Smart Sol – Bringing User Experience to Facility Management: Designing the User Interaction of a Solar Control Unit

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Abstract. While a lot of attention is paid to the design of consumer electronics like mobile phones, various other domains have been neglected so far when it comes to user experience. In this paper a user-centered design approach for designing the user interface of a controller for solar thermal plants and heat exchanger stations – called *smart sol* – is described. The design process is characterized by the cooperation of user experience designers on the one hand and engineers and programmers on the other hand.

Keywords: user experience, user-centered design, user interface design, human-machine interaction, nontraditional user interfaces, facility management.

1 Introduction

Electronic appliances can be found throughout our homes and are increasingly influencing our everyday lives. We are not just affected by consumer electronics like mobile phones, personal computers or flat screen televisions, but by a still growing number of information appliances like digital watches, heat regulators or control units for microwaves or ovens that can be characterized by small displays and hardkey interactions. Almost everyone interacts with this kind of devices on a daily basis [1], [2]. The way we deal with them is to a large extent affected by the usability and user experience (UX) they provide: Creating pleasurable designs is different from eliminating frustration: "This is where designing an experience – not just a product – begins." [3] User experience can be defined by the attributes *useful, usable, valuable, findable, credible, desirable* and *accessible* [4]. Research in the last few years has focused on user experience design for consumer electronics, e.g. [5], [6], [7], [8]. At the same time other everyday information appliances have received little attention in this respect [9], [10].

User interface guidelines and sets of predefined input controls limit the design space for desktop and mobile interfaces, e.g. [11]. While each application provides different functionality, users can expect consistent controls for standard operations such as opening, closing or setting preferences. This predictability is completely absent in nontraditional interfaces [12].

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In this paper we describe a user-centered design (UCD) approach for the solar control unit *smart sol* within a research, which is funded by the Bavarian Ministry of Economic Development[1] and involving user experience designers of the *University of Regensburg* on the one hand and engineers and programmers of the domestic and environmental engineering company *emz Hanauer*.[2] In the first section we start with a characterization of nontraditional interfaces taking a closer look at small-screen devices and the diversity of input methods for such nontraditional interfaces. In a second step, state of the art user interfaces of control units for solar heating systems for home environments are described. This is followed by a case study, which describes the user-centered design process of the *smart sol* user interface.

2 Nontraditional User Interfaces

[12] characterizes nontraditional interfaces as “beyond the GUI”. This definition includes all types of interfaces, which differ from the windows, icons, menus and pointer metaphor (WIMP) of standard personal computer software. Because of the huge variety of context of use, input and output devices, nontraditional interfaces have a lack of standards and common guidelines [1].

2.1 Small-Screen Interfaces

Examples of small-display devices are mobile phones, digital audio players, car entertainment and navigation systems or control interfaces for home appliances [2]. Designing for small-screen user interfaces is affected by particular constraints and characteristics including non-standardized input methods, limited screen-size and amount of information that can be displayed, the specific techniques for data input and in general the lack of standardized user interfaces [1], [2], [13]. Designers have to pay special attention to the way information is presented on the screen (visual angle, viewing distance, luminance, character and font attributes as well as display placement) as well as on the organization of the information (menu structure and depth, icons) due to the screen-size limitations and the variety of the context of use (private vs. public space, bright vs. dark environment etc.) [14], [2]. Due to the market penetration of modern mobile phones with their specific interaction design (touchscreens, gesture-based interactions), users’ expectations for other application fields have been raised. One of our observations is that user experience issues will become a decisive factor for a broad range of appliances.

2.2 Input Methods for Nontraditional User Interfaces

Nontraditional interfaces lack standardized input devices like mouse or keyboard known from human-computer interaction. Thus not just designing the elements of the user interface, but all aspects of the way the user interacts with the appliance have to be considered [15]. Therefore interaction design is challenged by a reasonable and

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2 `http://www.emz-hanauer.de`, a leading producer of heating, water and solar installation, based in Nabburg, Bavaria [accessed February 2011].

usable combination of hard- and software parts. Additionally, designing for a good user experience requires that the user interface is not just evaluated in terms of simplicity, ease of use, efficiency and effectiveness to complete a specific task, but also with respect to aesthetic and emotional aspects of design that influences users' perception of appliances as valuable or desirable [7], [16], [17].

An informative overview of the variety of input methods for nontraditional interfaces can be found in [18]. Common input controls used in conjunction with small displays are buttons, joysticks, arrow keys and touch interfaces [18]. Typical combinations involve sparsely labeled small buttons to be used for controlling the device along with small alphanumeric displays (e.g. seven-segment LCD displays).

3 Need for Action: HCI for Control Units in Facility Management

Facility management ensures the functionality of the built environment by involving multiple disciplines and integrating people, place, process and technology [19]. Facility management has to address private homes, housing estates and industrial environments individually, since their needs of management are fairly different. In this paper we will focus on facility management technology of home environments.

Fig. 1. Examples of a state of the art solar control units [20]

Facility management control devices are characterized by growing complexity: Continuously increasing feature sets are accompanied by large menu structures and heterogeneous user groups. Typically, user interface development lacks an (professional) outside perspective: The user interface of state of the art control units is designed and implemented by the very same engineers that are responsible for the features of the system, typically engineers or computer scientists without formal training in human-computer interaction. End user requirements (user-centered design) are not integrated into the development process. In many cases, usability and user experience are considered as nice-to-haves, but mostly ignored due to financial and time constraints or lack of awareness [9]. As a result, most user interfaces of solar control units offer a small monochrome display and the interaction is based on buttons or a combination of buttons and knobs. Complex and counterintuitive interaction steps which include pressing two or more buttons simultaneously for some seconds in order to de-/ activate a certain feature are widespread (see figure 1).

Because of their poorly designed interfaces, such control units are hardly ever used. The interfaces are not intuitive and hard to learn. As these devices are not used on a day-to-day basis, users will not remember complicated interaction steps and never touch them again.[3] Most users are still unaware that there are usability problems, but blame themselves when they cannot achieve their intended goal [9]. There are many reasons why such devices should actually be used by consumers after installation like changing user needs, necessary adaptions or saving energy. It is important for everybody to make a contribution to saving the environment. By optimizing the energy management of a facility, e.g. a family home, a small step can be done [21].

4 Case Study: *Smart Sol* - Designing for User Experience

In this chapter a user-centered approach for designing the user interface of the solar control unit *smart sol* is described. The design process implemented for this product involves the cooperation of user experience designers on the one hand and engineers and programmers on the other hand.

The philosophy of a user-centered design process easily spoken is that *the user knows best*. The process focuses on users` needs and goals they want to accomplish. Ideally users are involved in every stage of the iterative design process [22]. Figure 2 shows the applied user-centered design process (cf. [23]).

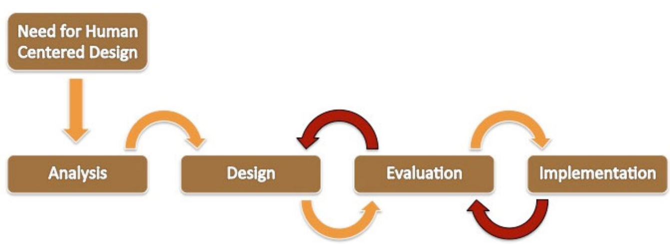

Fig. 2. User-centered design process

Implementing those needs in designing for an overall good user experience involves a wider range of parameters than traditional usability engineering, like performance and an easy to use interface. It also includes factors relating to affect, interpretation and meaning (e.g. aesthetic and emotional aspects) [24].

4.1 Need for Human Centered Design

To encourage people to use a solar control we detected three main goals.[4] Besides a high functional quality, it is essential to design an easy to use and intuitive interaction paradigm [7]. Our goal was to develop a product that can be used without reading the

[3] Results of market research and user and expert interviews conducted by the authors in 2009/ 2010.

[4] Results of user and expert interviews conducted by the authors in 2009/ 2010.

manual. To design for an overall good user experience, hedonic qualities also had to be considered [25], [26], [27]: "The aesthetic-usability effect concludes that more aesthetic designs appear easier to use – regardless of whether they are or not." [7]

Reaching these goals and providing a pleasant and welcoming feeling for the user, an iterative and user-centered design approach was used. We could identify two main user groups: the installer and the end user. Both groups have different needs. The installer is responsible for setting up the device and to handle errors when contacted by the end user. The end user needs a device he can rely on and customize to his own needs.

4.2 Analysis

First, usability professionals, programmers and engineers analyzed the functional specifications in terms of the required human-machine interaction. Based on this information a competitor analysis was conducted, which focused on the usability of state of the art user interfaces. Additionally, users were interviewed after asked to have a go on the controller about their impressions. The results indicate that most of the interfaces tested have very poor usability as the users were confused right after starting to use the interface. Among the reasons named are ill-designed or non-existing menu navigation, misleading onscreen information presentation and the hard-to-use interface due to non self-explanatory controls.

4.3 Design and Evaluation

Taking these results as a basis, the user interface was designed in an iterative process. In the early stage we used paper prototypes and wireframes for the design alternatives, asking users about their thoughts and opinions. For evaluating different color designs, fonts and font sizes mockups were chosen. The users` best-rated designs were implemented in click-through html-based vertical prototypes for usability testing. User interviews and post-test questionnaires were additionally used for evaluation of the interface. End users and installers participated in a closed card sort for defining the menu structure. For more detailed information on the conducted usability tests see [28].

4.4 Implementation

Results of the questionnaires, card sorting and user tests were translated into the final design.

Hardware and Navigation Design. Due to time constraints imposed by the production period, the device hardware had to be designed first. In cooperation with a product design company, user experience requirements were accounted for. A full color display improves the strictly technical image right from the start and communicates a pleasant impression [29]. 90% of the users prefer a color display and feel more comfortable using this type of interface.[5]

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[5] Based on the results of the usability post-test questionnaire.

Fig. 3. *Smart sol* solar control unit

The interaction is based on a click wheel for navigation as well as confirmation and an escape button for going back (fig. 3). Click wheel navigation provides fast navigation and data input (e.g. target temperature settings) and can be handled efficiently [18]. Click wheels are increasingly used in consumer electronics like digital audio-players and car entertainment systems (e.g. *Apple iPod*, *BMW*). The escape button gives the user the opportunity to leave the menu at any time and to return to a safe starting point. When pushed, it will go up one hierarchy level at a time until the main menu is reached. When changing parameters, e.g. the target temperature of the solar storage tank, the user has the possibility to undo his action or set the parameters back to factory settings with one click at any time. This is to guarantee the easy reversal of actions. Thus the users are encouraged to explore the functionality of the controller.

Screen Design. Based on guidelines for screen and small screen design (e.g. [30], [31], [2]) as well as on the results of our iterative design process and user interviews the final screen design is shown in figure 4.

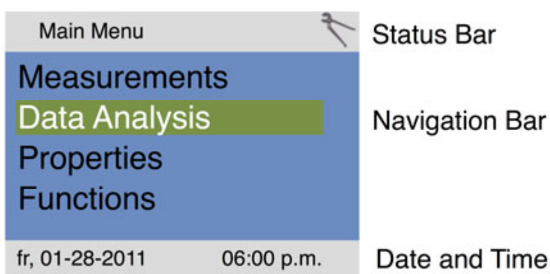

Fig. 4. *Smart sol* screen design

The basic design approach is derived from standard graphical user interfaces: Using familiar elements and well-known overall screen design, the user interface is easier to use because of previous experience [2]. The screen design of the smart sol unit follows a common trisection of everyday small-screen interfaces like smartphones. The overall screen and dialogue design is kept as simple as possible following the constraints of the small display. We use a full color display with a good contrast, a blue background and green highlighting. A small set of icons additionally indicates the type of assistant the users currently interacts with. This combination provides consistently positive and comfortable feelings [17]. Being asked in the post-test questionnaire, 90% of the users approved the final design as intuitive, pleasing and well-arranged.

Menu Design. The menu design represents the functionality of the device and should be carefully designed, so that basic and frequently used functions can be reached within a few steps [2]. Menu selection errors are most often due to miscategorization, overlapping and/or vague category titles [32]. We used card sorting in order to correctly represent the users' mental model in the menu structure [28], [33]. The final menu was designed with the help of common guidelines for menu design [2], [34], [35] and taking the particular challenges of small-screen devices into account.

Interaction Assistant Approach. To optimize the user experience of both user groups, the installer as well as the end user, we designed three intuitive interaction assistants: an assistant for a guided installation, a service assistant for error handling and an information assistant. These assistants are based on a survey on the most frequent problems end users have when using a solar control, which was also confirmed by interviews with installers.

The guided installation assistant simplifies the setting up of the solar thermal plant using a plug and play technique and offering a click-through guided installation. With this approach we mainly address the needs of the installer to quickly set up the solar thermal plant. The controller automatically recognizes the number of connected outlets and after selection of the kind of connected pumps a graphically representation shows a scheme of the possible solar plant settings (fig. 5).

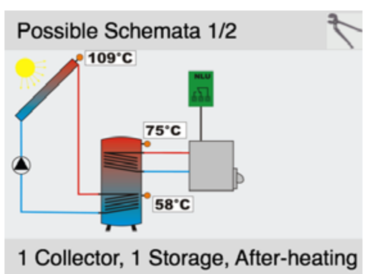

Fig. 5. *Smart* sol guided installation

When errors occur, e.g. a dysfunction, the service assistant guides the user through all possible sources of error and points out the solutions onscreen (fig. 6). No looking up in the manual is needed and hence a fundamentally faster problem solving process should be given.[6] The user is supported and given confidence in dealing with the situation. Special attention is paid on applying non-technical and easy to understand terminology.

[6] Based on the results of the usability post-test questionnaire.

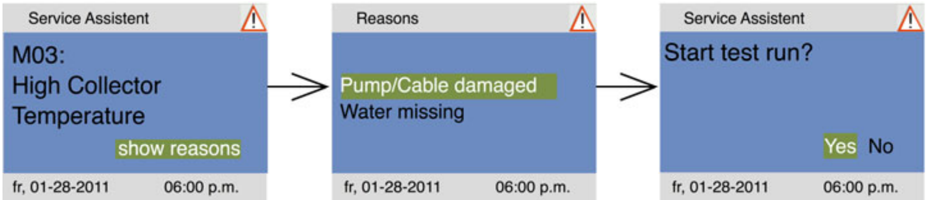

Fig. 6. *Smart sol* service assistant

Additionally a context-sensitive information assistant explains the user certain features of the control unit and describes the impact of his actions, e.g. activating the holiday function to support the user at any time to reach his goal.

5 Conclusion

In this paper a user-centered approach for designing the user interface of solar control unit is described. UX factors could be adopted successfully for use in the facility management domain. Presented at the world`s largest trade show for solar products, *Intersolar Europe 2010*[7], the overall design and in particular the interaction assistant approach were rated a success. The need for domain-specific usability engineering can also be seen in [36] and in the holding of the *1st European Workshop on HCI Design and Evaluation*[8] focusing on the influence of domains. While these first user studies show that the integration of user-centered design has been successful so far, the long term usage is hard to measure empirically. Continuing with the results of this project, the authors' further research will focus on an efficient approach to manage variability in interaction design for nontraditional interfaces, transferring research on software product families and product lines from software engineering.

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