Analysis of Metrics for the Usability Evaluation of Electronic Health Record Systems

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Abstract. Electronic health records are gradually replacing conventional paper-based health records. For a doctor, it is a working instrument, which can significantly reduce the time spent on paper work. At the same time, 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. A literature review was performed to identify existing metrics. The scope of the search included the analysis of existing usability evaluation metrics that are applied both in healthcare and other domains, where standards for storage and presentation of information are applied. The analysis focused on metrics that are applicable for evaluating GUIs of health information systems. Several approaches and standards have been studied. Finally, a set of metrics and evaluation methods that provide holistic evaluation facilities for graphical user interfaces has been identified.

Keywords. Visualization, metrics, evaluation, EHR

Introduction

Nowadays, conventional paper documents, relegated to the background, yield to more useful and convenient electronic documents. In healthcare domain, the prevalence of electronic health records (EHR) is growing rapidly and leads to the necessity of designing effective and friendly user interfaces [1-3].

Currently, healthcare professionals are the main users of EHRs [4]. 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 [5, 6]. 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 and the presentation of data in a simple and understandable

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manner for the patients. In that context, the development of complex methods for evaluating the effectiveness and usability of EHR systems is a critical issue [7]. The methods must provide a balanced evaluation of the solution.

1. Methods

To analyze usability evaluation methods, a systematic review of evaluation metrics was performed. The review aimed at defining the current state of the art of usability evaluation 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", and "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.

The queries resulted in 1363 papers, 13 of them were chosen conforming the following research criteria:

Inclusion criteria:

- Papers have to propose a usability evaluation method.
- Papers have to describe a practical application of usability evaluation methods.
- We also included usability evaluation standards in the review.

Exclusion criteria:

- Papers which concern medical devices and sensors usability;
- Papers that address usability only of certain interface elements

2. Results

Sixteen papers regarding usability metrics applicable in healthcare that met the requirements of the research were analyzed in detail [3-18]. Among the papers were the **National Institute of Standards and Technology (NIST)** guidelines for usability requirements specification: Common Industry Specification for Usability – Requirements (CISU-R) [8] and ISO 9241-11 Guidance on usability [9].

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 [9]. 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 a complex concept, system usability can be broken down to common components, which contain in all definitions useful for any domain [10]. In the current review, we paid the attention on the effectiveness, efficiency, and satisfaction, while the safety was not considered. 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 [11]:

- In the 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 the 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).

The metrics presented in the paper are applicable mostly to systems that provide GUI for one media (for example desktop) or can be used to evaluate usability of each media separately.

Most modern EHR systems offer a multi-client (e.g. doctors, nurses, patients) and multi-media (e.g. desktop, smartphone, touchpad, TV) GUI. Therefore, 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 the introduction of a new group of metrics regarding the multi-view potential of EHR systems. Standard based visualization methods that are being developed at the moment [1, 2] require in addition to usability evaluation the metrics to evaluate their potential to process the standard based data.

3. Discussion

New approaches in healthcare such as patient empowerment [19] require holistic evaluation to consider the requirements of different actors. At the moment we lack evaluation guidelines providing a set of usability evolution metrics that could extend the Guideline for good evaluation practice in health informatics (GEP-HI) [20] to provide holistic evaluation of user interfaces in health information systems and integrate this into the overall evaluation of medical software. A number of implementations of clinical information systems failed because of the users' reluctance [21]. As the users' acceptance can make or break a clinical information system it is essential that all the users' perspectives are considered within the development and evaluation process. The topic of standard based interface solutions evaluation also requires a future development to enable evaluation of the ability to process standard based data and produce optimal user interface.

4. Conclusion

The review analyzed current methods and 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 the healthcare domain. The usability evaluation methods and metrics that are generally accepted can also be applied for the

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

Type	Metric Class	Performance Metrics	Healthcare application
Efficiency	Essential Efficiency (EE) Estimates how closely a given user interface design approximates the ideal expressed in the use case model	Time to complete tasks: − % of tasks totally completed, − % of tasks half completed; − Comparison of task completion quality with software to task completion quality without software.	− Creating a Chart Note − Scheduling a Patient Visit − Prescribing a drug − Finding a Patient in the Data Base − Sending a Secure Message to a Patient
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	Surveys: − % of participants who respond they can always, most of the time, rarely, or never perform representative tasks.	− Prescribing a drug − Ordering a Lab Test (e.g. LDL cholesterol) − Handling a Drug-Drug Interaction Alert (e.g. digoxin-quinidine, warfarin-erythromycin) − Screening/Prevention (e.g. mammograms in females 65 years old) − Finding a Patient in the Data Base
	Task Concordance (TC) Measures how well the expected frequencies of tasks match their difficulty, favors a design where more frequent tasks easier are made easier (e.g., fewer steps)	− % of participants able to complete tasks; − Comparison of task completion ability with software to task completion ability without software; − % of errors.	− Creating a Chart Note − Prescribing a drug − Screening/Prevention (e.g. mammograms in females 65 years old) − Finding a Patient in the Data Base
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.	− Scheduling a Patient Visit − Ordering a Lab Test (e.g. LDL cholesterol) − Handling a Drug-Drug Interaction Alert (e.g. digoxin-quinidine, warfarin-erythromycin) − Screening/Prevention (e.g. mammograms in females 65 years old) − Sending a Secure Message to a Patient

EHR software. The reviewed papers have shown that usability evaluation is mostly performed for a certain user group, despite an EHR system supports for example communication between doctors and patients. In this case, the evaluation is focused on the patients. A complex approach to evaluation will allow the development of interfaces that will improve the performance of all user groups.

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