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PARTICIPATORY ICON DESIGN FOR MEDICAL INFORMATION SYSTEMS

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ABSTRACT

Medical information systems which support high quality electronic health records are significant part of hospital processes. Usable and efficient user interfaces should be developed by implementing user centered development methodologies to gather the reliable and accurate data in medical information systems. It is known that better human-computer interface can be designed by the user-participatory development processes. The proper design of icons would provide necessary results in reducing possible interaction problems. Especially in medical information services, relatively short data entry time and accuracy are crucial parameters on system success. This study includes the icon selection process for a medical information system developed for the emergency service of a hospital located in Istanbul, Turkey. The experiment is tested on 78 subjects who were selected from the healthcare staff. Medical terms are given to

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each subject, asked them to draw icons representing the given terms and most frequently drawn figures are selected for the interface. Actual performance of the end-users was examined and it is proved that the participatory icon design process is useful and effective.

Keyword: medical information system, icon design, participatory design

1. INTRODUCTION

Healthcare data intensive activities are crucial to gather accurate and reliable data in a short period of time while completing the hospital process in medical field. Medical authorities suggest the implementation of medical information systems especially to emergency services with the rapid improvements in software development technologies (Lipoff, 2001).

Efficient and usable user interfaces will provide more reliable data which is used to improve the quality of electronic health records (Kushniruk et al., 1997). Electronic healthcare record (EHR) is the digital format of personal medical records which includes current and historical health information, medical conditions of patients. EHR can provide more accurate and robust medical information by employing usable graphical interfaces which are designed by the user-centered development methodologies. Today, many end-users are facing usability problems such as learnability, flexibility and robustness with various kinds of software interfaces for computer applications, web sites or mobile devices (Saade and Otrakji, 2007).

Huang et al. (2002) reported many significant reasons of widely icon usage in many applications. Icons can be recognized and remembered easily (Weidenbeck, 1999), have more universal recognition than text (Lodding, 1983) and provide better cognitive affordance (Gaver, 1991). In addition, end-users prefer icons instead of text to complete their tasks (Nielsen, 1990). On the other hand, Waterworth et al. (1993) showed that there are some negative sides of icon implementation such as language and cultural barriers. Although Wickens (1992) concerned the difficulty of locating the needed icons on the interface, contemporary advanced information processing technology solved the

problem. However icons may deliver confusing meaning to users because of cultural differences (Saade and Otrakji, 2007).

Icon-based interfaces are believed to reduce system complexity and the mental load for the end-users when systems are designed in proper way (Lodding, 1983; Goonetilleke et al., 2001). Unless icons are meaningful and identifiable, the icons can cause simple or significant unexpected problems. Popularly used icons in most software applications or web sites are often ambiguous because of careless design, improper application, inadequate researches (Cheng and Patterson, 2007).

Researchers suggested many guidelines and principles to assist designers in designing more effective and efficient icons (Tognazzini, 1992; Goonetilleke et al., 2001; Preece et al., 1994). Huang et al. (2002) introduced five critical factors in icon design: styling quality, message quality, meaningfulness, locatability and metaphor. Lin (1992) also proposed that usable icons should be identifiable, meaningful, concise, associable, eye-catching and symbolic. It is known that icon designers can not examine and evaluate the icons properly by themselves and icons are still designed in artistic manner (Waterworth et al., 1993).

Salman and Karahoca (2005) showed that iconic interfaces are more usable than the textual interfaces in efficiency, satisfaction, effectiveness, and ease of learn. Cheng and Patterson (2007) also explained that software applications could be more user-friendly and easier to use by providing a pictorial interface acting as a physical metaphor.

Time-critical nature of healthcare activities and accuracy essence of information require icon-based interfaces for the better medical information system. The system was built with the implementation of user-centered development methodology by including the reactions of the users (Anderson et al., 2001). In this study, participatory icon design and selection process was attempted and introduced for an emergency information service of a hospital located in Istanbul, Turkey. The experiment was conducted by participation of physicians and nurses. The prototype consists of five categories: general information, health history, arrival information, treatment information, and observations.

Task analysis was performed by examining emergency medical process and interviewing with the healthcare staffs. In the icon selection process, medical terms are

given to each subject, asked them to draw icons representing the given terms and most frequently drawn figures are selected to be used for the interfaces. Actual performance of the end-users was examined and it is proved that the participatory icon design process is useful and effective to develop the hospital information system. Additionally in this paper, the main screen of the system is given as an example interface which consists of both icons and texts at the same time.

2. METHODS

2.1 DEVELOPMENT PROCEDURE

User-centered development is an approach that grounds the process such as planning, designing and developing a product by including the people who will use it. This methodology defines a general process for including human-centered activities throughout a development life-cycle, yet does not specify exact methods.

In Table 1, it is shown that the processes with their sub-processes which are related to the user centered development methodology and all are used one by one in the development process of the application.

Table1. Medical system development process

1. Requirements Phase	1.1 Identify user groups
	1.2 Identify user goals
2. Design and Develop Phase	2.1 Task analysis
	2.2 Iterative conceptual model design
	2.3 Iterative screen design
	2.4 Revise style guide
3. Build and Refine Phase	3.1 Quality assurance test
	3.2 Heuristic reviews
	3.3 Usability test
	3.4 Evaluate if the usability goals are met
4. Install Phase	4.1 User feedbacks
	4.2 Enhancements

Many studies have indicated that the satisfaction of user needs and requirements is a significant factor for developing successful products. It is shown that if the product is

efficient to solve the problem of users and give them some unique benefits, this product can be called as "superior" (Cooper and Kleinschmidt, 2000). Properly identified user requirements are the significant basis of product development with good usability analysis (Nielsen, 1993).The usability factors insisted by Nielsen's studies are learnability, user satisfaction, effectiveness, usefulness and efficiency. There are various names in the literature about the process of developing products based on user focus which are "customer orientation", "customer-focused product development" and "user-centered design". It is also reported that succeeding in the matching with the user requirements is not enough to get a good product; the whole development process must be implemented as user-oriented (Rexfelt and Rosenblad, 2005).

According to the user centered development methodology, and additionally, including heuristic evaluation and cognitive walkthrough approaches, a medical information system is developed for the use of emergency service of a hospital which is located in Istanbul (Salman and Karahoca, 2005). Required user focused processes are considered in the development process of the system. Yet, in none of the previous studies of the authors, the participatory icon selection process is not given with details and steps. In this paper, it is reported how the used icons in the interfaces are selected by the developers for the medical information system. The main screen of the system which consists of text and icons together is given as an example in the further sections.

2.2. TASK ANALYSIS

The system was developed for the nurses and doctors who are working for the emergency service of the hospital. The medical information system is used to enter EHR when a new patient arrived at the emergency service, observe and modify records about the existing patients in any time. Every patient is assigned a unique identification number and EHR of each patient is stored in a shared database. When a new patient enters to the emergency service, the information process begins and the goal of the system is entering, collecting and maintaining accurate data in a short time.

Required tasks for the emergency service were identified by surveying the healthcare staff of the hospital. Tasks represent the information that nurses should collect from the new patient for the further processes. Twenty three tasks are reported essential and

categorized into five different groups (general information, health history, arrival information, treatment information, observations) according to their similarities and priorities assessed by healthcare staff (Table 2).

Table 2. List of tasks for emergency center

1. General Information	1.1 Patient Identity *
	1.2 Family History
	1.3 Contact
	1.4 Religious Belief
	1.5 Translator
2. Health History	2.1 Previous Diseases *
	2.2 Previous Surgeries
	2.3 Addictions
	2.4 Still Used Medicine *
	2.5 Allergy *
3. Arrival Information	3.1 Arrival Way
	3.2 Triage *
	3.3 Judicial Event
	3.4 Arrival Complaints *
	3.5 Vital Symptoms
	3.6 Functional Efficiency
	3.7 Pain *
	3.8 Mood
4. Treatment Information	4.1 Required Inspections
	4.2 Requests and Applications
5. Observations	5.1 Vital Symptoms Observation *
	5.2 Nurse Observation
	5.3 Discharge Information *

* Crucial task

2.3. PARTICIPATION OF HEALTHCARE STAFF

Seventy-eight healthcare staffs (42 physicians, 36 nurses) were selected from the hospital and participated in the design survey. Average age for all participants is thirty-one. Fifty-two of the participants are female and the twenty-six are male. Eighty-two percent of the participants reported that having some familiarity with the computer icons by using the internet and the applications compatible with personal computers, mobile devices or web.

A questionnaire was prepared asking name of tasks for the developed medical information system in Turkish and distributed to the healthcare staff of the hospital in Istanbul. The questionnaire was distributed to the participants with an official letter signed by the head doctor. Physicians and nurses were asked to draw an icon representing given medical terms and tasks independently. Brief explanation was also given to the subjects about the study and the experiment. Finally the most frequently drawn figures for each task were selected to be used in the interfaces for the medical information system.

3. RESULTS

3.1 DESIGNED ICONS

All icons were designed by using black and white (Horton, 1994). Also the icons were drawn simply with three principles which are consistency, attractiveness and fitness (Mullet and Sano, 1995). Text was not presented in the icon design to avoid confusing as it is suggested by Apple Computer (1996). Table 3 shows each task and designed icons as an outcome from the experiment.

According to the icons shown in Table 3 about the specific tasks, it can be clearly seen the cultural affect especially on the icon corresponding to "Religious Belief" task. The icon about this task is representing a mosque which is holly for Islam belief. Almost ninety-eight percent of Turkish people's religion is Islam and except one of the participants, all are Muslims. It is not hard to notice the cultural and religious affect on this icon.

3.2 GUI (Graphical User Interface)

GUI for the system was designed by applying the participatory designed icons. A web-based medical application was developed with Microsoft .NET and ORACLE database and then usability test was conducted by the participants. For better applicability and usability, the application was developed as stand-alone PC based program, web application, and mobile phone application by employing WAP (wireless application protocol) technology (Salman and Karahoca, 2006). The navigation menu for the web

application is given in Figure 1 where icons and texts are used together. Sub-tasks are designed to be displayed when the main category is clicked. Although the combinatory presentation of icon and text requires more space on the screen and cognitive process of users, it was believed as practical and effective alternative interface design.

Table 3. Tasks and designed icons for each task

| Task Name	Icon	Task Name	Icon
1.1 Patient Identity		3.3 Judicial Event	
1.2 Family History		3.4 Arrival Complaints	
1.3 Contact		3.5 Vital Symptoms	
1.4 Religious Belief		3.6 Functional Efficiency	
1.5 Translator		3.7 Pain	
2.1 Previous Diseases		3.8 Mood	
2.2 Previous Surgeries		4.1 Required Inspections	
2.3 Addictions		4.2 Requests and Applications	
2.4 Still Used Medicine		5.1 Vital Symptoms Observation	
2.5 Allergy		5.2 Nurse Observation	
3.1 Arrival Way		5.3 Discharge Information	
3.2 Triage			
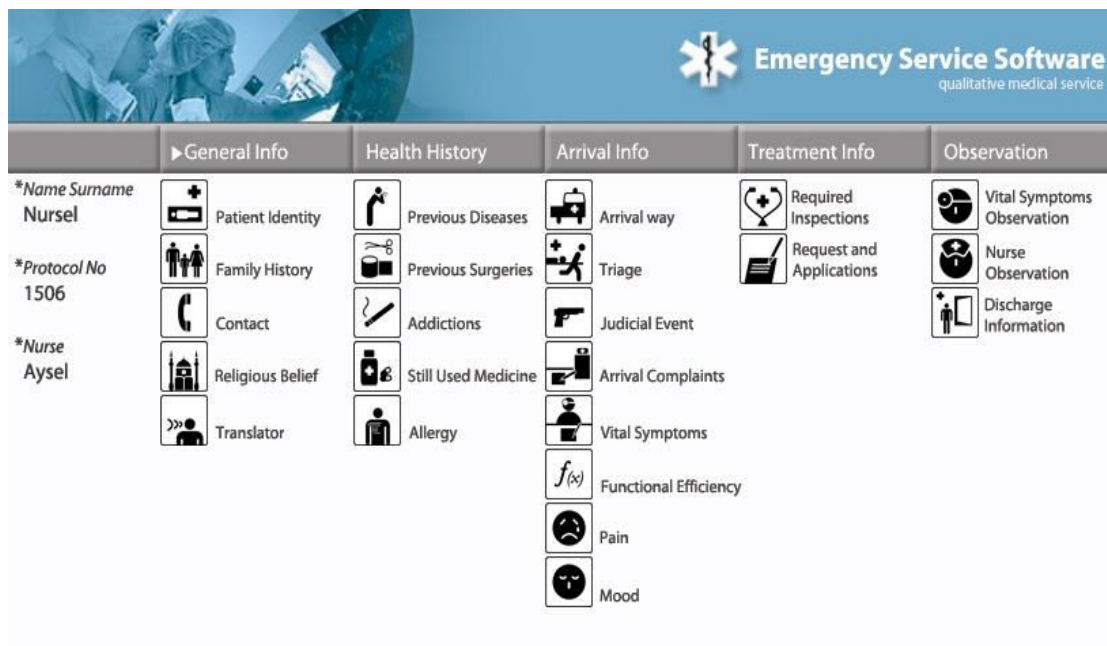
Figure 1. Iconic-based interface navigation

4. CONCLUSION

It is very crucial to develop medical information systems with usable GUIs to collect accurate and reliable data. Time and accuracy factors are significant in medical information systems. Galin (2004) suggested that user-centered development principles such as cognitive walkthrough and heuristic evaluation approach are essential to implement more usable solutions.

Icons should be designed cautiously and simply to be identifiable (Cheng and Patterson, 2007). Otherwise, ambiguity would be increased and various problems can be provoked. Properly designed icons would improve the performance of the end-users.

The proper designs of iconic-based interfaces are also significant for the correct functionality of the computer applications. The icons especially for the medical information systems should be recognizable, intuitive and easy to identify by the end-users with no error. In this study, actual end-users indirectly participated in the icon design process by answering the questionnaire. It was already proved that the

participatory icon design process is useful and effective to develop the medical information system by the task completion time and accuracy (Salman and Karahoca, 2005).

Further research can explore the efficiency and effectiveness of the participatory designed icons in the medical information system. The participatory icon selection process and design might be not enough to assure the accurate and proper usage. A better understanding of other significant design factors such as culture, styling, message quality, metaphor, meaningfulness, and simplicity would be required for more usable icons.

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