Homogener Multimodaler Zugang zum digitalen Zuhause für kognitiv behinderte Menschen

Homogeneous Multimodal Access to the Digital Home for People with Cognitive Disabilities

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Kurzfassung

Dieser Artikel stellt ein multimodales Dialogsystem vor, das kognitiv behinderten Menschen den Zugang zum digitalen Zuhause erleichtern soll. Die Benutzerschnittstelle ist auf einem Smartphone implementiert und erlaubt Interaktionen mit Hilfe von Sprache und Zeigegesten. Ein konsistentes Konzept und selbsterklärende graphische Darstellungen sollen die Bedienung möglichst intuitiv gestalten. Durch den ISO Standard URC kann das System heterogene Heimgeräte überwachen und kontrollieren. Ein Schwerpunkt liegt auf der gemeinschaftlichen Lösung von Problemen, wodurch Benutzer mit Gedächtnisproblemen bei der Planung und Durchführung von Aufgaben unterstützt werden. Weiterhin ist die Reaktion des Systems auf Benutzer und Interaktionskontext angepasst.

Abstract

This paper introduces a multimodal dialogue system, which facilitates access to the digital home for people who suffer from cognitive disabilities. The user interface is implemented on a smartphone and allows interaction via speech and pointing gestures. A consistent control concept and a meaningful graphical design allow an intuitive handling of the device. The ISO standard URC enables the system to supervise and control heterogeneous home devices. One focal point is collaborative problem solving which supports users with memory deficits in planning and pursuing objectives. Furthermore, the reaction of the system is adapted to user and interaction context.

1 Introduction

With the development of new technologies and appliances for home entertainment and household, the number of inhomogeneous user interfaces for home devices increased enormously. In a modern living room, people generally have to deal with a variety of remote controls, since devices such as TV, radio, stereo, DVD player or taper recorder, all come with their own remote control. TV, radio, stereo, DVD player or tape recorder. A mobile phone and an electronic organizer complete the picture of the control chaos. The difficulty for a normal user is to learn and to adapt to new control concepts since nearly every company follows their own design concept.

Developers face the challenge of creating new intuitive concepts, in order to make the user comfortable with using their new device directly after unpacking. A look into a normal household reveals that they are not always successful. Most remote controls and and mobile phones have a huge amount of buttons and a lot of functions a normal user never needs. While users with technical expertise and a great interest in modern devices cope with the controls after some time, especially the elderly or people with cognitive disabilities never get a chance to use all electrical devices in their home.

The i2home project [1] addresses this problem with an approach based on existing and evolving industry standards. It focuses on the use of home appliances and consumer electronics by persons with cognitive disabilities and older persons.

I2home will be build upon a new series of industry standards (ISO/IEC 24752 & CGA 2018) for interfacing networked appliances by means of a Universal Remote Console (URC). It will use an architecture that incorporates a Universal Control Hub (UCH) as core component which provides and manages the communication to networked (off-the-shelf) home appliances and consumer electronics devices through industry networking protocols.

1.1 User-Centered Design

The use case for the dialogue system we present in the next chapter aims at people with brain injuries and mild cognitive disabilities. Typical problems those people face

are summarized in the story of the fictive person Emma. Emma suffers from the follow-up of a car accident with brain trauma which results in concentration problems and memory deficits. She is 26 years old and open to new technical devices, trying to use them in her daily life. Her injuries affect her in learning new control concepts and Emma has difficulties in differentiating between the various functionalities of the remote controls for her TV, VCR, and stereo.
More complex tasks like recording a DVD are nearly impossible for her. Due to her memory deficits Emma's ability of problem solving is limited. She might thus forget her last step or even forget the complete plan.

The i2home project has been designed around the user centered design approach (UCD) [2]. The story about Emma and her limitations are the driving force for the development. Figure 1 depicts the four phases of the user-centered design. In the first phase the future users of the system get interviewed and corresponding scenarios are constructed. The result is used to implement a first version of the system including evaluation of mockups and pre-version of the system or parts thereof. In the next phase tests with the real system are performed in the participant's daily environment. The outcome of the tests are evaluated and become input of the next cycle of UCD.

For the i2home system the cycle is executed three times, each time with a more advanced system containing new interaction features and targets.

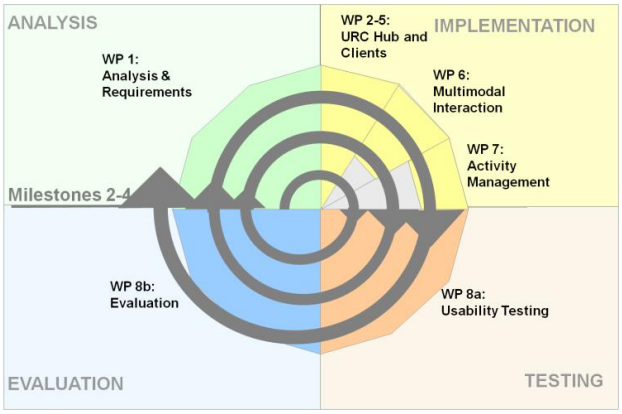

Figure 1: The four phases of user centered design: Analysis, Implementation, Testing and Evaluation

2 Pluggable User Interfaces

It is a commonly accepted opinion that most of today's technologies are not accessible to a major part of the society, which applies notably for consumer electronics as well as household devices. Most of the functionalities offered by modern automation solutions, that in fact are intended to ease the every-day use of home appliances, are too complicated to be communicated understandably to the end users. This situation is particularly disadvantageous for elderly and disabled persons, namely the group of users that should benefit the most from modern technologies.

Typically, in home control, home devices are equipped with user interfaces that are built-in or dedicated remote controls. In the first case, when remote controls are built-in, the user must for example go to the washing machine in order to switch on the device and to select the wash program parameters and then start the washing process. It is not provided that the user can remotely control the washing machine, let alone the option of taking away the control unit. Whereas the second case, when remote controls are dedicated, allows the portability of the control, though it lacks of compatibility with other backend devices since remote controls are normally bound to the device or service they control. Consequently, as home appliances grow, unfortunately the number of remote controls also grows.

Figure 2: Examples of remote controls made by various manufacturers

Remote controls typically differ between each device from different manufacturers in shapes, numbers of buttons and functions, manageability and so forth (fig. 2). The end-user is forced to reconstruct the functionality of the remote control each time a new target device is installed into his environment that is in particular not acceptable for i2home's target user; the elderly and persons with mild cognitive disabilities.

A key concept in i2home is the "Pluggable User Interface" approach that makes it easy to have a uniform design of the user interface and at the same time to have control over different home devices and appliances. The design where the user interface is separated from backend services and devices makes adaption and substitution of user interfaces and their components possible. To this end, the user interface can be exchanged, attached or detached at runtime as appropriate, e.g., a user operates a PDA by click gestures while another user prefers to interact via voice control with the same device. Personalization of the user interface enables to meet the needs and preferences of the target user, which is a striking criteria concerning user interface design in the i2home system. Due to the personalization aspect, it is proven that the usability of pluggable user interfaces exceeds the one of built-in or standard remote control user interfaces [3]. Moreover, scalability of the pluggable user interface concept ideally supports the user-centered design methodology in i2home [4]. It facilitates the process of improving the design of the user interface as a result of the evaluation of one cycle phase as the

development at the frontend side can be realized in an incremental fashion.

The URC framework is a publicly acknowledged standard [5] that is motivated by the notion of pluggable user interfaces. It gives a clear definition of the socket description representing the abstract user interface layer between the backend device and the frontend user interface. Coherence of the user interface is maintained in two ways: First, the description of the abstract user interface is standardized for each device enabling to deploy one controller for all devices. Second, pluggable user interfaces may span multiple sockets of respective devices, permitting the design of one user interface to embrace the functionality of a whole set of devices.

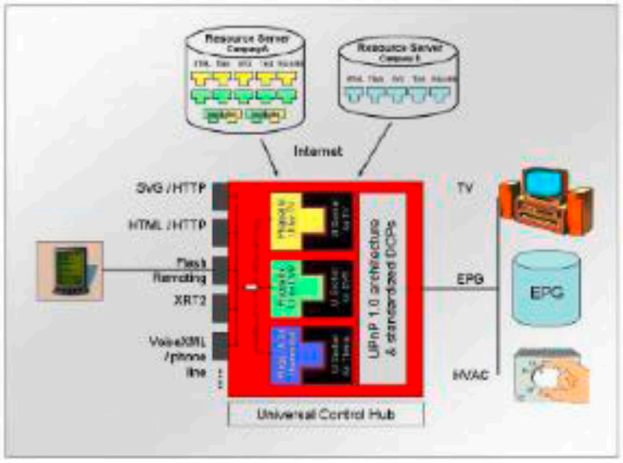

Figure 3: The Universal Control HUB architecture including the devices TV, EPG and HVAC controlled from a PDA

The i2home system architecture (fig. 3) is based on the Universal Control Hub (UCH) [6] which implements the URC framework in the home environment. The UCH represents the control center in i2home enabling the communication between any devices for interacting with the digital home and any backend devices that should be manipulated and/or monitored. A resource server makes pluggable user interfaces available that can be downloaded in order to apply the favored user interface by request. Currently, the i2home system includes target devices such as the TV, HVAC (Heating, Ventilation, Air Conditioning) the hood, a blood sugar meter, a calendar and an EPG service that are monitored by a single controller, a smartphone device (see section 3.2). The smartphone represents a generic controller equipped with a large screen that supports e.g. the customization of the button sizes so as to satisfy the preferences of i2home's target users.

3 Dialogue System

3.1 The ODP Framework

ODP (Ontology-based Dialogue Platform) [7] defines both a generic modeling framework and a run-time environment for multimodal dialogue applications supporting advanced dialogue phenomena. For dialogue authoring, ODP imposes a model-based design approach formalized in terms of ontological concepts and relations. Experience from several research and industrial projects like SmartKom [8] and SmartWeb [9] influenced the design of the dialogue system. The ODP architecture supports a number of functional components that deal with tasks like modality specific interpretation, context-based interpretation, interaction and task management, target control, presentation management and modality-specific generation.

On the technical side, ODP features the connection to external components on both the presentation and the backend layer. Interfaces to important third-party software, e. g. for speech recognition (ASR) and speech synthesis (TTS), are fix parts of the system. At the backend side of the i2home architecture, several, heterogeneous home devices, such as the hood or the TV, are plugged into the system, using the standardized interface URC. At frontend side, the idea of pluggable user interfaces is realized by supporting the connection to arbitrary devices like the smartphone.

3.2 A Multimodal User Interface

The user interface (fig. 4) jointly developed by the German Research Center for Artificial Intelligence (DFKI GmbH) and the Swedish Institute of Assistive Technology (SIAT) consists of a multimodal user interface implemented on a HTC advantage smartphone. It allows interactions as combinations of click gestures and speech. The main task of the smartphone is to function as a mobile remote control for a set of URC supporting home appliances by using consistent and easy to learn control concepts.
Additionally, an embedded calendar and reminder functionality supports the user in everyday life. The user can add new calendar entries, e.g. for taking pills, brush the teeth or visit the doctor. The built in alarm function reminds him to his keep appointments regardless which menu is currently displayed.

4 User Supporting Dialog

The multimodal dialog system supports Emma in two ways. First, the complexity of having to deal with several different remote controls disappears and is replaced by an easy to use, consistent and context-dependent user interface. Second, the planning act is supported by using an approach named Collaborative Problem Solving (CPS). So the system turns away from the classical function oriented approach to a goal oriented control concept, a concept introduced with the name "Situated Delegation-oriented Dialog Paradigm".

4.1 Context and User Dependence

We only use one user interface to control all home devices, which makes it very important to develop an intuitive and easy to handle menu structure. Hence the user should always be aware of the functionality of the

active display while navigating through the menu structure. This task is achieved by presenting one explicit menu for any functionality. In order to avoid a cognitive overload, only the essential information for a task are presented. Additionally, a classification for functions and buttons in different colors helps the user by providing an association between colors and functions.

Interviews during the requirement analysis yield to valuable information for the design engineering. It turned out that individual cognitive malfunctions lead to different problems. Therefore a high dynamical design approach is important to allow flexible interfaces adapted to a special user. E.g., some users have a reduced ability to see an object on the left side of their visual field.
Therefore the location of the buttons and tags is adjustable. Other individual information is the type of feedback the user prefers (audio or visual) or the appliances the user actually should be able to manipulate.

Furthermore the system takes the role of a mediator between user and application. If the user wants to switch the TV channel, e.g. to CNN, the simple commando "Switch to CNN" suffices to switch the channel, independent from the active graphical menu. Furthermore the actual context is regarded when interpreting speech input. If the display shows the graphical menu for the air condition the commando "Turn on" activates the air condition and not the TV or any other appliance.

Figure 4: The i2home user interface for multimodal interaction on a smartphone

4.2 Collaborative Problem Solving

Collaborative Problem Solving (CPS) [10] is a problem solving approach in which two agents jointly try to achieve a given objective. Generally, problem solving consists of three phases:

- Determining Objectives: The agent decides which object it commits to and which will drive its current behavior.
- Determining and Instantiating Recipes for Objectives: The agent determines a recipe in order to solve the objective either by choosing a recipe from a recipe library or by planning a new one.
- Executing Recipes and Monitoring Success: The agent executes the recipe and monitors the process to check for success.

In the collaborative approach, the dialogue system and the user jointly choose and pursue an objective. The user has two basic tasks: to initiate an objective by giving commands and to assist the execution of a plan either by providing additional information or by manipulating the real world, i.e. plug a cable from a DVD player into a tape recorder.
Say the user initiates the objective to create a new calendar entry. The system already has a plan for creating an entry and knows what information is needed for this objective. If some information is missing, a dialogue starts, asking the user for the required information such as date, start-time and end-time, reminder settings, appointment and further comments.
The conversation between system and user during this process can be performed through speech or by entering the data on screen. After all necessary information slots are filled, the dialogue system continues the execution of its recipe and creates the new entry.

5 Evaluation

I2home has adopted Cooper's persona approach [9] to represent users in various stages of the development process. Different concepts of user interfaces employing URC technology has been tested by different partners in the i2home project on different persona.

We report on the evaluation outcome based on the joint cooperation between the Research Center for Artificial Intelligence (DFKI GmbH) and the Swedish Institute of Assistive Technology (SIAT) exploring the needs and preferences on the user interface design of the persona Emma. The result of the evaluation based on the UCD methodology refers to the end of the first development phase which corresponds to the completion of the first cycle in the UCD. The usability of the user interface introduced in 3.2 has been tested by 10 persons living in Sweden. The test participants are in particular 8 male and 2 female participants, 9 in the age between 22 and 40 and one of age 50. Each participant was instructed to operate with two realized backend services, the TV and the calendar. As for the TV the tasks consist of switching on/off the device, changing the volume and to switch between different channels. More challenging were the tasks inherent to the calendar device such as to browse and to add calendar entries.

The feedback of the participants was very promising since all participants successfully completed the test. Further, the participants are instructed to rate the different parts of the GUI using a classification based on a four-choice scale (“bad”, “less good”, “good”, “very good”). We already can forestall that none of the participants has evaluated any of the functions as “bad”. All TV functions were considered as “good”, except the channel switching which was experienced by 5 participants as “less good”, by two participants as “good” and by 3 persons as “very good”. The calendar functionalities were mostly assessed as “good” or “very good”, where less satisfying according to the participants are the tasks changing the view between week and day and the rather complex task to add a calendar entry. Lastly, complaints of the participants were reduced to the physical condition of the smartphone, saying that it is too heavy and too clumsy. Four persons rated the user interface device as “less good” in the category weight and two persons believe that the device does not suit their needs.

6 Conclusion

We have presented a multimodal dialogue system that is specifically tailored for elderly and disabled persons in the digital home environment. The system is developed by a user-centered design approach, which was oriented at people with brain injuries and mild cognitive disabilities.

Interviews in the first phase of the project highlighted the main problems of the target group: reduced ability to memorize, decreased capability of problem solving, lack of attention, problems with reading, linguistic, verbal and visual comprehension. Based on these problems, the user support comprises a context and user dependent design access. The user only gets the information he needs in a special situation, while considering his cognitive problems. Furthermore he is supported in planning tasks by collaborative problem solving.

During evaluation a lot of the introduced menu and dialogue concepts were rated good or very good. These concepts will be resumed and optimized in the next implementation phase. Less good rated concepts will be reengineered with the new perceptions from evaluation.

7 Literature

[1] Intuitive Interaction for Everyone with Home Appliances based on Industry Standards (i2home). http://www.i2home.org/

[2] Julie A. Jacko. The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications. Technologies& Industrial Arts. Lawrence Erlbaum Associates, 2003

[3] J. Nichols and B.A. Myers. "Studying The Use of Handhelds to Control Smart Appliances". International Workshop on Smart Appliances and Wearable Computing, IWSA WC 2003, Proceeding of the 23rd IEEE Conference on Distributed Computing Systems Workshops (ICDCS'03), pp. 247-279.

[4] S. Trewin, G. Zimmermann, and G. Vanderheiden. Abstract representations as a basis for useable user interfaces. Interacting with Computers, Volume 16, Issue 3, June 2004, pp. 477-506

[5] International Standard ISO/IEC 24752. Information Technology - User Interfaces - Universal Remote Console (5 parts). ISO/IEC, 2008

[6] G. Zimmermann, and G.Vanderheiden. The Universal Control Hub: An Open Platform for Remote User Interfaces in the Digitsl Home. Springer LNCS, Volume 551/2007. Human-Computer Interaction. Interaction Platform and Techniques. pp. 1040-1049. Springer Berlin/ Heidelberg

[7] A. Pfalzgraf, N. Pfleger, J. Schehl, J. Steigner. ODP - Ontology-based Dialogue Platform. Technical Report, 2008, SemVox GmbH. http://www.semvox.de/ whitepapers/odp_whitepaper.pdf

[8] W. Wahlster. SmartKom: Symmetric Multimodality in an Adaptive and Reusable Dialogue Shell. In R. Krahl and D. Günther, editors, Proc. of the Human Computer Interaction Status Conference 2003, pages 47–62, Berlin, Germany, 2003. DLR.

[9] W. Wahlster. SmartWeb: Mobile Applications of the Semantic Web. In Peter Dadam and Manfred Reichert, editors, GI Jahrestagung 2004, pages 26–27. Springer, 2004.

[10] Nathan J. Blaylock. Towards tractable agent-based dialogue. Technical Report 880, University of Rochester, Department of Computer Science, August 2005. PhD thesis

[11] A. Cooper. The Inmates Are Running the Asylum. Macmillian Publishing Co., Inc., Indianapolis, IN, USA, 1999.