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A novel approach to improve the planning of adaptive and interactive sessions for the treatment of Major Depression ☆

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ABSTRACT

Human Computer Interaction (HCI) is a research field which aims to improve the relationship between users and interactive computer systems. A main objective of this research area is to make the user experience more pleasant and efficient, minimizing the barrier between the users' cognition of what they want to accomplish and the computer's understanding of the user's tasks, by means of user-friendly, useful and usable designs. A bad HCI design is one of the main reasons behind user rejection of computer-based applications, which in turn produces loss of productivity and economy in industrial environments.

In the eHealth domain, user rejection of computer-based systems is a major barrier to exploiting the maximum benefit from those applications developed to support the treatment of diseases, and in the worst cases a poor design in these systems may cause deterioration in the clinical condition of the patient. Thus, a high level of personalisation of the system according to users' needs is extremely important, making it easy to use and contributing to the system's efficacy, which in turn facilitates the empowerment of the target users. Ideally, the content offered through the interactive sessions in these applications should be continuously assessed and adapted to the changing condition of the patient. A good HCI design and development can improve the acceptance of these applications and contribute to promoting better adherence levels to the treatment, preventing the patient from further relapses.

In this work, we present a mechanism to provide personalised and adaptive daily interactive sessions focused on the treatment of patients with Major Depression. These sessions are able to automatically adapt the content and length of the sessions to obtain personalised and varied sessions in order to encourage the continuous and long-term use of the system. The tailored adaptation of session content is supported by decision-making processes based on: (i) clinical requirements; (ii) the patient's historical data; and (iii) current responses from the patient. We have evaluated our system through two different methodologies: the first one performing a set of simulations producing different sessions from changing input conditions, in order to assess different levels of adaptability and variability of the session content offered by the system. The second evaluation process involved a set of patients who used the system for 14–28 days and answered a questionnaire to provide feedback about the perceived level of adaptability and variability produced by the system. The obtained results in both evaluations indicated good levels of adaptability and variability in the content of the sessions according to the input conditions.

1. Introduction

Human Computer Interaction (HCI) is defined by the ACM Special Interest Group on Computer–Human Interaction[1] (ACM

[1] http://www.sigchi.org/.

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SIGCHI) as a discipline concerned with the design, evolution and implementation of interactive computing systems for human use, and with the study of the major phenomena surrounding them (Rusu et al., 2008). A good user interface facilitates effective communication between the user and the software application, but bad HCI design can cause non-acceptance, non-use of the system and user frustration (Bessière et al., 2006).

Karray et al. (2008) identified a new generation of HCI systems: (i) *Intelligent HCI*, which are interfaces that incorporates at least some kind of intelligence in the perception process with the user in order to respond accordingly (e.g. the use of natural language understanding and recognition of body movements); and (ii) *Adaptive HCI*, which allows adjustments of its behaviour to each user at any time on the basis of some form of learning, inference, or decision making (Sears and Jacko, 2009). Tomlinson and Baumer (2007) also defined an adaptive interface as the way of the features a user would find desirable and customisable.

In Adaptive HCI, verbal and nonverbal information (such as facial expressions, posture, point of gaze, and the speed/force used when a mouse is moved or clicked, and bioelectrical signals) can be analysed by the system to infer new knowledge about the user and adapt the functionalities of the system to maximise user acceptance, usability and satisfaction level. This adaptation might be related to the (i) *presentation*, i.e. HOW the interaction is conveyed (such as updating screen colours, sounds, etc. Börner (1994)), or to the (ii) *content*, i.e. WHAT are the actions to be done during the interaction (such as the content of the conversation with the user (Kharat and Dudul, 2009)). Additionally, when we are speaking about systems implemented on the Web, there are several authors (Bunt et al., 2007; Vasilyeva et al., 2005) who added a third adaption feature: (iii) the *structure* adaptation or adaptive navigation support which is the mechanism responsible for changing the appearance of visible links.

One of the applications where a good HCI design is important is in the medical domain because these kind of applications could provide great benefits in supporting tasks related to the treatment of patients. But if the design of these applications is faulty or erroneous, it could be harmful and it could have serious consequences for the users such as treatment abandonment, which could lead to a worsening of the patient's health, or cause a relapse (Novick et al., 2010). A particularly critical field is the use of HCI techniques in the mental health area where the discontinuation of treatment increases the risk of suicide and death (Ward et al., 2006). The design and development of good HCI systems applied to computer-based psychotherapy must be performed taking into account the particular characteristics of the targeted users, such as their cognitive/behavioural capabilities and limitations (Patel and Kushniruk, 1998). The identification and addressing of these special characteristics is particularly important in patients with Major Depression who have associated distorted and negative thinking, which makes them prone to suffering anxiety, frustration and stress when interacting with computer systems (Safford and Worthington, 1999). Significant efforts are still required to develop systems that can be widely accepted and that effectively promote the adherence to computer-based psychotherapy.

In this paper we describe an adaptive HCI framework as the core of a Clinical Decision Support System (CDSS), which in turn is one of the components of a Personal Health System (PHS) developed in the context of the Help4Mood European Research Project. The main objective of the project is to support the remote treatment of people who are recovering from a major depressive disorder. The work presented here is concentrated on the generation of tailored sessions (i.e. WHAT their contents are), based on the analysis of user (objective and subjective) inputs and the planning of the daily interactive sessions. The work performed related with HOW to convey the session contents to the patient is out of the scope of this paper but details can be found in Martínez-Miranda et al. (2014, 2012, 2015).

The hypothesis that conducts our work is that "the dynamic selection and planning of the activities to be included in daily interactive sessions for the treatment of Major Depression based on a user model would generate better adaptive and varied content. Hence, the generation of personalised and varied content can in turn contribute to facilitating the effective use and adherence from users to the system aiming to support the treatment of Major Depression".

The algorithm developed for the planning of the content for the daily interactive sessions is based on the knowledge inferred from (i) objective and subjective data collected from the patient; (ii) the historical data that forms a dynamic model of the user, and (iii) a set of requirements pre-defined by the clinicians. In addition to the content of the daily sessions, our proposed framework also produces periodic summary reports with textual and graphical information reflecting the patient's wellbeing evolution in an easy to digest format for both patients and clinicians. These summaries stimulate joint (clinician and patient) reflection about the evolution and improvements achieved by the patient at the different stages of the treatment (Wolters et al., 2013). All the different modules that form the complete framework of the system have also been designed to be smoothly extended with new content that can be included in the sessions or easily adapted to other mental health disorders where a continuous monitoring combined with daily sessions could benefit the treatment.

In order to assess how well our proposed framework is able to generate enough levels of adaptive and varied sessions, we evaluated our system using two different approaches: (1) massive simulations representing daily interactions between the user and the system in order to perform a quantitative analysis using statistical methods; and (2) clinical pilots with real patients ($N=9$) to collect subjective feedback about the perceived levels of variability and adaptability of the content produced by the framework. The rest of the paper is organised as follows: in Section 2 we present the related work. Section 3 describes the design and implementation of the proposed framework. The evaluation methods are described in Section 4, and the obtained results are showed in Section 5. Finally, Section 6 presents some conclusions and future work.

2. Related work

Human–Computer Interaction emerged in the early 1980s, but in the last decade there have been increasing improvements in the field, producing the development of new methods and technologies. Recent achievements in this area have originated new approaches such as adaptive HCI with applications in several areas. Regarding Web platforms, we can find adaptive user interface focused on web searching such as Kinley's study (Kinley et al., 2014), which examined the relationships between users' cognitive styles and their Web searching behaviour. This study may help to provide an adaptive navigation interface that can facilitate efficient retrieval of the relevant search results. In eLearning systems, the adaptive learning interfaces were used to adapt courses, learning material and activities to the learner's individual situation, characteristics and needs (Graf, 2014). The development of applications for mobile devices is one of the most popular areas in which adaptive HCI is applied. Mobile applications are complex since they need to provide sufficient features to a variety of users in a restricted space where small numbers of components are available. Some authors had proposed their frameworks for mobile applications to make the interfaces automatically adapted to the users. Using data mining (*K*-means clustering algorithm) Nivethika