Towards the Framework of Adaptive User Interfaces for eHealth

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Abstract

Diversity inside a group of users having their individual abilities, interests, and needs challenge the developers of eHealth projects with heterogeneous needs in information delivery and/or other eHealth services. This paper considers an adaptive user interface approach as an opportunity in addressing this challenge. We briefly overview the recent achievements in the area of user interface adaptation and discuss application of these achievements in the eHealth context. We introduce the basic elements of our framework for adaptive user interface (AUI) for eHealth systems. Then, we use this framework in our review of work in the area of AUI for eHealth applications. As a result, we conclude with a brief discussion on the current focus on AUI research in eHealth, and interesting directions for further research.

1. Introduction

eHealth is a developing branch of Medical Informatics aimed to significantly contribute to improvement in quality, access and efficacy of health care through: (1) development of an intelligent environment that enables people to manage their well-being through access to qualified and trusted sources of health information and active participation in illness prevention; (2) enabling patients to participate, with better knowledge and responsibility, in the processes of care and rehabilitation, through intelligent monitoring systems as well as through relevant and personalized health information; (3) providing health professionals with access to timely relevant information at the point of need, new tools for better management of risk and systems to acquire up-to-date medical knowledge; (4) ensuring that people worldwide can confidently and with full understanding of known risks realise the potential of the Internet in managing their own health and the health of those in their care; and (5) offering reliable and affordable personal health systems assisting people to manage their lifestyle [2, 22].

Recent dissemination and advances in internet, communication technologies and mobile computing offer possibilities to easily provide eHealth information to individual customer/patient. Health services include personal medical care, advice, and management of related data, communication between health care providers and/or patients, including bulletin boards, chat rooms, or other facilities to communicate health related information.

Health service provider has to ensure that health information is not only highly accurate and up to date, but at the same time easy to understand by heterogeneous groups of patients. Clearly, this requires personalization and/or adaptation of the content and representation of providing information. Both the group of medical experts (health service providers) and patients consist of individuals who beside different background and expertise have also different demographical, psychological, and cognitive characteristics. On the other hand, beside different contents of information also different forms of presentation are needed to communicate this information. These include at least text, graphics, audio, video etc. The

Proceedings of the 18th IEEE Symposium on Computer-Based Medical Systems (CBMS'05)
1063-7125/05 $20.00 © 2005 **IEEE**

diversity of users of eHealth systems and presentation methods point out to the necessity of user interface adaptation (UIA).

In this paper we review the recent achievements in AUI (Section 2). Then UIA is analyzed within the context of eHealth applications (Section 3). In Section 4 we introduce the basic elements of the framework for AUI for *e*Health systems. In Section 5 we conclude with the brief discussion on the current focus on AUI research in *e*Health, and suggest some interesting directions of further research that are not covered in present.

2. Adaptive User Interfaces

UIA has been recognized as a promising direction in intelligent system design more than ten years ago [24]. Langley [18] defines an AUI as "a software artefact that improves its ability to interact with a user by constructing a user model based on partial experience with that user". One of the important goals of UIA is to take into account special perceptual or physical impairments of individual users so as to allow them to use a system more efficiently, with minimal errors and frustration [13, 25]. Generally, adaptation is implanted to the one of the interface subsystems such as information lay-out (spatial arrangement, colour scheme, image, or text presentation), human-computer dialogue language, and navigation support. One of the most studied UIA techniques is the incremental one [5].

However, it should be mentioned that currently there exists only some systems that support UIA functionality [20]. Also, some HCI researchers are sceptical to the whole concept of intelligent user interfaces. There are probably two major reasons for such scepticism: (1) previous failures of AI to fulfil its promises, and (2) the lack of transparency and predictability that are main principles of usability [12]. Paymans et al. [20] have shown that in fact, a user do not experience any serious difficulty in building adequate mental models of the systems with UIA.

Still, according to Kobsa [17] AUIs have shown their promise (supported by experimental studies) in several application areas including recommendation systems and e-learning systems and content-based, social, and collaborative information filtering.

Adaptive systems are traditionally classified into adaptive and adaptable [17]. Adaptable user interfaces are customized by the user. For example, in some Internet portals a user is allowed to specify the information he wants to see. In our paper we consider adaptive user interfaces, where personalization is automatically performed by the system without explicit user commands. In the context of an Internet portal it means that the system dynamically generates individual user interface.

Adaptation technologies are aimed to provide: (1) content adaptation, (2) structure adaptation (adaptive navigation support), and (3) presentation adaptation [1, 6]. The system provides content adaptation by adaptive selection and prioritization of the most relevant items when a user searches for relevant information. Content adaptation is organized via several techniques, for example via page variants, fragment variants, adaptive stretch text, and adaptive natural language generation methods [6]. One example of adaptive navigation support is the incremental management of hyperlinks (hiding, sorting, annotating, removing, and adding) during a user navigation session. Presentation adaptation commonly includes the adaptation of visible components layout (text positioning, graphics, multimedia inclusion/exclusion, background, variations, and GUI interfaces).

UIA is traditionally organized on the base of a user model [4]. A user model is an abstract representation of application relevant properties of the real user [15]. Generally, the user model can be any individual, dynamic, or explicit model, represented as a collection of data stored in the system. This data determines user goals, tasks, beliefs, and other personal

characteristics, which are important for adaptation. Correspondingly, user modeling is the process of obtaining the information about the user needed for UIA [19].

User modelling techniques are classified into group and private modelling. In the group modelling several models are usually constructed and the approach is commonly called the stereotype approach [23]. In this approach a user is classified into one of the user groups and the corresponding user model is attached. Thus, this approach usually requires the fulfilment of three main tasks: (1) user subgroup identification, (2) identification of key characteristics, and (3) representation of key characteristics sets in (hierarchically ordered) stereotypes. In private modelling a user model is separately developed for each user.

Beside user characteristics that are usually being used in web-based systems adaptation, Kobsa [16] proposed to distinguish adaptation (1) to user data (various characteristics of the users), (2) to usage data (data about user interaction with the systems), and (3) to environment data (all aspects of the user environment that are not related to the users themselves) [16].

Acquisition of the user model can be classified to explicit (when the system asks the user for information about him/her), implicit (when the system performs user modelling based exclusively on its normal interaction with him/her) and mixed-mode acquisition [16].

3. User Interface Adaptation in *e*Health Applications

The existing adaptive medical systems mainly support content and navigation adaptation. For example, Bental et al. [3] describe an adaptive medical system for the patients with cancer. It uses both content and navigation adaptation. The content of the presented information is adapted to patient's situation and disposition, to the process of illness and treatment. The system decides both what to present and how to present. The additional hyper-links to the explanation of the terms used in the texts are generated according to the patient's profile.

Earlier medical systems were mainly used by the health professionals – medical staff, nurses, etc. Internet made health systems available to many kinds of users as to patients, their families, and others, who wish to receive certain *e*Health services or enhance their understanding though *e*Health content. Therefore, user interface adaptation (UIA) in a eHealth system requires the content customization at least to the two main groups of users, whose knowledge in the health area is considerably different (i.e. medical staff and patients). The important issue here is that the vitally risk of the misinterpretation of information provided by medical systems to patients (users without extensive medical background) significantly increases. This peculiarity distinguishes *e*Health content delivery from many other content delivery systems like eLearning or leisure information portals.

The stereotype approach is widely used for user modeling in medical systems. The users are classified into several groups. The users could be classified according to their main decease, to their background in medicine (patients, nurses, and physicians), and to their tasks (like consultation or education).

Besides the user's medical profile, user model in *e*Health system could include for example, user's tasks and goals, his cognitive and psychological individual peculiarities, and the interaction parameters such as the last visited pages, the main links used, and the number of the particular pages visits.

The Mars Medical Assistant (MMA) system [8] supports adaptive medical information delivery. Two levels of adaptation are used: 1) content service, which determines what medical information is required (especially in semantic context), and, 2) presentation service, which determines information presentation parameters. The adaptation is based on the joint use of the user model, the task model, and the situation (environment) model.

The user model of the Mars Medical Assistant [8] includes information about the user's

knowledge of each medical topic, knowledge about the system, interface/system preferences, and medical profile.

Model-based UIA for electronic patient records is presented in [21]. The system uses the stereotype models for various physician types (internists, oncologists, and infectious diseases).

"Homey" project [9] is one good example of how dynamic UIA (spoken dialog) is aimed to learn patient habits, to motivate (presenting possible outcomes of patient behavior in a certain way) a person to change something in his/her lifestyle.

The review of recent EU supported *e*Health projects shows that the concept "personal" is used quite often in their working plans compared to the rarely mentioned concepts "personalized" or "adaptive". Most of the projects even do not mention the challenge of user adaptive *e*Health. Only few of EU funded *e*Health project explicitly mention personalization among main objectives: "research and development on innovative ICT systems and services that process, integrate and use all relevant biomedical information for improving health knowledge and processes related to prevention, diagnosis, treatment, and personalization of health care." [2, 22]

The *e*Health project [14] aimed to monitor computer-user interactions for UIA and describe detection of user's cognitive changes. The basic idea is to introduce a relatively automated and unobtrusive procedure to track certain measures of patient's health. The popular computer game has been adapted for *e*Health purposes.

Greenwood [10] considers the use of reactive agents to provide a context for the application of emergence in the area of self-adaptive interfaces. She presented an emergent multi-agent system that uses a two-layer model including an interaction layer and a control layer.

Design of risk information formats for patients has also been studied in [7]. Particularly, it was argued that graphical displays of information increase the effectiveness of risk communication. HCI is understood by *e*Health community as important discipline concerned with the "design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them" [11]. However, the main emphasize is on "good and right" design or so-called design for all.

4. Towards the General Framework of Adaptive *e*Health Platform

In this section we present our general framework of UIA in *e*Health system, and consider some basic elements of adaptation in eHealth system. The goal of this framework consideration is two-fold: (1) to emphasize the main important issues and components of AUI in eHealth, and (2) to show within the framework which issues are covered in current eHealth research and development and which are new interesting directions for further research.

In Figure 1 we can see three major groups of framework components: (1) *participants*, (2) *data repositories* and (3) different *engines*. Participants of a *e*Health system include two major groups of users: *patient-oriented* (patients, their family, and other persons who are receiving different *e*Health services but are not medical experts), and *medicine-oriented* (medical staff, general practitioners, personal doctors, etc.). Besides users, participants are knowledge engineers, usability engineers, system architects (developers), administrators, and psychologists. Data repositories contain: (1) various eHealth related materials, (2) log data regarding user-computer communication, (3) management data that includes repository of user profiles and constructed user model, and (4) information on potentially adaptable interface parameters. Different engines provide the system functionality in all aspects and include at least an *adaptation* engine, a use-profiles engine, a contents delivery engine and an administrative engine. Our focus in on the adaptation engine, which consist of 3 major parts:

a *knowledge base*, a *model* (user, task, and environment) *generator*, and an *adaptation effect* (to contents, to presentation, and to navigation) *provider.* The arrows emphasize information flows crucial to the UAI process.

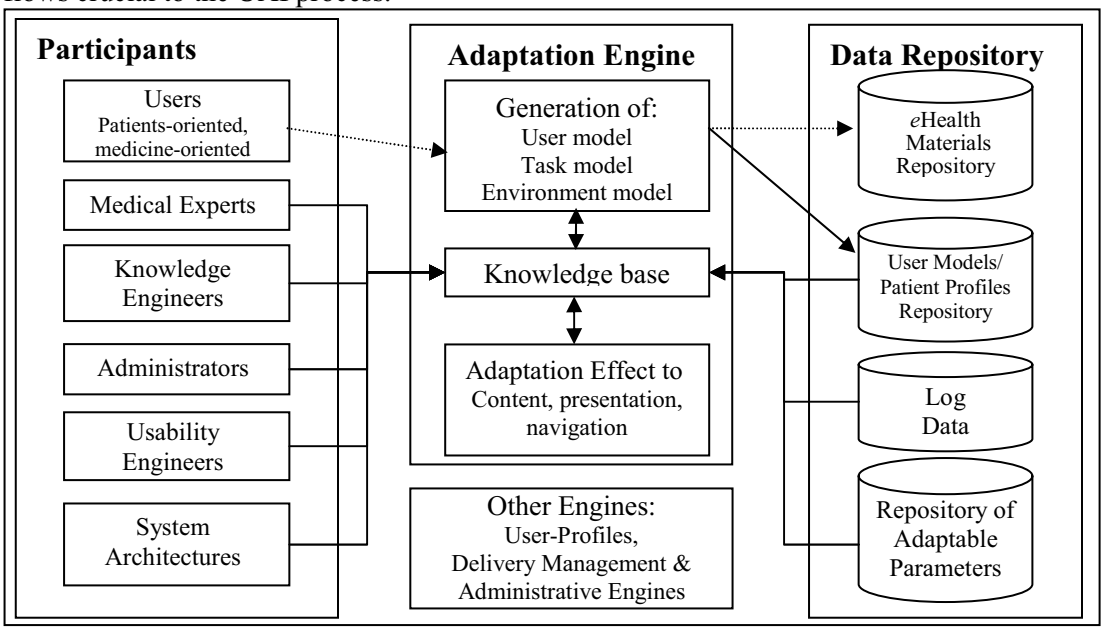

Figure 1. General framework of adaptive eHealth system

5. Discussion

Personalization of medical information to individual users of eHealth systems is a challenging target because of the large differences that exist among users including their goals, their ability to understand various types of information and their medical interests. Besides the content personalization it is important to address the issues of adaptive representation of and navigation through the provided content. *e*Health applications offer many possibilities for these adaptations.

In this paper we considered the AUI approach as the key opportunity in addressing the challenge of satisfying different needs of various users in eHealth services. We introduced the basic elements of the framework for AUI for *e*Health systems. Then, we provided the review of work in the area of AUI for *e*Health applications and place them within the introduced framework. Our review of recent *e*Health development projects and research shows that AUI issues are taken into account rather rarely and, when taken, they are still often poorly addressed. We found that the current focus on AUI research in eHealth is within the stereotype approach to user modelling that has proven to be very useful for application areas in which a quick but not necessarily completely accurate assessment of the user's background knowledge is required. Therefore, this approach is widespread for discriminating between main target user groups of eHealth services.

However, the following interesting directions of further research are not enough covered in present literature: (1) individual UIA of eHealth systems to user's personal cognitive and learning styles, (2) UIA to user's behaviour, and (3) recommendation of suitable UIA for users with perceptual or physical disabilities. Recent advances in knowledge management, knowledge discovery from databases, and data mining are not adopted in eHealth systems as it has being done in eLearning, Adaptive Hypermedia, and related fields. In fact, many achievements in eLearning research in our opinion can be successfully adopted for eHealth applications.

Proceedings of the 18th IEEE Symposium on Computer-Based Medical Systems (CBMS'05)
1063-7125/05 $20.00 © 2005 **IEEE**

We hope that our framework and discussions will help researchers and developers of AUI for eHealth system to better situate their research and developmental activities among the problems of the adaptive systems development and address more issues of individual interface adaptation to the user's psychological and cognitive characteristics, adaptation of the navigation and presentation of eHealth systems and to the experimental studies of the interrelations between user's characteristics and interface parameters.

Acknowledgments: This research is partly supported by the COMAS Graduate School of the University of Jyväskylä, Finland. We are thankful to Dr. Alexey Tsymbal for his comments and suggestions to the paper.

6. References

[1] Abidi, S.S.R.& Han, C.Y. E-Healthcare via Personalized Information Services: Addressing the Need for Factually Consistent Information. In Orlowska M.E., et al. (Eds.) LNCS, Springer Verlag, 2003.

[2] Applications Related to Health. Fifth Research and Development Framework Programme 1998-2002, Final report, April 2004, available at http://www.cordis.lu/ist/directorate_c/ehealth/publications.html

[3] D. Bental, A. Cawsey, R. Jones, J. Pearson, Adapting Web-Based Information to the Needs of Patients with Cancer. In Proc. of Int. Conf. on AH and Adaptive Web-based Systems, Springer, 2000, pp. 27-37.

[4] Benyon, D.R. Accommodating Individual Differences through an Adaptive User Interface. Adaptive User Interfaces-Results and Prospects. M. Schneider-Hufschmidt, T. Kühme, U. Malinowski .(eds.) Elsevier, 1993.

[5] P. Brusilovsky, E. Schwarz, Users as Student: Towards an Adaptive Interface for Advanced Web-based Application, In Proc. of the 6th Int. Conf. on User Modelling, 1997, pp. 177-188.

[6] P. Brusilovsky, M.T. Maybury, From adaptive hypermedia to adaptive Web, Communications of the ACM, 45 (5), Special Issue on the Adaptive Web, 2002, pp. 31-33.

[7] A. Edwards, G. Elwyn, A. Mulley, Explaining risks: turning numerical data into meaningful pictures. BMJ, 324, 2002, pp. 827-830.

[8] L. Francisco-Revilla, F.M. Shipman III, Adaptive medical information delivery: combining user, task, and situation models. In Proc. of Int. Conf. on Intelligent User Interfaces, ACM Press, 2000, pp. 94-97.

[9] T. Giorgino, et al. Automated Spoken Dialog System for Hypertensive Patient Home Management. International Journal of Medical Informatics 74(2-4), pp. 159-167, 2005.

[10] Greenwood S., Nealon J.L., Marshall P. Agent-Based User Interface Adaptivity in a Medical Decision Support System in Applications of Software Agent Technology in the Health Care Domain. (Eds. Nealon, J.L and Moreno, A.), Whitestein Series in Software Agent Technologies, Birkhäuser Verlag, 2003, pp. 35-48.

[11] Hewett et al., ACM SIGCHI Curricula for Human-Computer Interaction, ACM SIGCHI, available at: http://sigchi.org/cdg/cdg2.html

[12] K. Höök, Steps to take before IUIs become real, Journal of Interacting with Computers 12(4), 2000, 409-426.

[13] Jameson, A. Adaptive Interfaces and Agents. In J. Jacko & A. Sears (Eds.), Human-computer interaction handbook, Mahwah, NJ: Erlbaum, 2003, pp. 305-330.

[14] H. Jimison, M. Pavel, J. Pavel, Adaptive Interfaces for Home Health, Proc. 2nd Int. Workshop on Ubiquitous Computing for Pervasive Healthcare Applications, Seattle, Washington, 2003.

[15] Koch, N. Software Engineering for Adaptive Hypermedia Systems: Reference Model, Modeling Techniques and Development Process. UNI-DRUCK Verlag, PhD Thesis, München, 2001.

[16] Kobsa, A. User modelling: Recent work, prospects and hazards. In M. Schneider-Hufschmidt, T. Kuhme, and U. Malinowski, editors, Adaptive User Interfaces: Principle and Practice. Elsevier, 1993.

[17] Kobsa, A. Adaptive Interfaces. In: W. S. Bainbridge, ed.: Encyclopedia of Human-Computer Interaction. Great Barrington, MA: Berkshire Publishing, 2004.

[18] P. Langley, User Modelling in Adaptive Interfaces. In Proc. of the 7th Int. Conf. on User Modelling, Banff, Alberta: Springer, 1999, pp. 357-370.

[19] M.F. McTear, User modelling for adaptive computer systems: a survey of recent developments. Artificial Intelligence Review, 7, 1993, pp. 157-184.

[20] T.F. Paymans, J. Lindenberg, M.A. Neerinex, Usability trade-offs for adaptive user interfaces: ease of use and learnability. Proc. of Int. Conf. on Intelligent User Interfaces 2004, pp. 301-303.

[21] A.R. Puerta, Design of Adaptive User Interfaces for Electronic Patient Records. Proc. of CHI98 Workshop on User Interfaces for Computer-Based Patient Records, 1998.

[22] Resource Book on eHealth Projects. Sixth Research and Development Framework Programme 2002-2006, Working paper, April 2004, available at http://www.cordis.lu/ist/directorate_c/ehealth/publications.html

[23] E. Rich, User Modelling via Stereotypes. Cognitive Sciences, 3, 1979, pp. 354-359.

[24] L. Rothrock, R. Koubek, F. Fuchs, M. Haas, G. Salvendy, Review and reappraisal of adaptive interfaces: toward biologically inspired paradigms. Theoretical Issues in Ergonomics Science, 3(1), 2002, pp. 47-84.

[25] D.S. Weld et al. Automatically personalizing user interfaces. In Proc. of the Int. Joint Conf. on Artificial Intelligence (IJCAI03), Acapulco, Mexico, 2003, pp. 1613-1619.