Frame work for Adaptive Mobile Interface: An Overview

Kishor H. Walse
Research Scholar, S.G.B. Amravati University, India

Rajiv V. Dharaskar
Director, Matoshri Integrated Campus, Nanded

Dr. V. M. Thakare
Professor & Head, P.G. Department of Computer Science, S.G.B. Amravati University, Amravati, India

ABSTRACT
The field of Adaptive Interfaces has been an active area of research for over ten years. While there have been great advances, unresolved issues remain. We first define a general and theoretical model of adaptive mobile interfaces based on a survey of existing research. Using our generalized adaptive interface model, we then proceed to build taxonomies of variables used for adaptation. The objective of this effort is to provide researchers, designers, and builders a better understanding of the underlying mechanisms, processes, and outcomes of adaptive mobile interfaces.

General Terms
Algorithms, Human Factors

Keywords
Framework, Context, Adaptive, Mobile, User Interface, Soft Computing,

1. INTRODUCTION
Adaptive application means capability of application to modify its own behavior in response of changes in its operating environment. The Adaptive Mobile interfaces (AMI) is multidisciplinary field comprising of various fields of the Computer Science & Engineering like Ubiquitous computing, Pervasive Computing, Ambient Intelligence, Human-Centered Computing, Human Computer Interfaces, Mobile Computing Artificial Intelligence, Soft Computing, Graphical User Interface, Internet, Internet Programming Languages and Mobile Services. The advent and advancement of the Web and Mobile Services has brought forward adaptivity as an immensely important issue for both efficacy and acceptability of such services [1].

In the introduction of the special issue of Interacting with Computers about intelligent interface technology, Keeble and Macredie (2000) define an adaptive interface as:

"One where the appearance, function or content of the interface can be changed by the interface (or the underlying application) itself in response to the user's interaction with it."

Langley (1998) considers an adaptive interface as a special class of learning systems and defines it as,

"a software artifact that improves its ability to interact with a user by constructing a user model based on partial experience with that user." [2]

Wickens (1992) stipulates that the trigger for adaptation is not necessarily a user action by stating that,

"Adaptive systems are those in which some characteristic of the system changes or adapts, usually in response to *measured or* inferred characteristics of the human user." [2]

Rouse, Geddes, and Curry (1988) define an adaptive interface from a goal-oriented perspective so that the reason for its existence is

"For the operator to remain in control and be provided with aiding that adapts to current needs and capabilities, in order to utilize human and computer resources optimally and, thereby, enhance overall performance." [2]

Ling Rothrock, Richard Koubek, Frederic Fuchs, Michael Haas and Gavriel Salvendy (2002) define an adaptive interface to clarify the relation between the user and the system is "An adaptive interface autonomously adapts its displays and available actions to current goals and abilities of the user by monitoring user status, the system task, and the current situation."[2]

Adaptive applications behave differently, according to changes on the environment. Implementing this kind of application involves complex issues, so it is important to provide adaptive behavior following quality and productivity factors [3].

The field of Adaptive Interfaces has been an active area of research for over past decade. While there have been great advances, unresolved issues remain. There have been several studies investigating the numerous dimensions of adaptation in interactive software systems namely, what constitutes an adaptation constituent, the level and timing of adaptation, the controlling agent, the type of knowledge that is required to arrive at meaningful adaptations, etc. Nevertheless, despite the substantial contributions of these efforts to the study of adaptation, there are still several issues that need to pay attention, if user interface adaptation is to be adequately served by designers and developers of interactive software applications [4].

Future user interfaces will need to combine the personalization and adaptive aspects of the device with data-sharing enabled by the back-end infrastructure and the seamless integration with Internet services. In addition, they will incorporate an individual's unique characteristics (e.g., movements, activities, environment) and personal needs (e.g., preferred input/output modalities, service preferences, etc.) to seamlessly blend with their lives[5].

Research efforts in the domains of pervasive computing, ubiquitous computing, ambient intelligence and mobile computing aim to integrate computing technology into everyday life. These advancements will enable very diverse users to access many different services with devices in many different environments. It has been argued that this large diversity of changing factors will inevitably give rise to usability problems for the end-user. For at least two decades now researchers claim that user interfaces capable of adapting to the user and its context are the solution that will overcome these usability issues. However, successful examples of such user interfaces are still hard to find in practice[6].

2. REVIEW OF LITERATURE

2.1 User and Context Modeling:
Tim Hussein et al. (2007) [7] introduced a novel approach to determine the most important elements of a given ontology with regard to current context and past user interaction. The resulting weighted network of concepts and instances can then be used as a foundation for adaptation effects. In their approach context relations were fully integrated into the propagation process and thus affect the adaptation activities. After developing a fully functional prototype, they tested with entirely different settings.

P. Brusilovsky et al.(2004) [8] have argued that the evaluation practices for adaptive learning systems (ALS), and adaptive applications and services, in general need to informed and improved by adaptive system models. They have outlined layered evaluation framework, where the success of adaptation is addressed at two distinct layers: user modeling and adaptation decision making. They propose a 'structured approach' to evaluation, where the main phases are evaluated separately.

Karin Leichtenstern et al.(2007) [9] describe an approach of a usage model for specifying each context of the user and the environment as well as the user's goals and mental model. Moreover, they describe their used user-centered process to develop the usage model and rule-set, practical experience in development of mobile interfaces. They consider a need for interfaces which automatically adapt their interaction and presentation capabilities on the user's situational needs and expectations to decrease the complexity of the environment and increase the usability of the system. Therefore, a rule-set is required which gives knowledge on the mobile interface's adaptations as a consequence on a user's situations within the environment. This rule-set iteratively emerges within a user-centered development process by considering and testing each contextual situation of the user when interacting with the mobile interface.

Going towards a "ubiquitous" Web is a critical milestone for leading the Web to its full potential. Redefining the borders among Web, Telco services and businesses will be a logical consequence. Telecom Italia has been preparing to face these disruptive changes focusing on its assets and pursuing new service concepts, service enablers and platforms. Claudio Venezia et al. (2008) [10] tries to identify both constraints and opportunities of these new scenarios taking into account emerging standards and research initiatives. Telecommunication services tend to be too general and can hardly compete with Web 2.0 ones. Nevertheless operators handle much information regarding their customers such as their profiles or the context (connectivity, location etc.) they're operating in. Telecom Italia is planning to leverage on those data and is now creating the basis for future services to be sensitive to user context. Their paper describes the achievement of a context aware service platform for developing new context aware service concepts. They take into account various eligible standards or standardization proposals, a context management platform and a Web 20 context aware application case study.

Tommi Nykopp (2001) [11] In his work methods for Electroencepephalogaphy (EEG) signal preprocessing and statistical modelling related to the brain computer interfaces were studied. Brain computer interface is a device for controlling various applications by user's conscious control of thoughts. No use peripheral nerves or muscles is required.

Alfred Kobsa (1995) [12] work in user modeling has so far mostly been concerned with "normal" users. User characteristics which have been modeled include users' domain knowledge, goals, plans, interests, preferences and misconceptions. The adaptation takes place at the level of the content of the provided information (as opposed to the level of information presentation at the interface).

2.2 Adaptive Architecture:

With the advent of Graphical User Interfaces (GUIs) and the advances of input/output technologies, there has been a shift of perspective, from user interface programming tools to environments for designing interaction. This is partly attributed to technological maturity and partly due to the increasing requirement to support a need-driven and user-centered protocol for design, development and implementation of interactive systems. Constantine Stephanidis et al. (1998) [4] investigates the architectural shortcomings of existing user interface development systems and environments with respect to supporting adaptation of a user interface and discusses methods, techniques and tools that are needed to empower user interface designers. In particular, the paper describes a high level architecture comprising user interface software components that can provide the required design, development and implementation support that is needed to facilitate user interfaces for different user groups with diverse requirements abilities and preferences.

Esko Juuso et al. (1996) [13] presented adaptive and intelligent methods can enhance properties of simulation interfaces and usability of the simulators. Different methodologies of soft computing can find their own role in the overall system, and all the methodologies, including expert systems, should be adapted to appropriate levels in simulation applications. Expertise on different domains could be acquired into wider use through soft computing.

To achieve truly adaptive applications, we need to design and implement a number of components. Thomas Kunz et al.(2002) [14] presented an architecture for adaptive mobile applications that gives an overview of the relevant pieces and how they interact. In their architecture, they distinguish two proxies, a high-level proxy and a low-level proxy. They play distinctive roles and require different mechanisms for implementation.

J. Lindenberg (2003) [15] presented study was part of the CACTUS Research project (Context Aware Communication, Terminal and User) funded by the Dutch Government (www.cactus.tudelft.nl) and was carried out at the TNO Human Factors Research Institute were found that the users that were supported relied heavily on the user support and therefore spent less effort on actually learning the rules behind the adaptive behavior.

Zur Erlangung des Grades (2005) [16] presented a platform-independent, semantic web based, ubiquitous user modeling service for the deployment of (augmented) real world environments as well as world wide web applications, which has vastly been tested by several independent applications.

Eija Kaasinen (2005) [17] propose the Technology Acceptance Model for Mobile Services. The model is a modification of the original Technology Acceptance Model by Davis (1989). According to the Technology Acceptance Model for Mobile Services, user acceptance of mobile services is built on three factors: perceived value of the service, perceived ease of use and trust.

3 MAIN APPROACHES TO ADAPTIVE INTERFACE DESIGN

The literature on the subject of adaptive interfaces is very heterogeneous and closely linked with each domain of application. We can, however, classify existing designs and models along three main points of views: human-factors, human-computer interaction, and hybrid. In the following sections, we point out distinguishing concepts between the interface models, and clarify the terminology used by each of the research communities.

3.1 The Human Factors Approach

The human factors approach focuses on two main topics. The first topic addresses the appropriate choice of automation level and the degree to which a task must be shared between the operator and the system. The issues that are typically raised include the selection of tasks to be automated, the time at which automation should be switched on or off, and the entity (human or machine) that is responsible for the switch. The second topic focuses on the identification and measurement of the user's resources. Of particular interest is the issue of workload, which is assumed to be the main trigger of the adaptive process. To gauge user-triggering processes, human factors practitioners use a wide range of possible inputs about the user's physiological state (e.g., EEG, heart rate variability), and the user's behavior (e.g., eye tracking and task performance). An example of the human factors approach is the general framework proposed by Wickens (1992) called the Closed Loop Adaptive Systems. In his system, the switch to indicate automation level is controlled by a set of decision rules that resides within a computational mechanism called the CLAS manager.

3.2 The Human-Computer Interaction Approach

In the HCI field, adaptive interfaces are often called Intelligent User Interfaces. The number of applications using an "Intelligent Interface" is rapidly growing. This approach focuses on a table of variables that categorizes the user called the user profile. Of particular interest within the profile are user's goals and preferences. The profile is inferred by analyzing the user's behavior, which generally consists of his interactions with the system. The inputs are mostly restricted to the records of the user's action on the keyboard or the mouse. Typically, HCI models are designed for very specific applications. A standard framework for developing Intelligent User Interfaces is the one proposed by Benyon and Murray (1993) as is illustrated in Figure 4. The user model describes the user in terms of abilities (the psychological data, cf., profile information, and domain knowledge (the student model). The domain model defines the scope of the system by characterizing inferences about user goals (the intentional level), the logical construct of the system (the conceptual level), and the basic mechanisms through which the user interacts with the system (the physical level). The interaction model consists of a historical record of the user's interaction with the system (the dialogue record), means to carry out the adaptation process (adaptation mechanisms), ways to execute the inference process (inference mechanisms), and methods to conduct evaluations of system effectiveness (evaluation mechanisms).

3.3 Hybrid Approaches

To incorporate the user-centered focus of the human factors approach with the systems-oriented view of the HCI approach, researchers have derived hybrid frameworks. Jameson (1999) proposes a general diagram for processing in a user-adaptive system. Shown in Figure 5, the diagram is synthetic and outlines a process where the input feeds an upward inference to model the user, and a downward inference mechanism then infers decisions from generally relevant properties of the user model.

In a separate model, Brusilovsky (1996), also decomposes an adaptive system into two stages (Figure 6). The first process models the user while the second relies upon the generated user model to provide the basis of adaptation. The 19 important distinction of this framework is that the user model is supplied by the system designer.

A third framework proposed by Virvou (1999) requires two processes for an Intelligent Help System (IHS). This framework highlights the dynamic process between a User Modeler and an Advice Generator. An IHS, she proposes, usually consist of four components: the Domain Knowledge, the User Modeling Component, the Advice Generation component, and the user interface (Figure 7).

The domain knowledge component provides the information about the domain of the software package for which the IHS has been constructed. The User Modeling Component models the user's beliefs and intentions concerning the software package with which he is interacting. While this framework is appealing, Virvou (1999) does admit that the functionality of these components are not clear cut and may vary considerably in different implementations of help systems.

. Inputs

In order to adapt to the changing situation, the system must receive information from the user, the environment or the system itself. The raw inputs are usually recorded so that the system can identify state changes over time. Examples of raw inputs include user's actions on the keyboard, EEG records, and monitored output of the controlled machine.

3.4 Selected User Variables

All adaptive interfaces have user profiles which can be classified as sets of user categories defined by the values of variables. The variables selected in the user profiles are used by the system to trigger and define the adaptation. Examples of user variable include the user's knowledge and workload.

3.5 Identification Inference Mechanism

This mechanism infers the values of the user variables from the raw inputs. The inference mechanism is basically a classifier. It can be a neural network, a formal logic program or any technique that helps to classify a complex and uncertain situation into separate and identified variables. An adaptive interface can include several inference mechanisms of different types.

3.6 Interaction model

The interaction model is specified by the system designer. It contains the possible displays, the possible steps, and the rules of the interaction in order to perform a specified task. It includes an implicit structure of the task, and defines the presentation alternates and options. The interaction model can be constructed using a decision tree or logical rules. The model is later used to predict future steps of interaction.

3.7 Decision Inference

The decision inference can be considered as the second layer of the inference mechanism. It chooses the next steps of the interaction, according to the state of the variables inferred previously and the rules of the interaction model. The decision inference can be quite simple and logic-based. For instance, if the user has a certain profile, then a pre-specified aspect of the interface will be modified in a certain manner. The mechanism can also be more sophisticated if the system has to project the consequences of the adaptation before applying it or proposing it to the user.

3.8 Environment Variables

Changes in the environment (e.g., weather changes, unexpected mission changes, workspace changes) or changes in the system (e.g., part failure, power loss, efficiency reduction) can call for an adaptation of the interface. Some of the authors, like Virvou (1999), combine the environment variables and the system variables into an entity known as the domain model. Others merge parts of the environment model with the user model, and integrate the data of the system model in the user's goals.

4. A FRAMEWORK TO STUDY ADAPTIVE INTERFACES

Based on our review of existing work, we have constructed a general framework of adaptive interfaces. The objective of this effort is to enable researchers, designers, and builders to gain a better understanding of the underlying mechanisms, processes, and outcomes of adaptive interfaces. As a starting point, we describe a set of elements that are common to all adaptive interfaces. These include:

- Inputs
- User variables
- Identification inference mechanism
- Interaction model
- Decision inference mechanism

- System or environment variables
- Selection mechanism
- Evaluation mechanism.

We submit that while not all the elements are used in all adaptive interfaces, the set is inclusive of what may be needed in each adaptive interface. We present a survey of existing interfaces along key elements later in the paper.

5. CONCLUSION

In handheld and ubiquitous computing, a user's context is very dynamic. To promote a more effective use of context, we have provided definitions and categorizations of context.

6. REFERENCES

[1] Abdul-Rahim Ahmad, Otman Basir and Khaled Hassanein (2004), "Adaptive User Interfaces for Intelligent E-Learning: Issues and Trends", 4th International Conference on Electronic Business (ICEB2004) / Beijing, pp 925-934

[2] Ling Rothrock, Richard Koubek, Frederic Fuchs, Michael Haas and Gavriel Salvendy (2000), "Review And Reappraisal Of Adaptive Interfaces: Toward Biologically-Inspired Paradigms", Theoretical Issues in Ergonomic Science

[3] Dimitar Birov (2004), "Aspects Pattern Oriented Architecture For Distributed Adaptive Mobile Applications", International Conference on Computer Systems and Technologies - CompSysTech'2004

[4] Constantine Stephanidis, Demosthenes Akoumianakis, and Anthony Savidis, "Design representations and development support for user interface adaptation".

[5] Dr. Claudio Marinelli (2009), "Open Threads", Open innovation News Letter, Nokia Research Center (NRC), April 2009.

[6] Christos Efstratiou, K. Cheverst, N. Davies And A, Friday, "Architectural Requirements For The Effective Support Of Adaptive Mobile applications".

[7] Tim Hussein and J. Ziegler, "Adapting web sites by spreading activation in ontologies".

[8] P. Brusilovsky, C. Karagiannidis and D. Sampson (2004), "Layered evaluation of adaptive learning systems, Int. J. Cont. Engineering Education and Lifelong Learning", Vol. 14, Nos. 4/5, pp 402-421.

[9] Karin Leichtenstern and Elisabeth Andre (2008), "User-Centred Development of Mobile Interfaces to a Pervasive Computing Environment", ACHI2008, ACM Proc. CHI 2008, April 5–10, Florence, Italy

[10] Claudio Venezia, Carlo Alberto Licciardi, "Improve ubiquitous Web applications with Context Awareness".

[11] Tommi Nykopp (2001), Statistical Modelling Issues for The Adaptive Brain Interface, Department of Electrical and Communications Engineering, Helsinki University of Technology.

[12] Alfred Kobsa (1995), "Supporting User Interfaces for All Through User Modeling", proceedings of HCI International' 95, Yokohama Japan, pp155-157.

[13] Esko Juuso and Kauko Leiviska (1997), "Adaptive Interfaces and Soft Computing", http://www.ici.ro/SIC/sic1997_2/ESKO1.html

[14] Thomas Kunz and James P. Black, "An Architecture for Adaptive Mobile Applications", http://kunz-pc.sce.carleton.ca/mobile_research

[15] T.F. Paymans, J. Lindenberg, M.A. Neerincx (2003), "Usability issues of adaptive user interfaces",http://www.cactus.tudelft.nl.

[16] Zur Erlangung (2005), Ubiquitous User Modeling, Ph.D. Dissertation.

[17] Eija Kaasinen (2005), User acceptance of mobile services – value, ease of use, trust and ease of adoption, Thesis for the degree of Doctor of Technology, Tampere University of Technology, ISBN 951.38.6640.8