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.

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 (ODL - Blair 2000; Cristea & Okamoto 2001; Nkambou et al. 1998) 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 (Brusilovsky 1996; 2001; Marshallís University CIT; Oppenheimer 1997) 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 (Okamoto & Cristea 2001; Okamoto et al. 2001), 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.

Our two year long projectís main contribution will be to go one step further than plain UM (Learner Model IEEE LTSC; Rich 1979), by creating a common structure for the ODL systemsí adaptive response (Wu & De Bra 2001) to specific user needs, thereby creating a basis for modern European Education.

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 (Cristea & Okamoto 1999) and neural networks (Cristea & Okamoto 1997), 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 [0] 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.*

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.

Adaptability vs. Adaptivity

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.

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 (Brusilovsky, 2001). 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 (Fink et al. 1997).

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.

Adaptation Granularity

Another aspect to consider in doing user adaptation is the granularity of this adaptation.

- At the lowest level there are *direct adaptation techniques*, such as *adaptive navigation support* and *adaptive presentation*, as described by (Brusilovsky 1996), and implemented by such adaptive hypermedia systems as AHA. These techniques are usually based on threshold computations of variable-value pairs. They can be considered as the *low level adaptation techniques*.
- At a next level, we can envision more goal-oriented, or at least, domain-oriented adaptation techniques, based on a higher level language that embraces the primitive low level adaptation techniques (and serves as a wrapper to the former). These new techniques can form an adaptation language (as developed in Calvi & Cristea 2002), and can be considered *medium level adaptation techniques*.
- Finally, at the last level, we can include adaptation strategies, embracing and wrapping the layers above. These strategies are goal-oriented, although the same strategy could be, generally speaking, used for different goals. This layer is the *high level adaptation layer*.

In the following, we will shortly sketch some of the higher level features that can be included in adaptation techniques.

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 (Cristea & Okamoto, 2001a). 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 ñ Pham), 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.

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.

Kolb's Learning Styles

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

- *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?".
- *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?"
- *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?".

- *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?".

Dunn and Dunn's Learning Styles

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

- *environmental factors* (sound/noise level, light level, temperature, design setting)
- *emotional factors* (motivation, persistence, responsibility, structure)
- *sociological factors* (self-orientation, colleague orientation, authority orientation, pair orientation, team orientation)
- *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.

Herman Brain Dominance Model

Ned Herman classified in 1976 thinking styles into:

- *Quadrant A* (left brain, cerebral):
  analytical, logical, factual, critical and quantitative
- *Quadrant B* (left brain, limbic):
  sequential, structured, organized, planned, conservative and detailed
- *Quadrant C* (right brain, limbic):
  interpersonal, emotional, sensory, kinesthetic, symbolic and spiritual
- *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). Hermanís model has some similarities to the Kolb model ñ such as the Converger could map approximately over the Quadrant A ñ but there is no complete one-to-one mapping.

Figure 1 shows an intuitive example of simple adaptability in a WWW distance learning model for classifying students into different cognitive styles (Cristea & Okamoto 2001a).

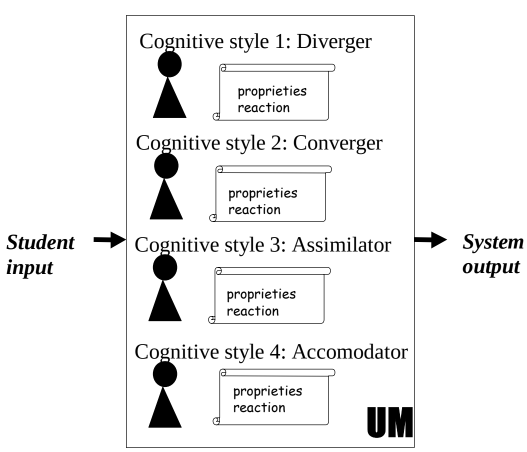

Figure 1: I-O UM white-box of an educational system w. student separation by learning styles based on the Herman brain dominance model

Other Models

There are many other models, but among all those we would like to mention also the famous 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.

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 Layers

UM implies more layers, as depicted in figure 2 (Abou-Jaoude & Frasson 1999).

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 ñ opportunity: Hoyer & MacInns 2001), not presented here.

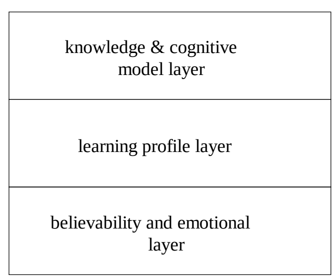

Figure 2: Layers in student modeling

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.

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.

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, officially starting autumn 2002, can be found at our local Minerva site.

References

Abou-Jaoude, S. & Frasson, C. (1999), Integrating a Believable Layer into Traditional ITS, *AI-ED99*.

Brailsford, T. et al. (2001), A Technical Overview of Whurle: an XML/XSLT Adaptive Hypermedia Learning Environment, *Hypertext conference*.

AHA, Adaptive Hypermedia for All, http://aha.win.tue.nl/

Brusilovsky, P. (1996), Methods and Techniques of Adaptive Hypermedia, *User Modeling and User-Adapted Interaction 6* , 87-129.

Brusilovsky, P. (2001), Adaptive Hypermedia, *User Modeling and User Adapted Interaction*, Ten Year Anniversary Issue (Alfred Kobsa, ed.) *11* (1/2), 87-110, http://kapis1.wkap.nl/oasis.htm/270983

Blair, J. (2000), Colleges, Education on the Web, Jan. 19, http://www.edweek.org/ew/

Calvi, L. & Cristea, A. (2002), Towards Generic Adaptive Systems: Analysis of a Case Study, AH 2002, *Adaptive Hypermedia & Adaptive Web-Based Systems*, LNCS 2347, Springer, 79-89.

Cristea, A. & Okamoto, T. (1997), Neural Network Knowledge Extraction, *journal Rev. Roumaine des Sciences Technique, Serie EE (Electrotechn. et Energ.), 42*(4), (Oct.-Dec.), 477-491.

Cristea, A. & Okamoto, T. (1999), The Development of a Sub-Symbolic Knowledge Eliciting Environment from Feedforward Networks, serving as an Education Process Assistant, *Journal of Educational Technology Research*, *JET soc., 21*, 15-24.

Cristea, A. & Okamoto, T. (2000), MyEnglishTeacher ñ A WWW System for Academic English Teaching. *ICCE 2000*, Conference on Computer in Education, Learning Societies in the New Millennium: Creativity, Caring and Commitments, Taipei, Taiwan.

Cristea, A. & Okamoto, T. (2001a), Considering automatic educational validation of computerized educational systems, IEEE International Conference on Advanced Learning Technologies, *ICALT2001*, USA, http://wwwis.win.tue.nl/~alex/ConferencesICALT/ICALT.doc

Cristea, A. & Okamoto, T. (2001b), Object-oriented Collaborative Course Authoring Environment supported by Concept Mapping in MyEnglishTeacher, *Educational Technology and Society*, *4*(2) (April 2001), Special Issue on ìDeveloping Creativity and Large Mental Outlook in the Computer Ageî, http://ifets.ieee.org/periodical/vol_2_2001/v_2_2001.html,

De Bra, P. & Calvi, L. (1998), AHA! An open Adaptive Hypermedia Architecture, *The New Review of Hypermedia and Multimedia*, 115-139.

De Bra, P., Brusilovsky, P. & Houben, G.-J. (1999), Adaptive Hypermedia: From Systems to Framework. *ACM Computing Surveys*, Symposium Edition. http://wwwis.win.tue.nl/~debra/public.html

De Bra, P. & Ruiter, J.P. (2001), AHA! Adaptive Hypermedia for All, *WebNet Conference*, 262-268.

Fink, J., Kobsa, A. & Schreck, J. (1997), Personalized Hypermedia Information Provision through Adaptive and Adaptable System Features: User Modeling, Privacy and Security Issues, *Intelligence and Services Networks: Technology for Cooperative Competition*, Eds.: A. Mullery, et al., Springer, 456-467.

Garzotto, F. & Thuring, M. (1995), Proceedings of the First Workshop on Evaluation Methods for Multimedia Applications, *ACM Multimedia í96 Conference*, S. Francisco, CA, Nov.

Garzotto, F. et al. (1996), *Hypermedia Design*, Springer.

W. D. Hoyer, & D. MacInns (2001), *Consumer behavior*, Houghton Mifflin Company, second edition.

Learner Model. IEEE LTSC Committee, http://ltsc.ieee.org/wg2/index.html

Marshall's University's Center for Instructional Technology, Comparison of Online Delivery Software Products, http://multimedia.marshall.edu/cit/webct/compare/comparison.html

Microcosm homepage, http://www.mmrg.ecs.soton.ac.uk/projects/microcosm.html

Millard, D. E., Davis, H. C & Moreau, L. (2000), Standardizing Hypertext: Where Next for OHP?, Springer.

Minerva project, http://wwwis.win.tue.nl/~alex/HTML/Minerva/

Nkambou, R., IsaBelle, C. & Frassoun, C. (1998), Supporting some pedagogical issues in a Web-based distance learning environment, *NTICF'98*, November.

Okamoto, T. & Cristea, A. (2001), A Distance Ecological Model for Individual and Collaborative-learning support, *Educational Technology and Society*, *4*(2), April 2001, Special Issue on Developing Creativity and Large Mental Outlook in the Computer Age, http://ifets.ieee.org/periodical/vol_2_2001/v_2_2001.html

Okamoto, T., Kayama, M. & Cristea, A. (2001), Consideration of building a Common Platform of Collaborative Learning Environment, *ICCE*.

Oppenheimer, T. (1997), The Computer Disillusion, *The Atlantic Monthly*, http://www.theatlantic.com/issues/97jul/computer.htm

Pham, P.N., Learning Style, http://www.payson.tulane.edu/ppham/Learning/lstlyses.html

Rich, E. (1979), User Modeling via Stereotypes, *Cognitive Science*, *3*(4), 329-354.

Self, J. (1996), The Development of the Computer Based Learning Unit: A Discussion Document, http://cblslca.leeds.ac.uk/~jas/discussion.html

Stock, O., Strapparava, C. & Zancanaro, M. (2000), Explorations in an Environment for Natural Language Multimodal Information Access in M. Maybur (ed.) *Intelligent Multimodal Information Retrieval*, AAAI Press, Menlo Park, Ca./MIT Press, Cambridge, Mass.

W3C Recommendation (2000): Authoring Tool Accessibility Guidelines 1.0,3 February 2000, http://www.w3.org/TR/ATAG10/

TeleTOP homepage, http://teletop.edte.utwente.nl/

Wu, H. & De Bra, P. (2001), Sufficient Conditions for Well-behaved Adaptive Hypermedia Systems, *Proc. Web Intelligence Conference*, Lecture Notes in Artificial Intelligence, 2198, Springer, 148-152.

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