Quality of Life through Quality of Information
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Application of Usability Metrics in a Multi-User and Multimedia EHR Evaluation Framework

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Abstract. Electronic health records are replacing conventional paper-based health records. For a doctor it is a working instrument, which can significantly reduce the time spent on paper work. Patients can benefit from accessing the electronic health records even though they usually do not have a medical background. Therefore, when specifying a graphical user interface (GUI) it is necessary to take into account the requirements of the different users: e.g. the functionality for the doctors and the presentation of data in an understandable manner for the patients. The study aims to review and analyze metrics used to evaluate the usability of user interfaces in health information systems. The scope of the search included the analysis of existing usability evaluating metrics that are applied both in healthcare and other domains, where the standard of storage and presentation of information are applied. We identified a set of metrics and evaluation methods that provide holistic evaluation facilities for graphical user interfaces.

Keywords. visualization, metrics, evaluation, EHR

Introduction

Nowadays conventional paper documents relegated to the background yielding to more useful and convenient electronic documents. In healthcare domain the prevalence of electronic health records (EHR) are growing rapidly and it leads to necessity of design effective and friendly user interfaces.

Currently healthcare professionals are the main users of EHRs [1]. However, there are strong indications that the involvement of patients will improve healthcare, and that a personalized access to the patient's electronic health record will support patient empowerment [2-4]. Therefore, when specifying a graphical user interface (GUI) it is necessary to take into account the requirements of the different user groups: e.g. the functionality for the doctors [5] and the presentation of data in a simple and understandable manner for the patients. Therefore, the development of complex methods for evaluating of effectiveness and usability of EHR systems is a critical issue. The methods must provide a balanced evaluation of the solution.

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1. Methods

To analyze the usability evaluation methods a literature review of evaluation metrics was made. The review had the goal of defining the current state of the art of the usability evaluation area in medical and other domains in order to specify the most holistic and effective evaluation methods. The search included the following scientific databases and journals: Medline, Cochrane Library, CINAHL, EMBASE, sciencedirect.com and ACM Digital library. The following queries were used: “usability evaluation”, “usability metrics”, “GUI evaluation”. The reviewed papers were purposefully chosen to cover the whole process from the first works on the EHR usability evaluation to the most recent projects. The papers also represent different domains not limited to the healthcare. The search was performed in November-December 2011. All papers that seemed eligible were read by two researchers. Any differences of interpretation in the evaluation were solved by discussion.

2. Results

Sixteen papers regarding usability metrics applicable in healthcare that met the requirements of the research were analyzed in detail [3-18]. The papers cover the period from 1992 to 2011. Among the papers were **National Institute of Standards and Technology (NIST)** guidelines for usability requirements specification: Common Industry Specification for Usability – Requirements (CISU-R) [6] and ISO 9241-11 Guidance on usability.

Usability of a computer system can be defined as the capacity of the system to allow users to carry out their tasks safely, effectively, efficiently and enjoyably [7]. ISO 9241-11 defines usability as "The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use." Being complex concept system usability can be broken down to the common components, which contain in all definitions and useful for any domain [8]. There are numerous methods that can be used to evaluate the usability of a system and these methods can be classified to one of three categories: inspection, testing, and inquiry [9]. In usability **testing** approach, users work on typical tasks using the system (or the prototype) and the evaluators use the results to see how the user interface supports the users to do their tasks. In usability **inspection** approach, usability specialists examine usability-related aspects of a user interface. In **inquiry** methods, usability evaluators obtain information about users' likes, dislikes, needs, and understanding of the system by talking to them, observing them using the system in real work, or letting them answer questions.

The analysis of the papers resulted in a summary table that contains types of metrics with the examples of performance metrics and their possible application for EHRs (Table 1).

Table 1. Usability evaluation metrics for electronic health records systems.

Type	Metric Class	Performance Metric
Efficiency	Essential Efficiency (EE) Estimates how closely a given user interface design approximates the ideal expressed in the use case model	% of tasks totally completed, Comparison of task completion quality with software to task completion quality without software. % of participants who respond they can always, most of the time, rarely, or never perform representative tasks.
Effectiveness	Layout Appropriateness (LA) Favors arrangements where visual components that are most frequently used in succession are closer together, reducing the expected time of completing a mix of tasks	Time to complete a task or a series of tasks; Time to complete a task taken on first attempt; Number of key presses taken to achieve task;
	Task Concordance (TC) Measures how well the expected frequencies of tasks match their difficulty, favors a design where more frequent tasks are made easier (e.g., fewer steps)	Time to perform a particular task after a specified period of time away from the product; Comparison of task completion ability with software to task completion ability without software;
Satisfaction	Task Visibility (TV) The proportion of interface objects or elements necessary to complete a task that are visible to the user	number of positive comments; number of negative comments; % of participants who made positive comments; % of participants who made negative comments. The proportion of interface objects or elements necessary to complete a task that are visible to the user

Effectiveness. A user is given a series of tasks to be performed:

1. Finding a Patient in the Data Base;
2. Adding vital signs data of the patient;
3. Prescribing a drug;
4. Scheduling the next Patient's Visit;

% of tasks totally completed and half completed tasks is calculated and compared to the same tasks that are performed without the use of the EHR system.

Efficiency. The routine work of the user without the system being evaluated is explored in order to compare the time to complete the same series of tasks using the new system and applying the familiar to the user tools.

Satisfaction. A user is asked to complete the tasks specific for a certain user group. The examples of tasks for the doctors are presented above in the Effectiveness section. The proportion of necessary to complete a task objects to the elements that visible to the user is calculated.

The metrics presented in the paper are applicable mostly to the systems that provide GUI for one media (for example desktop) or can be used to evaluate usability of each media separately. The modern EHR systems offers a multi-client (e.g. doctors,

nurses, patients) and multi-media (e.g. desktop, smartphone, touchpad, TV) GUI; that means that a set of usability metrics must consider that the same software can provide different usability potential for different devices and users. To be able to evaluate such systems the usability evaluation method should be developed in order to enable the application of existing metrics and introducing the new group of metrics regarding the multi-view potential of EHR systems.

3. Discussion

The literature search identified that the existing metrics are not sufficient for evaluation modern multiuser and multimedia electronic health record systems. Different users have different needs that they want to satisfy by using the data managed by an EHR system (e.g. patients: therapy tracking; nurses: care tracking). Data can be shown via different multimedia devices (e. g. smartphones, tablets) which are chosen according to different criteria of convenience (e. g. mobility, screen size, view distance). Having in mind that there is not only a homogeneous user group (e. g. doctors) on a homogeneous (e.. g. mouse- and keyboard-based) multimedia device type requires the application of different metrics for different user groups since they have a different perspective on the data (e. g. data editing vs. monitoring); and different metric for different device types (e. g. size, distance). Therefore, the metrics are to be applied in a different fashion to consider the above mentioned user- and environment-specific needs.

The usability evaluation framework for electronic health records systems (Table 2) can be applied as a holistic framework in addition by integrating the user/device-specific metrics. It allows a fine-grained comparison of EHR systems which offer different frontends (multimedia access) for different user groups. The matrix takes into account the different device categories and user groups on the top level and weights the applied device/user-specific metrics score according to their impact for the specific user group (in percentage; total = 100).

Table 2. Usability evaluation framework for electronic health records systems.

EHR System		Device category															
		PC/Desktop			Tablet			Smartphone			TV			….			
		Impact	Score	I*S/100	Impact	Score	I*S/100	Impact	Score	I*S/100	Impact	Score	I*S/100	Impact	Score	I*S/100	
User group	Doctors	75	n		10	n		15	n		0	n		…	n		$\sum_1$
	Nurses	40	n		60	n		0	n		0	n		…	n		
	Patients	40	n		30	n		30	n		0	n		…	n		
	…	…			…			…						…			
				$\sum_2$													$\sum_3$

Applying this matrix with meaningful metrics (which take into account device specific approaches) when comparing different EHR systems instead of the sole metrics (applied equally to different user groups and devices) allows an accurate comparison in every detail. The application of the matrix also makes it possible to derive cumulated scores on several dimensions by normalizing the sum of the overall scores (I*S/100). Therefore, several questions which come along when comparing EHR systems can be easily answered easily, e. g.

- Which EHR system provides the best (according to the applied metrics) desktop PC/tablet/smartphone/TV GUI for doctors/nurses/patients?

- Which EHR system provides the best GUI for desktop PCs (Σ_2)?
- Which EHR system provides the best GUIs for doctors (Σ 1)?

4. Conclusion

The review analyzed existing metrics for evaluating the usability of graphical user interfaces and their possible application for the EHR systems. The analysis identified metrics that are applicable for a healthcare domain. The review showed the necessity for common and universal usability evaluating metrics which can provide a useful and holistic evaluation of user interfaces in health information systems.

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