PERGAMON: A serious gaming and digital coaching platform supporting patients and healthcare professionals

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Abstract

This paper describes the design of a platform for serious gaming and digital coaching supporting healthcare and self-management of chronic patients. An instantiation of the platform outlined here supports self-management of adolescents with Type 1 diabetes that is integrated with their usual paediatric diabetes care. The platform integrates a sensor network (i.e., physical activity and blood glucose monitor), a gamification component and a virtual coach that functions as a coach as well as a game guide which provides hints and tailored feedback based on the patient’s sensor data, behavioural goals in the game world or in the real world. The application is available for registered patients on a website and as an Android app. The platform was developed over two years in a Horizon 2020 Industrial Leadership project. We discuss the planned user evaluation studies with adolescents diabetic Type 1 patients, the challenges faced in integrating pervasive serious gaming and digital coaching technology and implications for regular continuous care of patients with chronic conditions with this platform.

Keywords: serious game; digital coaching; e-health care; integrated platform

1. Introduction

Self-management is of key importance in the successful treatment of young people with chronic conditions, such as Type 1 diabetes. The success of diabetes control highly depends on how a patient perceives his/her
condition, what he/she learns from their own experiences and their self-management skills. There is a clear need to support patients beyond the medical environment in their daily life. Serious games, driven by instructional goals and appropriate application of game mechanics, have considerable potential to engage, motivate and influence behaviours of learners. Studies showed that serious games for health care education can be effective in improving knowledge and self-management in young people with chronic diseases [1], [2]. Research has shown that regular measurement of blood glucose level is critical for effective self-management of adolescent with Type 1 diabetes. Digital diabetes coaches that use physical sensor data can make patients aware of their condition and give feedback and hints tailored to the patient’s personal preferences [3], [4]. Can we improve user engagement and support self-management in maintaining a healthy lifestyle by a virtual coach that monitors the patient’s activities and achievements in the game world as well as in the real world? Such a pervasive coach could encourage the patient to perform activities in the game world or in the real world to make progress.

In this paper we describe the PERvasive serious GAmes suppOrted by virtual coachiNg (PERGAMON) platform that is developed in the European PERGAMON Horizon 2020 project. The PERGAMON platform is tailored to both patients’ needs and the health care system services. From the healthcare perspective, in particular for the pediatric department of the hospital partner, Gelderse Vallei Hospital, the aim is to see how gamification and digital coaching can be integrated into the continuous care of patients with chronic conditions. The implementation of the platform that we describe here targets adolescents with Type 1 diabetes aged 12-18, and is called “Tako Game”, because the game is set in a fantasy Oriental world populated by little squids (“tako” in Japanese). It implements the diabetes educators [5] through the use of an adventure game, called the Tiki Tako Game, several integrated educational mini-games and by small educational elements such as video’s called “educational candy”. A virtual coach monitors health related activities of the user in the game world as well as in the real world and functions also as a game guide.

This paper is organised as follows: in Section 2 we review related work in e/m-health platforms for supporting self-management in healthcare and point out how our work contributes to that field. In Section 3 we describe the design and the different components of the PERGAMON Tako Game application. In Section 4 we discuss the user evaluation study planned for the second half of 2016 in cooperation with the partner hospital. The acceptance of the system critically depends not only on ease of use and efficacy but also on privacy and security concerns as well as on the reliability of the data collected by sensors. Section 5 concludes with conditions for acceptance of this type of technology and typical challenges that should be addressed for the platform to successfully implement into regular health care services.

2. Related work

Type 1 diabetes treatment requires daily insulin injections or the use of an insulin pump together with a regular diet and frequent blood glucose monitoring. To control their blood glucose level by a regular insulin intake the patients have to measure their blood glucose level multiple times a day, and they have to keep track of their food intake and physical activity. Frequent self-monitoring of blood glucose has shown to be significantly associated with better metabolic control [6]. Patients encounter many barriers while dealing with diabetes self-management in everyday life. Diabetes management in adolescence is poorer than in other age groups so they need interventions that suits the needs of this age group [7], [8]. Since smartphones are common nowadays they are a potentially powerful tool to assist diabetes patients in managing their disease. In particular for this age group the use of serious games and gamification techniques are expected to have a positive impact on the patient’s engagement and adherence to his health care regime.

An experiment with 30 young diabetes Type 1 patients carried out at the Gelderse Vallei Hospital analysed the effect of a closed-loop diabetes decision support system (BLink). In the experiment blood glucose data were synchronized between a glucometer and web-based personal health record (PHR), linked to the electronic medical record system (EMR) by a smartphone [6]. One of the main conclusions of the study was that patients who engaged in regular daily measurements of glucose level showed improved glucose control.
Together with the same hospital, the Human Media Interaction group of the University of Twente developed and tested a personal coach for young Type 1 diabetes patients, the GO-Coach [9]. The target of the coaching was the regular daily measurement of glucose level. The patient using the mobile coach could pre-specify how often a day he/she wanted to measure their blood glucose and at what time intervals. Also he/she could pre-specify how often he wanted to be reminded about measuring blood glucose by a simple message from the coach when blood glucose was not measured at the pre-set times. Other features of the system included a diary, a virtual character and a personal website through which he could contact the caregiver. The sensor data was sent to the secure server of the hospital. In the GO-Coach the coaching engine ran on the smartphone, not on a central server as in the PERGAMON platform (see [10] for a discussion about pros and cons of various platform architectures). To provide the virtual coach with actual information about glucose values, the user could send their glucose measurements from the Glucometer to the application on the mobile. Most patients did that only once in a week, a practice acceptable for the caregivers. A pilot test with 5 patients over 3 months showed that the main effect of using the GO-coach was that patients sent their data more regularly to the system than before the test.

There are many apps available for public use that support diabetes patients offering the user functions as the one we developed [11]. Gamification mechanisms are already used by organisations for stimulating the public to promote a healthy life style, e.g., clients of a health insurance company can send their physical activity data collected by an app using GPS (e.g., Runkeeper) to their health insurance. When personal targets are reached points gained can be exchanged for goods or a reduction in insurance premium. The PERGAMON platform takes a step further in the integration of serious gaming and coaching for specific target groups as part of a medical care for patients with chronic conditions.

3. The PERGAMON platform

The platform that has been developed provides a pervasive gaming experience through gamification mechanisms and is integrated with sensors and personalised user support by a virtual coach. Figure 1 provides an overview of the platform. The objective of applications developed on this platform is to generate behaviour change in the user by encouraging correct behaviour, monitoring behaviour through sensors, engaging and motivating the user through pervasive gaming techniques and teaching new knowledge or refreshing existing knowledge. The platform can be used for many applications, using different sensors, targeting on behaviour change, but in this paper we will describe the development of an application to empower young diabetes Type I patients. In the following sections we will describe each component of the platform in more detail.

Figure 1 The PERGAMON platform
3.1. Game Platform and Ground Layer

The central place of the platform is the “game platform and ground layer” components (see Figure 1). These components are able to communicate with all the other components among the platform via RESTful APIs. Data from other components are stored in these components and can be accessed via an API.

These components are also responsible for translating data collected by other components (e.g., the sensor network described in Section 3.3) into the gaming environment of the pervasive serious game. The idea of this gaming environment is to engage the user by turning routines needed for self-management into fun and challenging activities. Self-management activities are translated into (sub-)tasks, e.g., to do some physical exercises, or to play an instructive game. The game platform keeps track of the activities of the users and rewards the user with points when the user finishes the tasks. These points are needed to play the adventure game discussed in the next section.

3.2. Serious Game

The game component of the platform represents the serious game within the platform. The goal of the game is twofold. First of all the game should be fun to play and improve the user adherence and persuade the users to keep on using the system. The second goal of the serious game is to teach the diabetic patients required knowledge of their disease or refresh their existing knowledge and some basic skills for self-management. In the Tako Game, the application for diabetic patients, the adventure game “The Mystery of Tiki Tako” includes seven mini-games embedded in the main adventure game. Within the serious game users have to play and finish the mini-games to continue the main adventure game. The mini-games help the player acquire some key abilities needed for diabetes management. They have certain educational objectives, themes covering the diabetes educators, e.g., how to measure the blood sugar level, count carbs in food, or how to recognize first symptoms of a hypoglycaemia. Users need to collect knowledge, experience and evolution points in order to reach new levels in the game. Points can be earned by executing specific activities in the real world (e.g., daily physical exercises, glucose measurements) or in the game world (play a mini-game). Mini-games have enabling conditions that set personal goals in the real world.

3.3. Sensor Network

The “sensor network” component of the platform collects data from sensors about the activities of the users in real-life. The sensor network is running on an Android tablet or smartphone device, turning it into a sensor network hub to which different devices can be connected. The architecture of the sensor network makes it possible to add new devices and services in an easy and modular way. Compatible sensors and services connected to the sensor network will automatically record data. The sensor network will gather the recorded data, process the data and pushes it to the gamification component where it is stored and can be accessed by other components of the platform. The sensor network also provides the possibility of manual entering data, e.g., insulin injections are recorded by manual input.

3.4. Virtual Coach

The virtual coach knows the active personal objectives of each of the users as well as their achievements in the real world and in the game world. It uses this information to assist the users in achieving their objectives by processing collected data and offering guidance in the form of reminders, notifications and suggestions about certain actions and events. The virtual coach component consists of a coaching engine and a graphical representation [12], [13], [14], [15]. Coaching rules defined in the coaching engine analyse data available in the
gamification component and coming from the sensor network. The conditions and targets of the coaching rules are based on self-management behaviours and are defined together with knowledge provided by healthcare professionals.

The coaching rules are executed on triggers. These triggers are event or time based. When coaching rules are executed the virtual coach will compare the data from the gamification platform to the user’s personal goals. The result of these coaching rules can be: Suggestions to play certain serious (mini-) games where the user will learn educational objectives in which the user needs knowledge, or to perform some activity to enable a mini-game to reach the next level in the Tiki Tako game. Suggestions to take a look at diabetes related educational videos or materials to read and gain knowledge (“educational candy”). Suggestions to take a look at the user’s own data in the application. Reminders or notifications about certain actions or events (e.g., when goals are reached or users forgot to measure their glucose levels).

The virtual coach is able to send text messages and notifications to the website and to the Android app. The virtual coach is currently displayed as a cartoonlike character from the game that displays text messages and an image of doctor Tako.

4. User evaluation studies

The Tiko Tako Game implementation of the PERGAMON framework will be evaluated with adolescents Type I diabetic patients of the Gelderse Vallei Hospital. The user evaluation will take place in real-life conditions, involving patients, their families, medical staff and caregivers. A number of 30-50 patients will be involved. The main question is “What are the user experiences of adolescents with Type 1 diabetes regarding this first prototype of PERGAMON?” The primary aim of this pilot study is to examine the usability of the PERGAMON platform. User Experience includes all the users' emotions, beliefs, preferences, perceptions, physical and psychological responses, behaviors and accomplishments that occur before, during and after use. Different methods will be used to collect data varying from focus group sessions, observations, interviews and self-report questionnaires (e.g., Problem Areas in Diabetes Questionnaire [16] and System Usability Scale [17]). The test results will be input for further development of the platform. The user evaluation studies are planned for the second half of 2016.

5. Conclusions and challenges ahead towards integration in the health care system

The PERGAMON platform allows the integration of serious gaming and digital coaching to support patients with chronic conditions. The introduction of mobile intelligent agent platforms that support patient’s self-management meets several challenges. Patient portals and e/m-health application raise privacy and security issues distinct from the ones involved with the usual clinical information systems. Patients as well as caregivers indicate that privacy concerns are an important factor that determines if they trust a patient portal or an e/m-health application [18]. Another challenging issue is the reliability of the sensors and the network required for “real-time” and adequate coaching instructions. The sensor network supports the services of Google Fit for physical activity, several devices for glucose measurements and pedometers.

Initially iHealth sensors were selected for the platform, because of their open API. According to iHealth the Wireless Smart Gluco-Monitor is “an FDA and CE approved device. It meets the rigorous accuracy standards set by the governing bodies in the USA and Europe”. However, hospitals and health insurance companies in many European countries, such as The Netherlands, require a more restricted certification. Therefore, in the coming pilot study, the iHealth glucometer will be replaced by a glucometer that meets the certification in our country (Glucofix Tech). Ideally the sensor network allows to plug-in most of the commonly used blood glucose sensors. Commercially available sensors such as iHealth provide an open API so they can be easily used by our platform. On the other hand medical sensors that comply with these high quality standards often do not provide an open API for integration in the platform. Close cooperation with providers of these high quality
sensors is thus a requisite for successful embedding and implementation of the platform into the medical healthcare ecology.

Another challenge is the embedding of the use and maintenance of the platform in diabetes care services. Most importantly, all members of the diabetes teams have to be informed about the possibilities and limitations of the platform. They should be involved in the development of this type of new e/m-health information technology in order to make them useful as enhancement of their patients’ self-care. We expect that the user evaluations will also inform us about the meaning and impact of the use of the PERGAMON platform for the caregivers.

Acknowledgements

This is a product of the PERGAMON consortium. The PERGAMON project receives funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No. 644385.

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