Method to Design Adaptable and Adaptive User Interfaces

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Abstract. In order to study and develop adaptive user interfaces with the purpose to guarantee socialization, safety and environmental sustainability in a domestic day-by-day living space, a new method of holistic and adaptive user interface is proposed to support the modelling of information related to the user and the context of the interaction to generate the user profiles, subjects older than 40 years with different levels of technology affinity have been considered. The new adaptive user interfaces prototypes will be tested through different use cases in the context of smart home environments.

Keywords: User interfaces · Adaptive interfaces · User-centered design · Design for AAL

1 Introduction

Designing a multi-user adaptive interface means designing for a diversity of end-users and contexts of use, and implies making alternative design decisions at various levels of the interaction. To this end, a method for the construction of a single interface design instance is inappropriate, as it cannot accommodate for diversity of the resulting dialogue artifacts. Therefore, there is the need for a systematic process in which alternative design decisions for different parameters can be designed with appropriate dialogue patterns, along with their associated parameters (e.g. user and usage-context-attribute values). The present study provides an overview of the methods currently applied to the definition and development of Adaptive User Interfaces (AUIs). Then an approach to support the definition and design of a novel adaptive user interface able to react with the human behavior is presented, showing the results of a pilot conducting with older and disable users with a new AUI.

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2 Research Background

The concept of a system able to adapt itself depending on requirements or criteria other than, or even at user's request, is not new. The research literature describes many approaches that can be used to design flexible user interfaces, which can be classified into two broad categories: adaptable and adaptive. Adaptable User Interfaces (AdUIs) can be defined as systems in which the activation and selection of user-computer interaction, is performed by the final user through the selection of a specific user profile from a predefined list. The Adaptability is based on the users' known characteristics and preferences; these are defined prior to their interaction session and, in any case, are assumed to remain static during the session [1]. Benyon [2] defines Adaptive Systems as systems, which can alter aspects of their structure or functionalities in order to accommodate different users' needs and their changes over time. Adaptive systems are based on the principle that the system should be capable of identifying those circumstances that necessitate adaptation, and accordingly, select and effect an appropriate course of action. The most important advantage of adaptable systems is that the users are in total control of the individual appearance and interface. Otherwise, the use of adaptive user interface seems to help to improve user interaction with systems by facilitating user performance, minimizing the need to help request, easing system.

The Adaptive User Interface research field aims to provide highly usable systems for people with different needs and characteristics in different context of use. Consequently, Adaptive User Interfaces constitute one of the major direction of Human Computer Interaction research. The AUI design is not a simple task [3] and nowadays a unified methodology wasn't modeled because many aspects are involved. Its development requires assessing the state of mind, state of psychology and level of awareness about the target user; defining a suitable adaptation behaviour [4]; assessing the adaptation timeliness [5]; defining a general method in the absence of a experimentation; assessing the usability and acceptability of a user interface without an established methodology; avoid to damage user's privacy, and give unwanted information. Therefore the AUI design is started from several fundamental choice: (1) Establish who should adapt and what should be the role of User Interface in the adaptation process, (2) Define what goals should be mainly considered in the adaptation process, (3) Define a proper set of rules to manage the adaptation, (4) Define what level of the interaction should be considered and what are the adaptation variables. (5) Define methods in the adaptation process, an inference mechanism for the user's choice. Furthermore, some studies indicate that an intermediate level of adaptivity mixed to adaptability should be consider as a good compromise, as it can help to keep users involved in the task and help them to become more skilled to perform routine and non-routine tasks [6, 7]; consequently the interface design has been implemented in order to make it adaptable and adaptive at the same time.

3 Proposed Method

In order to study and develop an adaptive and adaptable user interfaces with the purpose to guarantee socialization, safety and environments sustainability in a domestic day-by-day living space, a new method of holistic and adaptive user interface is proposed to support the modelling of information related to the user and the context of the interaction to generate singular user profiles. This implies the definition and development of holistic and adaptive user interfaces aiming to satisfy the different utilization profiles/contexts and user requirements/skills. The target of this work is the development of new methodologies for human-machine interaction and for user interfaces, according to the "design for all" paradigms [8]. The user interfaces will be adaptive, meaning that they will be easy-to-use and friendly for users, including elderly and weak people. The novel user interfaces will react with the human behaviour, and interact in accordance with the environmental conditions monitored by local sensors. The adaptation management system is based on the knowledge provided by three information models: the User Model, the Environment Model (or Domain Model) and the Interaction Model (Fig. 1).

The User Model (UM) provides the description of the user's profile pattern, according to its cognitive and physical structure, status and preferences. The user's profile pattern is outline according to the coding provided by the International Classification of Functioning, Disability and Health [9].

The Environment Model (EM) supplies the information pattern necessary to describe the environment of the human machine interaction. Such information are related to its physical characteristics (e.g. typology of interactive devices, available means of interaction, etc.) as so as to its functionalities (e.g., supported activities or tasks) and its logical characteristics (e.g., information relates to management of the system functionalities performed by the adaptive interface).

The Interaction Model (IM) is the core of whole adaptive process: this model is in charge of the user and environmental model data management. The IM have to recognize the user and store its needs and preferences. In addition it have to be able to extract human-computer interaction information, provide the correct logical and task interpretation, allow a much more suitable environmental usability and define the event activation

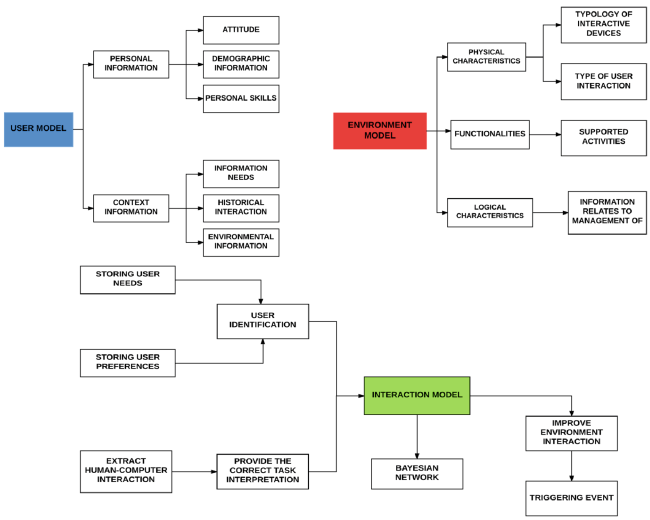

Fig. 1. The adaptation management system

schedule. Such complex adaptive systems require inference and evaluation mechanisms, which need to learn and interact with the local environment. In an adaptive mechanism there is no direct access to the whole domain reality; the system to be developed must act within a range of uncertain data: such as unreliable, missing and inaccurate data. In addition incorrect environmental data may raise inaccuracy. Probabilistic theories provide the methods to correctly deal with inaccurate data systems, resulting from lack of domain knowledge. The Bayesian approach provides a robust theory that merges together different technologies. Automatic learning is based on the idea that experience may improve the "agent" capability behaviour and future events, providing the ability to automatically update users profiles and predict users behavior [10].

4 Adaptive and Adaptable System Layout

On the basis of the model mentioned above a preliminary view of the architecture for managing the user interfaces implementation has been conceived as follows.

The system architecture is based on 3 main units, continuously communicating between each other: the database, the core engine and the user interface (Fig. 2).

A Database Management System (DBMS) is designed to achieve a large set of structured data inputs and processes the amount of data requested by numerous users; this unit is in charge to collect the data arising from the different input of the system. In particular, the information is structured in four semantic areas. User Features Profile includes the Personal Information described previously in the User Identification; User Use Profile includes the User Model Context Information: previous interaction's history, user's preferences and information needs. Log Adaptation Actions represents the collection of all adaptation actions performed by the interface. It receives the information each time that the system performs an adaptation action: this information is necessary to control the system's adaptation degree and simultaneously the user's skills improvement in the process. Context Data, upon which are gathered all relevant data for the context user definition of the system. It shall record the information derived from environmental sensors (spatial context) associated with temporal coordinates.

The core module represents overall adaptive system pivot: it is composed of two adaptive mechanisms and a monitoring system of changes. Adaptable Engine shall

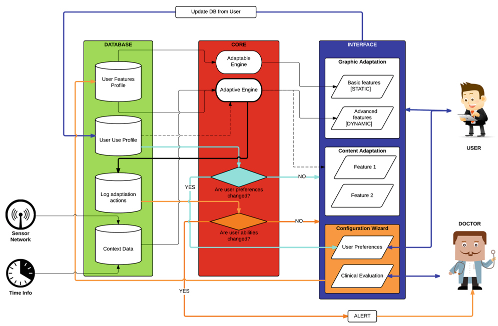

Fig. 2. Adaptive and adaptable system architecture layout

make the system adaptable according to user profile. Adaptability is based on features and preferences that are known at a first interaction, and they are assumed to remain static during a single session of interaction. This engine takes as input the collected information in the User Profile Features to adapt the graphical interface features, such as text, size and type of font. Adaptive Engine shall make the system adaptive according to the use profile. Adaptivity is based on change mechanisms which include all dynamic features, such as interaction story based preferences, information contents, icons, layout, etc. The working systems take advantages of Bayesian Network adaptation mechanism, by using software called Netica. It depends on information by User Features, User Use and Context Data database, and apply changes on the Interface level: graphical (dynamic) and contents. Change monitoring system allows to generate two alert types: User Preferences Changes takes into account the user preferences changes, in terms of both graphics and content; User Abilities Changes takes into account the interface changes (both graphical and content), store them and send an alert when they frequently change, both in a positive and negative way, going to update the User Features Profile. Finally, the interface module allows enabling system interaction and communication with user. In particular, system identifies two types of users: the consumer is the target user the adaptation support process is implemented on; the specialist doctor who represents the linking point among ICT system and health condition evaluation of the consumer. The interface structure can be synthetized into two aspects described below. Graphics can be organized basic features (static), i.e. standard features uniquely related to a disorder (colour blindness, visual disturbances, etc.). These features are related to loss of body functionalities and feasible with the aid of existing guidelines. Advanced features represent all dynamic features about adapted interface items according to specific residual function consequent to a specific disorder and they is designed on a single user. Contents represent all interface items editable according to user and actions the user acts on interface, own preferences and needs. For instance, considering a kitchen, if the user decides to enter in the oven section, the system will offer in evidence more used recipes. Finally, Configuration Wizard is a tool able to allow modify User Preferences (by user or specialist doctor) but also the Clinical Evaluation (by only specialist), a high-level questionnaire is presented in to clinical parameters configuration.

5 Conclusion and Future Works

In order to develop a novel AUI according to the “design for all” paradigm, an holistic approach is proposed. It is based on modelling information related to the user and the context of the interaction. In particular the target of this work is the development of a new methodology for human-machine interaction and for user interfaces. In accordance with the project, some areas of weakness have been highlighted; these outline the specific characteristics of the user such as sensory disturbances/perceptual, cognitive and mood disorders. A preliminary pilot is defined to evaluate the users’ performance analysing on one hand, adaptability of the text elements adaptivity of interface layout and icons (size, position and contrast), on the other hand, the subjective skills in the use of technology and appropriateness of features characteristics. Subjects older than

40 years with different levels of technology affinity will be considered to generate the user profiles. All the information gathered from the pilot study will be used to define the main guidelines of the adaptation criteria interface based on disorder users. The final goal is to produce features able to automatically satisfy the different skills, abilities, needs and human preferences, and not simply finding a single solution for everyone. Future application scenarios will be the living room and the kitchen that are characterized by a large number of household appliances.

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References

1. Grundy, J., Hosking, J.: Developing adaptable user interfaces for component-based systems. Interact. Comput. **14**, 175–194 (2014)
2. Benyon, D.I.: System Adaptivity and the Modelling of Stereotypes. National Physical Laboratory, Division of Information Technology and Computing, Teddington (1987)
3. Yen, G.G., Acay, D.: Adaptive user interfaces in complex supervisory tasks. ISA Trans. **48**, 196–205 (2008). Oklahoma State University, School of Electrical & Computer Engineering, Stillwater, OK 74078, USA
4. Billings, C.E.: Aviation Automation: The Search for a Human-Centered Approach. Erlbaum, Mahwah (1997)
5. Horvitz, E.: Principles of mixed-initiative user interfaces (1999)
6. Bunt, A., Conati, C., McGrenere, J.: What role can adaptive support play in an adaptable system? In: 9th International Conference on Intelligent User Interfaces, Funchal, Madeira, Portugal, 13–16 January 2004
7. Zimmermann, G., Vanderheiden, G.C., Strobbe, C.: Towards deep adaptivity – a framework for the development of fully context-sensitive user interfaces. In: Stephanidis, C., Antona, M. (eds.) UAHCI 2014, Part I. LNCS, vol. 8513, pp. 299–310. Springer, Heidelberg (2014)
8. Sacco, M., Caldarola, E.G., Modoni, G., Terkaj W.: Supporting the Design of AAL through a SW Integration Framework: The D4All Project (2014)
9. International Classification of Functions, Disability and Health (ICF), World Health Organization
10. Cooper, G.F., Herskovits, E.: A bayesian method for the induction of probabilistic networks from data. Mach. Learn. **9**(4), 309–347 (1992)