing Science (The Netherlands): one of the pioneers of the use of adaptivity in hypermedia (first project: 1990), is also the home of the world-wide Adaptive Hypertext and Hypermedia Homepage (http://wwwis.win.tue.nl/ah/) and of the Adaptive Hypermedia mailing list. A general framework for adaptive hypermedia has been developed (AHAM [34]) and a prototype adaptive Web-based system that is used for courses and online information systems (the world-renown AHA system) is already available [3,12,13,14]. The main adaptation techniques that were introduced are link hiding and conditional inclusion of fragments.
- University of Twente (UT), Faculty of Educational Science and Technology (The Netherlands): pioneer in the use of technology in teaching and research, gave one of the first courses in the world using Web technology. They are known for their TeleTOP project [33] that systematically supports the professional staff development in terms of potential applications of telematics in their teaching. They introduced learner support via adaptive task-based information retrieval.
- Milano Politechnical University (MP), Information and Electronics Department (Italy): is, through the group of Dr. Franca Garzotto, specialized in the analysis and detection of design patterns (e.g. hypermedia). They bring expertise in hypermedia modeling [17], online

multimedia courses [16], UML based design specification, context aware ubiquitous systems, design tools, data-based driven dynamic generation of web sites, ECA (event-condition-action) rules.

- Institute for Scientific and Technological Research (IRST): (Italy) the group led by Dr. Carlo Strappavara is specialized in natural language generation [31]. Their expertise is useful in adaptivity and adaptability terms for, e.g., the analysis of techniques and technology of conditional inclusion of fragments at the low level, for the efficient concatenation of small fragments into fluent natural language and the feasibility studies.
- University of Southampton (USH), Electronics and Computer Science(UK): the Learning Technologies Group is specialized in AI, intelligent agents, multimedia. Dr. Hugh Davis is an inventor of Microcosm [21], one of the few commercial open hypertext systems [22]. They are pioneers of open hypermedia technology (documents contain no links except from mapping user profile, preferences over link database). They are known for first introducing conditional shading of fragments and linking in context.
- University of Nottingham (UN): (UK) the Web Technologies Research Group headed by professor Helen Ashman is concerned with hypermedia and online learning, represented by the Extending XML's linking project and the WHURLE [2]. The group is known for first introducing the adaptive technique of conditional transclusion (dynamic inclusion of an arbitrary component of one document inside another).

9. FUTURE RESEARCH DIRECTIONS

The projectís main outcome is to significantly contribute not only towards standardization of the new generation of ODL adaptation techniques and tools, but also to provide alternate styles of teaching and learning, optimally suited for ODL or a combination of ODL and traditional classroom teaching.

In particular, the projectís output and products will follow the objectives and include:

- a set of relevant good practices of (UM based) adaptation techniques for education, based on current technology;
- as a byproduct of the above, it will generate counter-examples of sets of bad practices (or techniques) of (UM based) adaptation techniques for education, for a clear distinction from the above;
- a minimal set of relevant, necessary features for adaptation techniques in education. Generate typical features for distributed (Internet) environments, multimedia environments.
- a supplementary set of relevant (but not essential) features for adaptation techniques in education, as well as a few counter-examples of irrelevant features detected.
- Reports of the above, both internal (mid-stage), for partnerís information and usage, and external, at conferences, workshops, etc. (e.g., AH, WebNet, ITS, UM, ED-MEDIA, CEC, etc.); final report will also be sent to standard bodies (IEEE, LTTF)
- a sample authoring system for adaptive techniques in education generated above;
- separately, one (or more) training system(s) based on the minimal set of relevant adaptive features, with possible addition of supplementary features
- evaluation, dissemination and promotion of results, especially focusing on the spread of understanding the innovative impact of the new issue of adaptivity and adaptability in the ODL, for classroom-based learning, distance learning modes or a combination of both and on the transferability to other domains.

10. CONCLUSION

This paper succinctly presents an emerging collaboration project of European dimension, with possible international significance. We clearly explain the necessity, at this stage, of a centralization of the accumulated knowledge on adaptivity and adaptability for WWW, especially in the domain of ODL (but also beyond). Moreover, we show that a unified standardization of adaptation techniques and technologies would benefit at first the European community, as this is a European project, but also the International WWW community, by establishing a common ground (vocabulary, ontology, methods, techniques, methodologies) towards more evolved UM techniques, and ultimately, increased user satisfaction. We start with a small group of experts in the field, but gladly invite specialists all over the world to join us in our effort towards improving and enhancing the Web and fully using the WWW potential. More information about this emerging project can be found at [23].

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