User-Centered Interface Design for Disabled and Elderly People: First Experiences with Designing a Patient Communication System (PACOSY)

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Abstract. At the clinical department of Oncology at the Medical University Hospital in Graz, a pilot system for an interactive patient communications system (PACOSY) was examined. The patients are able to retrieve and enter information interactively via a touch screen panel PC connected to the Hospital Intranet. The Interface is designed for patients with little or no computer experience (i.e. people with a low computer literacy or patients with visual impairment and/or restricted motoric ability). This paper reports on the selection of a suitable hardware and on first experiences during the User Centered Design (UCD) and in particular gives insights into problems discovered during experiments with elderly people.

"Programming is such a difficult and absorbing task that it dominates all other considerations, including the concerns of the user" (Alan Cooper, 1999, [1]).

1 Introduction

The pilot system of an interactive patient communications system (PACOSY) was developed at the Institute for Medical Informatics (IMI). The User Centered Design was developed with patients of the clinical department of Oncology at the Medical University Hospital in Graz.

1.1 Terms of Reference

The system is primarily designed for elderly and/or disabled patients. A stable system, designed to return to a defined initial state on exiting, was a compulsory prerequisite. No special precautions were taken to avoid deliberate vandalism.

An interactive questionnaire is completed by the oncology patients immediately on arrival in the Oncology Department and particularly asks about their psychological state of mind. From the viewpoint of the departmental psychologist in charge the objective is a screening: on the basis of the responses the psychologist is able to build

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an opinion as to the necessity of immediate support etc. Up to the present an ordinary paper and pencil questionnaire was used. Investigations on comparisons between conventional usage of paper questionnaires and computerized versions (e.g. from Peterson & Johannsson (1996), [2]) showed that computerized versions could be advantageous. An automatic alert is being considered, either over the network and/or in the form of a screen output and/or on the mobile phone of the psychologist in charge, and will be implemented in a further implementation level. The patient is not supposed to fill in the questionnaire anonymously (for identification) but during the filling in confidentiality is necessary to inspire trust, for example, no one else should be able to see the screen. Special concern was given to the navigation through the questionnaire (cf. Nielsen (1990), [3]) and the simplicity of the user interface.

1.2 Technological Requirements

The solution was preferably near standard, scalable, and cheap within the Hospital Intranet. The same software supports touch screen and mouse alternatively. Extensive use of the hospitals standard equipment (PCs, Microsoft-Windows, MS server) was used as far as possible. In the future this solution should be adaptable to other clinics with a minimum of technical expenditure, that is, the expenditure has to be primarily targeted at flexible content, involving minimum or preferably no supplementary programming. The most important objective was maintainability of the content by clinic personnel (secretary etc.) with a minimum maintenance requirement.

Basically, the system was constructed to act as a client server system. The client connects, using a standard browser (in the hospital mainly MS Internet Explorer) via a TCP/IP connection to the server within the Intranet. The client requests the Webpage from the server. The communication between client and server is defined by HTTP (Hyper Text Transfer Protocol). The server sends the response in the form of HTML (Hyper Text Markup Language). The browser interprets the HTML correspondingly and displays the page graphically.

2 Touch Screen Technology

The first step was choosing the right hardware technology. Several experiments were carried out to find the most suitable equipment. The central component of the system is a touch screen. Each touch screen system includes three components that can be configured in various ways:

1. Sensor touch screen which serves as the user interface;
2. Controller, which processes the signals from the sensor screen and passes the event data to the computer; and
3. Driver software, which makes the touch screen compatible with the local operating system.

There are several different types of technology employed by the touch screens on the market today; resistive, capacitive, surface acoustic wave and infrared light. The technical constraints that limit the development and deployment of these touch screens are very specific to each type. In general, these constraints deal with factors such as the clarity of display, the specifics of the interaction with the touch screens, and the maintenance of the touch screen equipment. Because of such constraints, touch screens' deployment is limited in/to certain environments and in specific manners (Holzinger (2002), [4]).

1. Resistive: A mechanical pressure on a resistive touch screen closes an electrical contact between two conductive layers. Since the pressure only sets up a connection between the two layers, the resistive touch screen can be activated by any solid object: a gloved finger, a pencil etc. This technology is used mostly in, for example, Personal Digital Assistants (PDAs) e.g. the Psion and Palm. Advantages include no alignment (justifying) is necessary, exact positioning, mainly used in the Medical field, i.e. use with gloves is possible;
2. Capacitive: A pane of glass coated with ultra-thin metal lies over the actual screen of a capacitive touch screen. From the corners of the display, a low voltage of alternating current, which creates a weak electrical field, is applied to the electrode grid of the conducting layer. When the user touches the screen they represent a form of condenser electrode and "ground" the area (field). From the (low) electricity, which is diverted around the users finger, the touch controller determines the respective coordinates of the contact point. Correspondingly, capacitive touch screens only respond to the touch with a conductive object (special metal pen, finger etc.). Advantages include higher resolution, higher light efficiency, not influenced by surrounding light; Disadvantages include that calibration is necessary and it is sensitive to errors from exterior influences.
3. Acoustic: Surface acoustic wave (SAW) technology. This technology is based on sound waves. The edges of the screen are equipped with ultra sound transmitters with reflectors at each opposite edge and a piezoelectric receiver in one corner. Ultra sound waves are continuously being sent across this reflector system. As long as this field is undisturbed the waves arrive without obstruction at the receiver. However, if the field is disturbed, through a finger, pen or similar, then the position of this object is determined from the missing wave course within this field.
4. Light: Infrared touch screens with infrared technology work, on principle, as light barriers. The infrared senders and infrared receivers in the screen frame build up a light grid, which is invisible to our eyes. If this grid is disturbed by a finger or other object, the sensor electronics detect the appropriate x and y coordinates of the contact point by means of the missing rays. Advantages include no light reduction of the screen, no wearout failure; Disadvantages include interference sensitivity (reacts on approach), resolution is low, position errors with convex screens.

3 User Centered Design

Involving the users in our design process from the outset was a primary concern, to understand how our users work and to provide a system, which is easy and pleasant to operate, with no learning effort.

We first discussed the system with the people involved i.e. the clinical psychologist who expressed her demands of what the system should do. In a requirement analysis a verbal description of the system emerged. First, screen designs and dialogues were sketched on paper. The second step was a paper prototype mock-up, which was further adjusted working with the psychologist. The use of the paper mock-up provided a first usability feedback with minimum effort and maximum feedback.

Further, a first working prototype was tested before the implementation of the final design, which was used for the user-studies.

Our core philosophy during the design was a minimalist design following the *less is more* principle: irrelevant information distracts.

4 Methods Used

Thinking aloud: According to Nielsen (1993) the method of thinking aloud allows us to understand how the users approach the interface and what considerations the users keep in mind when using the interface [5]. During the test procedure the users are asked to verbalize and describe their thoughts, feelings and opinions while interacting with the system. Although the main benefit of the thinking aloud protocol is a better understanding of the user's mental models and interaction with the touch-screen system, there are other benefits as well. For example, the terminology the user uses to express ideas or functions should be incorporated into the system design [6].

Questionnaires: These are generally an inexpensive way to gather data and allow a quantitative analysis of the results. A well-designed questionnaire, that is used effectively, can gather information on both the overall performance of the system as well as information on specific components of the system. Including demographic questions about the participants, they can also be used to correlate performance and satisfaction with the test system among different groups of users. According to our special target population we paid special attention to the order of the questions and kept it as short as possible [7], [8].

Qualitative interviews: Although interviews may be capable of discrimination from questionnaires in terms of their degree of formality they should not be considered less important. Instead, they should be used in a manner that makes the best use of their respective strengths. Rubin (1981) suggests that interviews are used at the beginning and end of an evaluation, initially to gather general information to form the basis for a questionnaire and afterwards to clarify its results and fill in gaps. However there are no absolute rules for the use of questionnaires and interviews, as with most human factors research, it depends very much on the circumstances and the type of system being evaluated. In many respects, within the context of a usability evaluation, the choice between structured interviews and directly administered questionnaires is likely to be determined by cost and convenience. The evaluator has to make a decision based on knowledge of the domain and of the advantages and limitations of the two techniques as discussed in the following sections [9].

5 Experimental Setting

12 patients of the Oncology Department took part in the first experiments on an anonymous and voluntary basis. 70% were female. There ages ranged from 60 to 82 years. All of them had absolutely no computing experience. The attending clinical psychologist selected these people, arranged the appointments and provided them with information about the broad aim of the experiments. It was their first time

operating any touch-screen system. The first tests were conducted in German and consisted of four parts:

1. Briefing Interview: Introducing the test person to the aim of the experiment. Explaining the experimental setting and the sequence to follow. Obtaining permission to use video and audio recording and take pictures during the experiment.
2. Pre-Test Questionnaire: Collecting background information (as mentioned before e.g. age, experience with computers, etc.) by using a written questionnaire.
3. Running Test: The test person was asked to follow the sequences on the touch-screen and to think aloud about what s(he) is doing at every moment. The aim of the thinking aloud procedure was explained again but no further instructions as to how to use the touch screen were given. Video and audio recording was running and written notes were made.
4. Post-Test Questionnaire: Collecting information by using a specially designed questionnaire (see below).
5. Debriefing Interview: Finally we let the person summarize their impressions and feelings during the test.
6. Closing: Thanks were given to the test person and some information about the ongoing process and how important the input of the test person was.
7. According to Christensen (2001) this design can be used to provide some interesting information, although one should remain constantly aware of the possible confounding extraneous variables that can jeopardize the internal validity, [7].

6 Findings

Generally: According to Greenstein & Arnaud (1988) the most obvious advantage of touch screens is that the input device is also the output device [10]. Due to the use of direct eye-hand co-ordination, the operation of our system was easy for all of the examined patients. According to Srinivasan & Basdogan (1997) being able to touch, feel and manipulate objects on a computer screen, in addition to seeing and hearing them, provides a sense of immersion.

Touch Screen Technology: Because of the rise in demand for touch screens, more and more touch screen providers are emerging. Almost all of these companies sell integrated touch screen systems as well as components that can be added to non-touch screen monitors to convert them into touch screens. Based on the results of our examinations we decided to rely on a Panel solution and excluded whole Kiosk-Systems due to the fact that they are too heavy and unwieldy. The resistive technology was not suitable due to the disadvantages: unfocused, low brightness, and the monitor is less durable. This technology, determined by the number of layers applied, has less brightness and less focus. For example, if a normal LCD monitor has a brightness of 200 cd/m², then the LCD monitor with surface wave technology lies at 185 cd/m² and our five-wire resistance monitor had less than 150 cd/m^2 which was to less. Since the brightness must constantly be turned on fully the durability of the monitor is less. A model with capacitive touch screen had more than 200 cd/m^2, which is sufficient. The surface acoustic wave technology proved to be the most usable technology in our case due to its single glass panel and highest clarity. Its drawback is that it is affected by contaminants on the screen, which absorb the waves and cause dead zones. Also it is not very flexible, in order for an acoustic wave to be sent, the screen must always be touched with a finger; something hard like a pen did not work, although this was not critical in our case.

Viewing Angle: The Viewing Angle proved to be highly important and differences caused adaptations, which are very disturbing during the experiment [11].

Content: The use of a thermometer scale (fig. 1) instead of a typical ranking scale to measure the emotional strain proved to be effective. The patients reported that they want a feedback in two ways: Having the input acknowledged by presenting a "tock" sound and setting the thermometer to the selected value by marking it in the same way as a thermometer mercury column (see fig. 1):

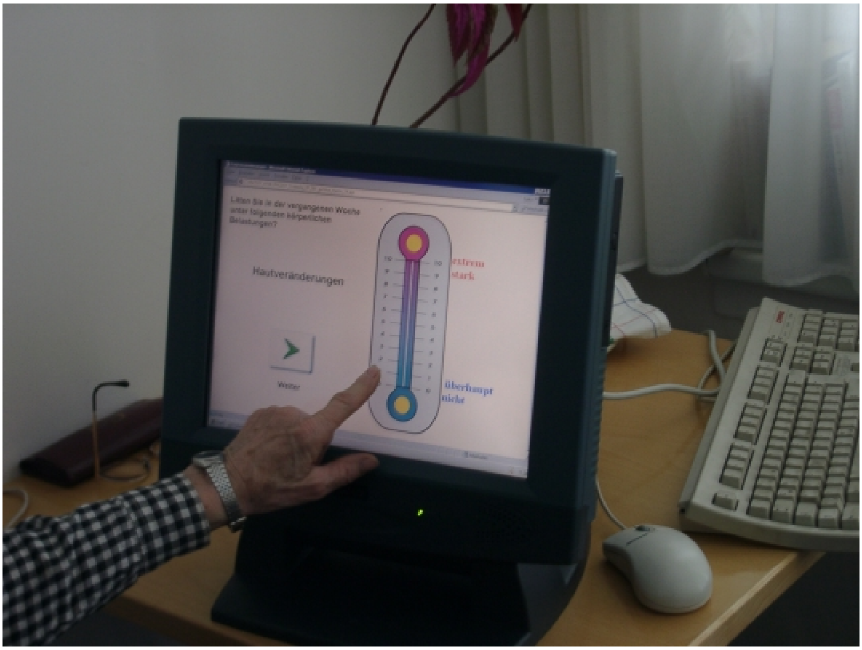

Fig. 1. The thermometer mercury column indicated the patient’s emotional strain

Content Problems: Text intended only to give information to the user was unclear in the first cycle and was further simplified. The legibility of text was a crucial factor from the beginning. Some patients often had problems to decide which value they should assign to a specific question.

Design Problems: After clicking the thermometer the patients often think, that everything is done on this page. They see the reaction of the thermometer and are satisfied because the system has responded to their action and wait what happens next, instead of pressing the Next-Button. Sometimes the patient complains about a false value in the thermometer, commonly one point to much or to few. Patients are not sure what to do when the would answer the question with “absolutely not”, or none or anything else. After proceeding to the next page the patient thought that it is the same again. Pages with decision questions (button A – button B) are confusing, especially if both are not corresponding to the patient's situation.

7 Future Outlook

At a further implementation level a generally usable Software/Hardware solution for patients on a variety of different terminals is supposed to be implemented (a possible application both in the Graz University Hospital and in all Styrian County Hospitals). Patients can for example gather information about the department, their illness, therapy and so forth, with the possibility of providing feedback: Questionnaires, contentment, concerns etc. or for example simply the ordering of menus. Qualitative studies concerning what kind of information patients would prefer are necessary to gain further insight [12], [13]. Perhaps even surfing on the Internet will become possible for elderly and/or handicapped patients. Such simple, cheap and easy-to-use solutions can be according to Stepanidis & Savidis (2001) a step further to the information society for all where all people can have access to information [14].

8 Conclusion

Generally: Most of the patients reported that they "liked this kind of computer" and all patients who have never used a computer before found that touch screen interface simple to use.

Touch screen: Many different hardware solutions were examined including whole Kiosk systems, but the favorable hardware solution was a Panel-PC. Due to a brightness of less than 150 cd/m^2 the resistive touch screen was not sufficient. Although the surface wave technology was a solution, they were easy affected by contaminants on the screen. Finally a capacitive touch screen with more than 200 cd/m^2 was sufficient. Special care must be given to the viewing angle, which caused some trouble.

Content: To make it easier for the patient to quantify the answers it is intended to provide a concise on screen help system on demand.

Design: The User Centered Design proved to be a suitable method to design the system which must be simple and easy to use, according to the proverb: *less is more.* The patients reported the design of the buttons as being satisfactory in shape, color and size. Additionally they wished to have an audio feedback to confirm the given input. It's a problem for some patients that they have to click <Next> after pushing the thermometer value. One solution would be a timeout if the button is not pressed and a replacement of the button.

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