Automatic adaptation in self-monitoring systems for MCI patients: conceptual approach and a software prototype

DAVI DE OLIVEIRA CRUZ, Laboratory of Computer Applications for Health Care, Graduate Program on Information Systems, School of Arts Sciences and Humanities, University of São Paulo, Brazil

CARLOS ALBERTO CHECHETTI JUNIOR, Department of Neurology, Cognitive and Behavioral Neurology Unit, University of São Paulo, Brazil

SONIA MARIA DOZZI BRUCKI, Department of Neurology, Cognitive and Behavioral Neurology Unit, University of São Paulo, Brazil

LEONEL TADAO TAKADA, Department of Neurology, Cognitive and Behavioral Neurology Unit, University of São Paulo, Brazil

FÁTIMA L. S. NUNES, Laboratory of Computer Applications for Health Care, Graduate Program on Information Systems, School of Arts Sciences and Humanities, University of São Paulo, Brazil

With the growth of access to mobile devices, more applications are emerging for the most diverse purposes. In the health area, applications for monitoring patients with some type of dementia facilitate the day-to-day tasks of both patients and caregivers. However, a remaining challenge is to maintain patient loyalty in using the application so that their data can be constantly collected and analyzed, and treatments and follow-ups can be effective. One approach to trying to improve this situation is to customize and adapt the system, bringing it closer to the preferences of each user. This paper presents the conceptual approach and a prototype of a mobile self-monitoring system for patients with Mild Cognitive Impairment (MCI), a pre-dementia condition, which aims to maintain user loyalty in using the system.

CCS Concepts: • **Human-centered computing** → **Mobile computing**; **Mobile devices**; • **Applied computing** → **Health care information systems**.

Additional Key Words and Phrases: software adaptation, mobile, self-monitoring, mHealth

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1 INTRODUCTION

Software adaptation is an approach that aims to enable the system used to meet specific user needs [1]. Interface adaptation, for example, can favor changing visual elements such as text size and colors. Several areas have used software adaptation to improve the user experience and keep the user active in the system. Such adaptations are often perceived in games, web applications, and healthcare applications [6].

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Automatic change of components can contribute to improving the attractiveness of self-monitoring systems by encouraging the continuity of using it [8]. There are several approaches to automatically adapt the system, based on user preferences [3], through facial expression recognition [2] or even through capturing user physiological data [6].

This article presents the conception of an automatic software adaptation approach for self-monitoring systems for the health area. An initial prototype was created to monitor medication schedule, cognitive questionnaire, and physical activity, whose main users are patients and caregivers of people with Mild Cognitive Impairment (MCI), a stage before dementia.

The next sections are presented as follows. Section 2 presents related work about software adaptation. In Section 3 the proposed approach is described together with the prototype created. Initial results and discussion are presented in Section 4 and the Section 5 concludes this paper.

2 RELATED WORK

Software adaptation for health applications has been explored considering different approaches and goals. Adaptations focused on the interface elements, allowing caregivers to define elements such as colors, menu icons, and fonts, are presented in Mulvenna et al. [8], which proposed an application for monitoring, risk notifications, and reminders. Jönsson et al. [4], proposes a system to notify mealtimes at nursing homes through a tablet. The adaptation allows modifying the image displayed when the software is inactive, as well as the background color of the notification screen, text color, and notification ringtone. Similarly, in Øksnebjerg et al. [9] a system with basic calendar functionalities with events and notifications, diary, to-do list, and contacts are presented and evaluated.

Although the applications offer several functionalities, a great challenge is to keep the user motivated to use them, to keep the results consistent [7]. Approaches such as Affective Computing and gamification can collaborate to better understand the users, adapt the system to their profiles, and maintain their interest in the application [1, 5], increasing their adherence even in patients with different stages of dementia [5].

3 CONCEPTUAL APPROACH AND PROTOTYPE

This work intends to develop an approach for self-monitoring applications by using automatic adaptation to provide customization. As proof of concept, we are directing the application to patients with MCI. Figure 1 presents a conceptual approach, as well as the interaction flow of the patient and the healthcare professional.

The application captures the patient's facial expression, the emotion will be recognized, and the application interface will be adapted according to the settings established by the health professional. The web service is responsible for notifying the application and sending the adaptations to be carried out. Initially, neutral or smiling expressions will be recognized, and the adaptation will be made by detecting a neutral expression during the execution of daily tasks. The tasks will have generic themes and themes targeting the user's pre-configured preferences. These themes will be adapted according to the recognized expression.

To first evaluate functionalities and usability, we build a prototype that includes some initial monitoring functionalities and a cognitive questionnaire. From evaluations and discussions with the research group, the prototype will be refined, and the initial version will be made available for testing with users.

An initial prototype was developed with functionalities to monitor the medication schedule and physical activities, besides a cognitive questionnaire (Figure 2). The registration page allows the user to input basic information for identification and registration (Figure 2a). The medication schedule allows the patient to register the medications in use, define the frequency of use, and control when a medication was administered by receiving a notification at the

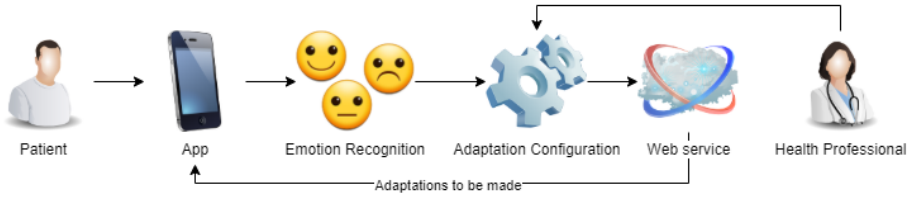

Fig. 1. Overview of the proposed approach

configured time (Figures 2b and 2c). The cognitive questionnaire aims to periodically evaluate the current state of the patient with simple and direct questions with fixed alternatives (Figure 2d). Finally, the physical activity record is integrated with Google Fit [1] and allows viewing the steps captured and recorded by the mobile phone (Figure 2e). The prototype was developed for the Android platform with React Native framework [2].

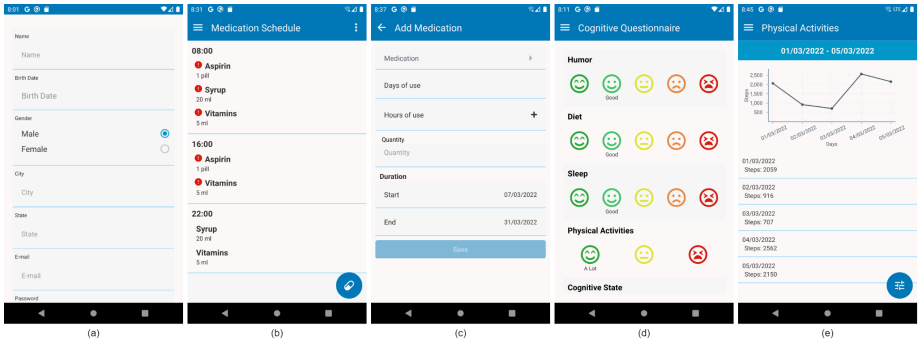

Fig. 2. Prototype screenshots: (a) Registration, (b) Medication Schedule, (c) Medication Input, (d) Cognitive Questionnaire, (e) Physical Activities

4 INITIAL RESULTS AND DISCUSSION

An experiment was conducted to evaluate the usability and functionality of the prototype created. Three volunteers, who are health professionals, answered the proposed questionnaire. Each item evaluated had a navigation proposal and five questions about usability and interface. Grade percentage was calculated based on the score of each positive or negative answer and is presented in Table 1. The lowest percentages of each item are highlighted in bold.

As noted in Table 1, the system was well accepted by users; however, some relevant points were raised. The three items with the lowest acceptance are highlighted in the Mean column and must receive greater attention. In the first item, Login and User Creation, a user had difficulty with the date component to select the date of birth. The component can be updated to allow the user to input directly this date, instead of selecting the date in a calendar. The Cognitive Questionnaire questions and options need to be clearer, with a better description of each item, as suggested by the users. Finally, in navigation through the application, a user identified that today's list could contain all the items to be performed on a determined day, such as the proposal to do physical activities or answer the cognitive questionnaire, in addition to the medications to be administered.

[1] https://www.google.com/fit/
[2] https://reactnative.dev/

Table 1. User acceptance for each system functionality

Evaluated Item	User 1	User 2	User 3	Mean
Login and User creation	**60%**	80%	80%	**73%**
Cognitive Questionnaire	**40%**	100%	100%	**80%**
Screen "Today Medications"	100%	**80%**	**80%**	87%
Screen "Add Medication"	**60%**	100%	100%	87%
Screen "Medications List"	**60%**	100%	100%	87%
Screen "Usage History"	**80%**	100%	100%	93%
Screen "Physical Activities"	**80%**	100%	**80%**	87%
App Notifications	**80%**	100%	100%	93%
App Navigation	80%	**40%**	80%	**67%**

5 CONCLUSION

This paper presented a conceptual approach for automatic adaptation in self-monitoring software, a prototype to monitor patients with MCI, and the initial results of an experiment conducted with health professionals. This prototype will be improved and used as a proof of concept of an automatic software adaptation approach for self-monitoring systems based on emotion recognition. The next steps will be the emotion recognition by using facial expressions, as well as the definition and implementation of the automatic adaptation after detecting that the patient is not having a good experience when using the application. Finally, usability tests will be conducted with end users (patients and caregivers) to evaluate the impacts of the automatic adaptation on the use of the proposed application.

REFERENCES

[1] Renan Vinicius Aranha, Cleber Gimenez Correa, and Fatima L.S. Nunes. 2019. Adapting software with Affective Computing: a systematic review. *IEEE Transactions on Affective Computing* (2019), 1–1. https://doi.org/10.1109/TAFFC.2019.2902379

[2] Sandra Baldassarri, Isabelle Hupont, David Abadía, and Eva Cerezo. 2015. Affective-aware tutoring platform for interactive digital television. *Multimedia Tools and Applications* 74 (5 2015), 3183–3206. Issue 9. https://doi.org/10.1007/S11042-013-1779-Z/TABLES/2

[3] Vlado Glavinic, Sandi Ljubic, and Mihael Kukec. 2008. Transformable Menu Component for Mobile Device Applications: Working with both Adaptive and Adaptable User Interfaces. *International Journal of Interactive Mobile Technologies (iJIM)* 2 (5 2008), 22–27. Issue 3. https://doi.org/10.3991/IJIM.V2I3.285

[4] Karl-Ebbe Jönsson, Kajsa Ornstein, Jonas Christensen, and Jeanette Eriksson. 2019. A reminder system for independence in dementia care: A case study in an assisted living facility. In *ACM International Conference Proceeding Series (PETRA '19)*. Association for Computing Machinery, New York, NY, USA, 176–185. https://doi.org/10.1145/3316782.3321530

[5] Evdoxia Eirini Lithoxoidou, Ioannis Paliokas, Ioannis Gotsos, Stelios Krinidis, Athanasios Tsakiris, Konstantinos Votis, and Dimitrios Tzovaras. 2018. A Gamification Engine Architecture for Enhancing Behavioral Change Support Systems. In *Proceedings of the 11th PErvasive Technologies Related to Assistive Environments Conference* (Corfu, Greece) *(PETRA '18)*. Association for Computing Machinery, New York, NY, USA, 482–489. https://doi.org/10.1145/3197768.3201561

[6] Nelly Condori-Fernandez ANDFranci Suni Lopez. 2017. Using Emotions to Empower the Self-Adaptation Capability of Software Services. In *2017 IEEE/ACM 2nd International Workshop on Emotion Awareness in Software Engineering (SEmotion)*. 15–21. https://doi.org/10.1109/SEmotion.2017.8

[7] David C. Mohr, Ken R. Weingardt, Madhu Reddy, and Stephen M. Schueller. 2017. Three problems with current digital mental health research. and three things we can do about them. *Psychiatric Services* 68, 5 (5 2017), 427–429. https://doi.org/10.1176/appi.ps.201600541

[8] Maurice Mulvenna, Suzanne Martin, Stefan Sävenstedt, Johan Bengtsson, Franka Meiland, Rose Marie Dröes, Marike Hettinga, Ferial Moelaert, and David Craig. 2010. Designing & evaluating a cognitive prosthetic for people with mild dementia. In *Proceedings of the 28th Annual European Conference on Cognitive Ergonomics* (Delft, Netherlands) *(ECCE '10)*. Association for Computing Machinery, New York, NY, USA, 11–18. https://doi.org/10.1145/1962300.1962306

[9] Laila Øksnebjerg, Bob Woods, Kathrine Ruth, Annette Lauridsen, Susanne Kristiansen, Helle Dalsgaard Holst, and Gunhild Waldemar. 2020. A tablet app supporting self-management for people with dementia: Explorative study of adoption and use patterns. *JMIR mHealth and uHealth* 8, 1 (1 2020), e14694. https://doi.org/10.2196/14694