Stationary pill-dispenser with calm reminders and automatic dosing

I. M. N. Christiansen, S. M. Clausen, S. R. E. Datondji, M. Nielsen, L. K. Pedersen, M. N. Skov, C. F. Pedersen, S. Wagner

Aarhus University, School of Engineering, Finlandsgade 22, 8200 Aarhus N

{09781, 10061, 10506, 10520, 2012202215, 08139, cfp, sw}@iha.dk

***Abstract* — The aim of this paper is to support and empower early satges Parkinson's patients. Studies show that chronic patients (ex. Parkinson's patients) have a low medication adherence. The suggested solution consist of an automatically pill-dispenser and an application. The system dose, register and calmly reminds the patients about the medication. The registration is stored in a local database accessible to the patient's medical practitioner.**

To evaluate the project a lab test and a user test were conducted. In addition two patients from the target group were interviewed, and they both expressed that remembering the medication was a common issue, and that there was a need for a calm medication reminder. The design of the current pill-dispenser is not recommended by the interviewed patients because of size and a lack of mobility. This exploration of the suggested solution showed a desire and need for a calm reminder of medication, without making the patients feel stigmatize and excluded from social events.

Keywords: pill-dispenser, Parkinson's disease, Android application, Phidgets sensors, automatically dosing of medicine.

I. INTRODUCTION

Parkinson's disease is caused by a progressive loss of dopamine producing brain cells [1]. The disease affects around 165 per 100.000 persons in Denmark ([2], p.408-409). Symptoms range from a number of different muscle dependent disabilities like difficulty swallowing, muscle aches and pains to tremors and low blood pressure. The disease can cause a number of sequela which may include dementia, depression, hallucinations and memory loss [1]. It is crucial for Parkinson patients that they take their medicine at the same time, every day, to obtain a constant amount of dopamine in the cells and thereby avoid severe symptoms ([2], p.408-409). The severity level of the symptoms is classified into five stages [3], where the focus in matter will be on patients in the tree earliest stages. Compliance in early stages of the disease has shown to be challenging and medication aids has proven helpful [4].

The cost of every Parkinson patient in Denmark is a total of 140 million €PPP (2010), with a mean cost per patient of 11,959 €PPP. The costs consist of both direct and indirect costs. Helping the Parkinson patient staying independent and compliant can significantly reduce direct healthcare- and non-medical costs [5].

The aim of this paper is to support and empower Parkinson's patients in the early stages of their disease by automatically dosing and calmly reminding them of forgotten medicine intake.

II. METHOD AND MATERIALS

The Adherence Strategy Engineering Framework (ASEF) [6] was used in the development process of investigating problems in domain, context, technology, stakeholders and adherence. The analysis leads to a design suggestion and the development of a prototype. In the development the reduced adherence model (RAM) [6] was used and sensors were implemented to work as verifiers to register the actions of the patient.

This project was developed as a proof of concept; therefore the prototype was produced to represent the main ideas of the concept, but it does not resemble a finished, nor a suitable product.

A. Suggested solution

The solution consists of two corresponding systems; a stationary, automatic pill dispenser and an Android application.

The pill dispenser gives a calm reminder with a LED-light up 10 min. prior to scheduled medication time and will be active until medication has been taken. To take medication the patient activates the pill dispenser by pressing a button. The dispenser then delivers the pre-defined amount of medicine into a cup situated in the compartment below. The patient removes the cup to take the medicine. A sensor registers when the cup is removed and a light will indicate that the cup should be returned to the compartment. If the medication has not been registered as taken within the scheduled time, a red light will activate. If then the medicine has still not been taken 20 minutes past scheduled medication time a notification will be send to the patient through the Android application. The patient does on the tablet press either "I'm going to take the medication" or "I will take the medication now". If the first button is pressed, the red light will turn off and nothing else happens until next medication time. If "I will take the medication now"-button is pressed the red light turns of and the green light turns on. Then the normal medication procedure is followed

The pill dispenser is then connected to a user-application for an Android tablet, which will display a notification if the medicine has not been registered as taken. The patient then registers that the notification has been received by giving

input to the application. The patient can also register notes on medication, physical well-being or complications in to the database. The application registers activated notifications in a local database. This data will be available for a medical practitioner for evaluation of the patient's adherence.

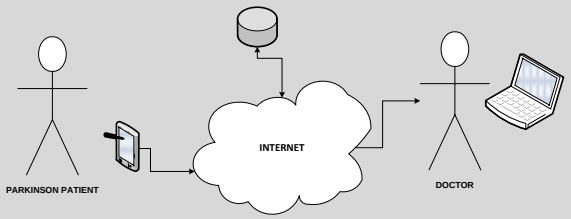

Figure 1 Suggested solution

B. Evaluation

To evaluate the project a lab test and a user test were conducted. The lab tests were used to verify the functions and reliability of the complete prototype. Functions that were tested in the lab were the following:

- Automatically dosing of pills
- Alarm functions
- Light functions
- Registration of the adherence

All the requirements were continuously tested 30 times and were not approved if tests were unsuccessful more than 5 out of the 30 times.

As a supplement to the hypothesis about Parkinson's patients' need of a pill dispenser with a calm reminding system, two patients from the target group was interviewed using a semi-structured interviewing method (7).

C. Materials

The prototype was constructed of a mix of acrylic and metallic materials. Furthermore the dispenser contained the following:

- Solarbotics GM12a 100:1 Mini Metal Gear Motor
- Bc547b transistor
- 12 V power supply
- Three standard 5mm LED-lights (green, red, and yellow)

The application is using a SQLite database for registration of data. Sensors, lights, and motors are connected to a Phidgets SBC board, [8] which is connected to an Android tablet through a Wi-Fi connection.

The application is developed with Android 4.0 for a 7" Android tablet (Samsung 8GB Galaxy Tab 2).

III. RESULTS

Because of time restrains and construction problems a user-test and a test of the whole system was not conducted at the time of this papers publication. The systems elements where though tested individually.

A. The interviews

Interviewing the two Parkinson's showed a desire for a discrete medication reminder. Both interviewed patients need to take their medicine every 2½-3 hours during day time. To remember the medication they both use alarms set on their mobile phones. Though, they both found using the alarms frustrating and disturbing to themselves and to their surroundings. They expressed a general feeling of attention being drawn to them and their disease, by the alarm-noise and therefore they felt more sick, exposed and stigmatized. Both patients expressed that remembering the medication on the right times was a common issue.

None of the patients expressed a need for an automatic pill dispenser. The use of a pill dispenser requires that the dispenser is small and portable, as they do not wish to be tied to their home.

B. The Application

Looking at the user side of the application there is three tabs; Notes, Medication and Settings. In "Settings" (figure 2) it is possible for a user to log onto the system. In "Notes" (figure 3) the user can type in any notes about their current psychical or mental condition. In "Medication" (figure 4) the patient is able to add the medication specified by name, frequency of intake and description. When added, the application displays a list of medication connected with the reminder. Three indicators in the top corner (figure 3) indicate if morning-, noon- and evening medicine have been taken. The application has proven able to turn on and off lights on the pill-dispenser. The patient is required to activate the application in the morning, after that the medication reminder will run automatically during the day-time.

The database has been tested together with the application, but not with the pill dispenser. The database works as intended in corporation with the application.

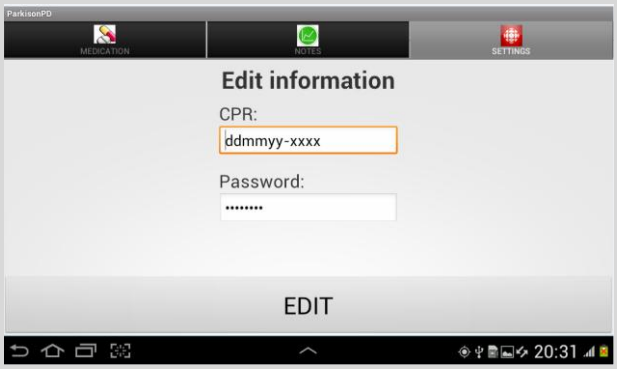

Figure 2 Settings

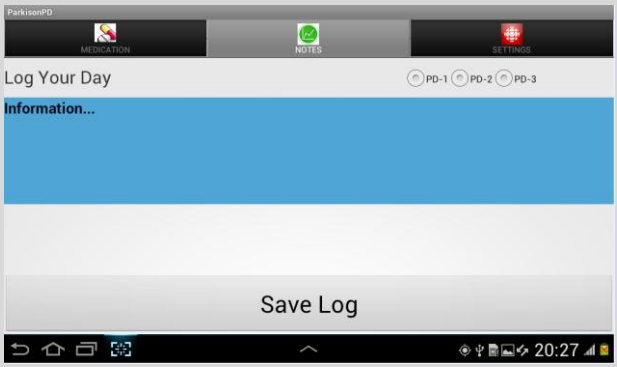

Figure 3 Notes

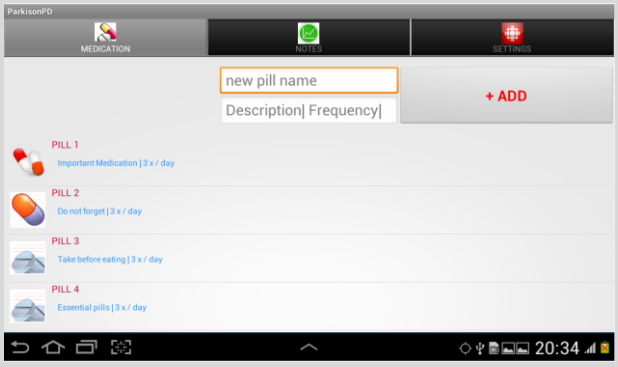

Figure 4 Medication Overview

C. The pill-dispenser

The functionality of the pill-dispenser currently does not work as first required. The system is still undergoing an iterative improvement process. However, at the time of the publishing the prototype (figure 5) was able to indicate by a yellow light that the cup, situated in the compartment below the pill-container, was removed. The light continues to be active until the cup is returned into the compartment.

A button on the dispenser can be pushed to activate medication delivery. This button activates the motor and delivers a pill in the cup situated in the compartment below. At the time of publishing, the dispenser was only able to deliver one pill at a time. Due to time- and construction constrains, it was not possible to create a prototype containing a required 200 pills. Lab tests of the dispenser showed that the system is stable and dispenses a pill every time activated.

Figure 5 Pill dispenser prototype v.1

IV. Discussion

A. The application

The use of smart technology has its pros and cons. There is lot of beneficial functions in smart technology, but if the patient is not familiar using smart phones, a thorough introduction is necessary. Other problems using smart technology are the battery lifetime and that the device always has to be within reach.

The 7” Android tablet was chosen because of its user friendly screen size for patients with light tremors, especially keeping the users age and level of disabilities in mind. To ease the user’s experiences the applications user interface was designed minimalistic. The design layout may be too simple in the prototype to have a beneficial effect on the patient’s adherence and further exploring of the systems user-interface design is found to be needed.

The interviewed Parkinson’s patients expressed that audio alarms is intrusive and disturbing to their social life. They also expressed a wish to be notified by a discreet reminder, something that no one else than themselves would notice. This discreet notification could be given by a light indication or a vibration. The user-applications functions were well received. Though most Parkinson’s patient are considered elderly, both interviewed patients seemed to trust the use of technology as part of their daily treatment. Extending the application to a platform involving relatives did not seem to be of any interest.

B. The pill-dispenser

A stationary pill-dispenser could create limitations in the patient's social life. As the prototype is not portable use of it requires the patient to be home at all times.

If the patient is required to take a number of different pills, the design and size of the pill-dispenser must be taken into consideration. The dispenser must not become too large. This could make the patients reluctant in use of the technology. The size could also keep patients from having the dispenser in their homes.

Another issue with the current prototype is the noise of the motor as the pills are dispensed. The noise can be a barrier for use of the dispenser, as it draws attention to the patient' need of medication.

Parkinson's patients need to continuously exercise their cognitive and physical functions to decrease the negative acceleration of their disease [1]. Being responsible for dosing their own medication could be a way of training the cognitive functions. By automatically dosing the medication this cognitive training could be eliminated and this can leave some patients worse off. The desire for an automatically dosing pill-dispenser was not expressed in the interviews. Dosing the medicine was not an issue to the patients, but created instead an additional way to train their cognitive functions. The need for an automatic pill-dispenser must be explored further to evaluate the positive effect versus the negative consequences.

An element worth to further investigate is where the pill-dispensers function as a stationary pill-dispenser really is desirable. A situation where the pill dispenser could be desired is at nursing homes or at hospitals wards.

The "Danish Health and Medicines Authority" found 34.418 reports about unintended events in 2010 where medication had been dosed wrong, this was an increase of 36 % from the year before. Errors in dosing, handling and dispensing of medicine could have severe consequences for patients and this could end up being very expensive for the Danish healthcare system [9]. These statistics could possibly be improved with an automatic pill-dispensing system.

C. The overall-system

This system uses an indirect method for measuring the adherence of the patient. The use of an automatic pill-dispenser can be precise and results are then easily quantified. These data can if misinterpreted be misleading. The pill-dispenser system does not measure if the patient actually takes the medicine, only that the medicine has been removed from the dispenser. The pill dispenser system can give the physicians an easy overview of forgotten medicine ([10], Table 1). In addition to the electronic adherence measurement, the current conditions of the patients, is reported through the notes-system.

Having all this information set together the physician maybe could evaluate the progression of disease better. When having data about the patients feelings at the time of medicine intake, risks of a white-coat-barrier could be eliminated [10].

Using an indirect registering method of the patient's adherence could increase efficiency in the patient's treatment and in the general healthcare system [10]. Studies have shown that medication adherence decrease over time, while looking at chronic patients and/or patients with multiple types of prescribed medication [10]. The Parkinson's patient group covers both of those scenarios, and is therefore considered to be at a higher risk of non-adherence, than critical patients [10]. The ability of medical physicians to recognize non-adherence, has been shown to be poor ([10], p. 1 bottom) and furthermore expensive to the healthcare system ([10], p.1 top). A focus on medicine adherence registration could not only improve patients' treatment, but also the quality of life, according to the interviewed patients.

This project showed that there was a need for a calm reminder, and that the measurement of adherence was desired. The automatically dosing of pills was found, to be less important for the patients.

D: Future work

Through the development process many future additions and improvements to the system were discussed, some of which worth mentioning in this context.

Application

An addition to the patients' application could be a medication management system. This system should make it possible to directly (on the tablet) order medication from the pharmacy, access information about prescript medication. A further extension could be an automatic update of prescriptions, when altered by health personal. A possibility to scan information on the medication containers, and then get doses and leaflet for this medication type could be desired.

A contact-function, where the patient easily could access contact information to the desired health personal and a through this function directly contact them either via mail og phone calls. Furthermore we discussed the prospects of making the application on an open platform, where it would be possible to connect the application to information homepages about the disease, e-journals, patient forums, GPS-tracking ect.

From the medical practitioner's application, it should be possible to access graphs over medication adherence during a period of time and then add notes about the patient's adherence. An option of synchronizing and connecting data and notes to the common electronic patient journal system should be applied, like the Danish EPJ.

A future prospect of the solution could be using of the system, as a part of a TeleCare solution, where patients could be consulted and treated despite long distances.

Dispenser

A realistic model of the pill dispenser has to be mobile, as the patients cannot be expected always to be at home, while taking their medication. The medication-reminder should be as discreet as possible; a vibration and/or a light could be a solution. The dispenser should be able to manage more than one kind of medicine and then still dose them differently.

REFERENCES

[1] Zieve MMD, Eltzz DR, Jasmin MPL. Parkinson's disease. 2011; Available at: http://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0001762/. Accessed 02/05, 2013.

[2] Schulze S, Schroeder TV. Basisbog i sygdomslære. First edition ed. Denmark: Munksgaard; 2008.

[3] Johnels B, Carlsson M. Sygdommens faser. Available at: http://www.parkinson.dk/indhold/sygdommens-faser. Accessed 02/18, 2013.

[4] Johnels B, Carlsson M. Aftagende effekt og svingninger. Available at: http://www.parkinson.dk/viden/aftagende-effekt-og-svingninger. Accessed 02/07, 2013.

[5] Gustavsson et al. A. Cost of disorders of the brain in Europe 2010. 2011(21):718.

[6] Wagner S, Bertelsen OW, Toftegaard TS. The Adherence Strategy Engineering Framework (ASEF). 2012.

[7] Daniels K, Johnson G, de Charnatonay L, Isabella LA, Lyles MA, Schwenk C. Semistrukturerede interview. Available at: http://www.strategylab.dk/portal/tools/strategibanken/metoder/kognitionsmetoder/semistrukturerede-interview/. Accessed 2/1, 2013.

[8] Phidgets. Product Manual - 1070 PhidgetsSBC. 2010 28/10/2010.

[9] Sundhedsstyrelsen. Markant flere rapporterer om utilsigtede hændelser. 2011; Available at: http://www.sst.dk/Nyhedscenter/Nyheder/2011/DPSDaarsrapport2010.aspx. Accessed 3/14, 2013.

[10] Osterberg MDL, Blaschke TMD. Adherence to Medication. 2005 04/08/2005;353(5):487.