Models to Extend the Scope of Usability Testing for Telemedicine Systems

[Extended Abstract]

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ABSTRACT
Some of the changes brought about by the introduction of telemedicine into healthcare organisations can be partly addressed by a better consideration of usability in telemedicine system design. Nevertheless, the costs of performing pre-deployment usability testing often make it infeasible. Moreover, usability problems are difficult to foresee, even more so if the system is to be deployed in several contexts differing in key aspects related to the user, task or environment or at different scales. We propose a structured methodology, together with a work-in-progress modelling approach, which can help predict whether usability problems would appear in a telemedicine system in new contexts, and if so, which.

Categories and Subject Descriptors
D.2.4 [Software/Program Verification]: Validation

General Terms
Human Factors, Verification, Design

Keywords
telemedicine, scaling-up deployments, usability evaluation, prediction, methodology, cognitive modelling, simulation

1. INTRODUCTION
Health and social care systems worldwide are challenged by an ageing population [4]. More patients suffer from long-term conditions (LTCs), requiring continuous care and frequent hospitalisation [1, 4]. In the UK, it is estimated that the number of people aged over 65 will increase from 10.1 million to 16.5 million over the next 25 years, requiring the tripling of public expenditure on social care [3]. Human resources in healthcare are limited and patient expectations increasing, so models of care need reconfiguring [2].

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Telemedicine is promoted by the European Commission as a solution for the management of LTCs [2]. By the continuous remote monitoring of patients at home, it promises to reduce the costs and anxiety of face-to-face consultations and allow for the stabilisation of the disease and the avoidance of exacerbations, leading to fewer and shorter hospitalisations. However, there is not enough proof yet of the feasibility of this technology (e.g. as shown by [8, 18, 17]).

Introducing telemedicine brings about important changes in healthcare organisations: e.g. the type of resources used (e.g. electronic health records instead of paper records), the daily work practices, responsibilities and division of labour between different roles [9, 14]. Some changes are necessary for managing care and reducing costs in the long run. For example, it is important that general practitioners delegate some of their responsibilities because otherwise they will not be able to cope with the increasing number of patients suffering from LTCs. Other changes, such as the resources used or the daily work practices, can be partly addressed by a better consideration of usability in telemedicine system design. By ensuring a closer match between user needs, tasks and environment and the functionality of the system, using processes which are familiar to users and good affordances, usability has been shown to improve satisfaction and trigger better user acceptance of the technology [7]. Nevertheless, usability has only been considered at a very late stage, and is often seen as less important than functionality, in telemedicine system design [16, 15]. Moreover, pre-deployment usability testing is costly to perform, which often makes it infeasible. Usability problems are hard to foresee in the complex medical domain. This becomes even more true if the system is to be used in several contexts which differ in key characteristics (e.g. user workload, work patterns), as observed in [5].

The UK is currently in the planning stages for the Delivering Assisted Living Lifestyles at Scale (DALLAS) programme, which aims to go beyond limited trials to large-scale deployment of telemedicine systems [3]. In this context, finding cost-effective ways to predict success or otherwise of telemedicine system deployments into new sites, so as to ensure that resources are not wasted, becomes urgent.

We propose a principled way to use suitably parametrised models to allow, based on a system’s usability in a reference deployment, predictions about whether and which usability problems will arise in a new deployment. We instantiate the methodology using a modelling approach inspired by work on the Icarus cognitive architecture ([13, 6, 10, 11, 12]).
2. THE METHODOLOGY

First we investigate a reference deployment site of the system. We gather information such as: task analysis; flow models of user interaction with the system; errors that users make; auxiliary systems that they use; numerical data (e.g. on their workload, level of criticality of their patients, number of successful/failed attempts in contacting them, frequency of system delays, etc.); user perceptions of the system. Depending on the situation, this analysis could be carried out in conjunction with user centered design of the system in the first site, alongside initial usability testing, or in operational use. We gather the information using a mixture of observation, documentation, interviews, log files and other instrumentation of the system.

During the analysis stage we also try to understand the ways in which future deployments are likely to differ from the reference deployment and what the major perceived risks are, as this will help us decide on an appropriate modelling approach. For example, if the major risks seem to be that it is easy for users to make errors with serious results, then a form of cognitive modelling for the user such as the one we describe in the next section may be appropriate. On the other hand if the major concern is whether users will be able to complete the expected workload in the time available, then we need a model that incorporates time and some kind of statistical information about workload (a stochastic model). We must also make sure that the modelling approach allows the creation of configurable and properly initialised (using gathered data) models for different deployments of the software and that it can be used for making verifiable/falsifiable usability problem predictions.

We instantiate the modelling approach for our particular system and then run the resulting model. To validate its usability problem predictions, we compare them against identified usability problems in the reference deployment site. There follows an iterative model improvement and revalidation process that ensures the model is good enough to identify the problems of interest in the reference site. We end up with a validated formal model of the use of the system in the reference site and an understanding of the acceptable and problem areas of the system.

Before the system is deployed in a potential site, we can interview or survey potential users and their managers, to understand the differences in user and environment characteristics and needs between this potential site and the reference site. This allows us to change the inputs for the model in simple ways (e.g. changing the mean number of patients or the probability for a patient to need urgent care) or more complex ways (e.g. changing the process for handling a task). Using the same modelling technique, we build a new model taking the new inputs and rerun it to obtain new usability problem predictions. By comparing these new predictions with predictions for the reference deployment site, we can conclude what different or more critical usability problems the change in context has led to. Moreover, having collected information on user perceptions about the system in the reference site, and having new predictions as to its usability in the potential site, we can also predict where the potential users will have better, similar or worse perceptions. These findings could inform the decision of whether and how to deploy the system in the potential site.

An overview of the methodology is provided in Fig. 1.

3. A PROPOSED MODELLING APPROACH

We are currently in the process of implementing a modelling approach to be used together with our methodology. It represents the user as a cognitive model and the system as a basic non-deterministic labelled-transition system (LTS). The choice of cognitive modelling for the user is motivated by observed user mistakes caused by usability problems from previous work ([5]). Our user model is inspired by work on cognitive architectures and in particular on Icarus ([13, 6, 10, 11, 12]), its structure reflecting user perceptual, memory and motor abilities (Fig. 2). The user model can also be seen as a non-deterministic LTS.

We propose running simulations using automatically generated workloads (number and characteristics of patients, their criticality etc. sampled from a chosen probability distribution). Given a goal to perform on the system, the user perceives elements from the environment which includes the computer system, derives beliefs about their relations by inferring them from concepts (general knowledge) which apply to the acquired percepts, and chooses skills which satisfy the goal and its subgoals which it executes in the environment. Skills may trigger the execution of actions on the system which lead to a new system state (actions are transitions in the system LTS).

A ‘controller’ checks the consistency between user and system states in what concerns system elements, such that any inconsistencies can be detected as the user having a wrong interpretation of the system. When such a problem (generally known as ‘mode confusion error’) occurs, the controller sends out a warning as to a potential usability problem or an error as to a clear usability problem to the analyst (the user of the model). It also warns about situations where intended user actions on the system do not have a system correspondent (unsupported functionality) or this correspondent is unavailable as a transition in the system LTS for the current system state (unavailable functionality), where users are required to use remembered information (which is error prone) and where users do not manage to solve the main goal in an available timeframe. A trace of the relevant cognitive processes having occurred prior to a triggered warning/error explains to the analyst the causes of user problems on the system, helping her to find solutions which are more acceptable to users. The use of probabilistic input generation and a high number of runs allows to also derive probabilities about most common usability warnings/errors and in particular allows us to flag cases where a usability error that arises rarely in the reference site would affect a proposed system, helping her to find solutions which are more acceptable to users. The work is still in progress. We are instantiating the approach by using an invented, but realistic case study: probabilities are invented based on previous work ([5]) to evaluate telemindcare systems as the ones described there.

4. CONCLUSION

We have described a methodology which can be used for predicting usability problems in different deployment scales and contexts of a telemindcare system. We have also described one modelling approach that can be used in conjunction with it. Work in progress involves the implementation
It is important to note that our work is not intended to compete with model-based usability evaluation methods, as its advantage lies in the prediction of usability issues in different potential deployment sites, and at scale, based on lessons learned from a reference deployment.

Future work includes the evaluation of the methodology and modelling approach by trialling them for assessing the success in terms of usability in potential deployments of a telemedicine system in use.

5. REFERENCES


