MedFit: a Mobile Application for Recovering CVD Patients

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ABSTRACT

The third phase of the recovery from cardiovascular disease (CVD) is an exercise-based rehabilitation programme. However, adherence to an exercise regime is typically not maintained by the patient for a variety of reasons such as lack of time, financial constraints, etc. In order to facilitate patients to perform their exercises from the comfort of their home and at their own convenience, we have developed a mobile application, termed MedFit. It provides access to a tailored suite of exercises along with easy to understand guidance from audio and video instructions. Two types of wearable sensors are utilized to allow motivational feedback to be provided to the user for self monitoring and to provide near real-time feedback. Fitbit, a commercially available activity and fitness tracker, is used to provide in-depth feedback for self-monitoring over longer periods of time (e.g. day, week, month), whereas the Shimmer wireless sensing platform provides the data for near real-time feedback on the quality of the exercises performed. MedFit is a simple and intuitive mobile application designed to provide the motivation and tools for patients to help ensure faster recovery from the trauma caused by CVD. In this paper we describe the MedFit application as a demo submission to the 2^{nd} MMHealth Workshop at ACM MM 2017.

CCS CONCEPTS

• **Applied computing** → *Health care information systems*; • **Human-centered computing** → *Mobile computing*;

KEYWORDS

Cardiovascular disease, Mobile Application, Wearable Sensors, Activity Recognition, Repetition Counting

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1 INTRODUCTION

The third phase of the recovery from cardiovascular disease (CVD) is an exercise-based rehabilitation process. This is usually delivered through a community-based rehabilitation programme where patients come together each week in order to exercise. However, it is well known that attendance for such programmes and consequently adherence to an exercise regime is typically not maintained by many patients due to various reasons such as lack of time, financial constraints, etc. [3]. To explore how technology can help to address this, we are investigating the use of mobile and wearable technology in order to allow patients to complete their exercises from the comfort of their home and at their own convenience. We have developed a mobile application, termed MedFit, that provides patients access to a suite of exercises with audio and video guidance, along with personalised feedback on their progress and provision of additional information on maintaining a healthy lifestyle.

This technology driven solution is similar in spirit to other solutions developed with CVD patients in mind [4]. Our system extends previous similar systems in three ways. First, The proposed application is based on a collaboration with behavior psychologists who have expertise in behavioral change techniques, crucial to ensuring the effectiveness of any technical solution. The design and selection of each component in the application is backed up by state-of-the art research in the fields of behavior change and social cognitive theory. Second, the application utilizes two types of wearable sensors to provide feedback to the user. A commercial fitness tracker

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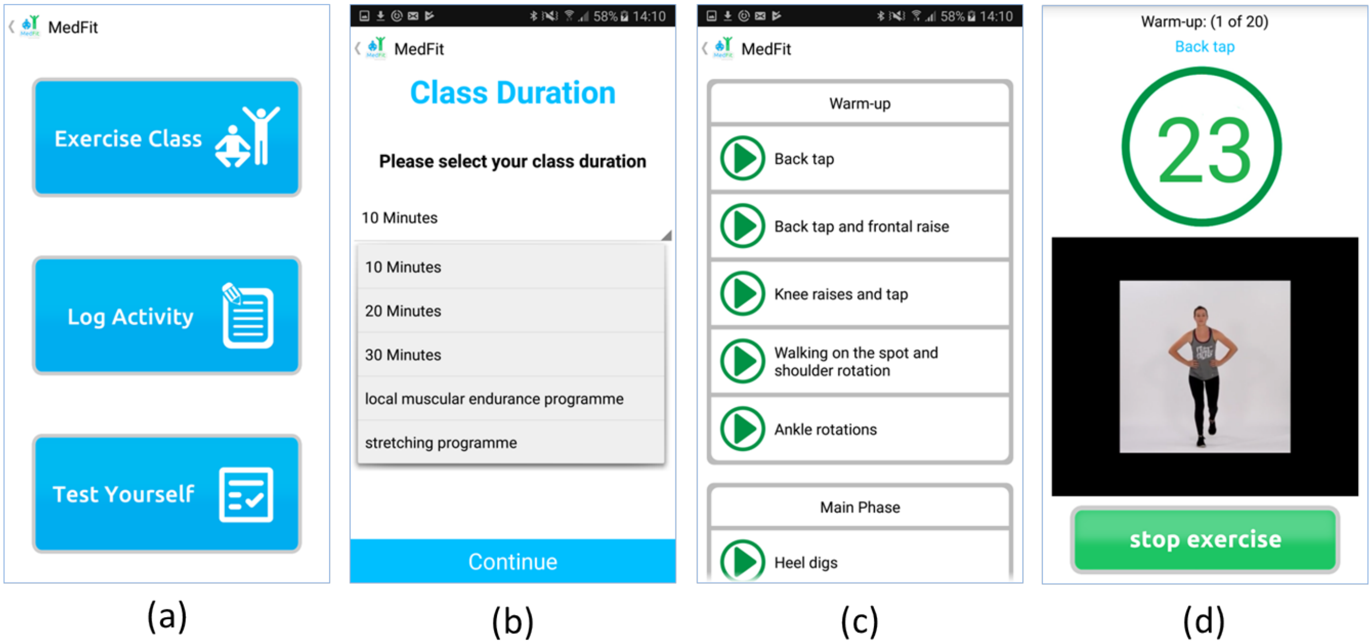

Figure 1: Exercise options for the user. Users can choose the duration and nature of the exercise to be performed. An instructional video is provided for each exercise.

provides high level daily statistics of the activities performed, and a more specialized research-grade sensor is used to provide personalized feedback to the user while performing the exercises. The near real-time feedback (i.e. directly after the completion of a specific exercise) displays the number of exercise repetitions to assist patients to keep the correct pace and to indicate that a particular exercise is being performed correctly. It provides motivation towards the completion of each exercise within the programme.

Feedback mechanisms are important to motivate patients toward the completion of their cardio-rehabilitation program [1]. With this in mind, the third innovation of the application is a variety of types of feedback that is provided to the user. In addition to the feedback outlined above, two more types of feedback have been integrated in the MedFit system. Users are provided with the option to see performance history and comparison of the history to current activity levels which allows them to self-evaluate their progress.Based on the result from the research on effectiveness of behavioral change interventions [6], a notification system is also implemented to send SMS messages to patients on a regular basis to remind them to exercise, to give encouragement or just to give feedback on their progress.

In the following sections we provide an overview of the application that we propose to demo at to the 2^{nd} MMHealth Workshop at ACM MM 2017. It should be noted that key aspects of the system, such as exercise programmes, menu options, supplementary material, etc, were carefully selected by cognitive scientists based on state-of-the-art behaviour change research. The research leading to these selections will be the basis of future publications in the relevant fields. In this paper we focus on a high level demonstration of the use of the MedFit application. First, the availability of a tailored exercise program will be described. It comes with the option to provide feedback in near real time (i.e. immediately after exercising) based on the readings from a Shimmer sensor[1]. Then it is described how feedback based on the exercises performed within the application, the exercises logged manually and the readings from the Fitbit sensor[2] are processed and provided as motivational feedback to the user via both personal and group statistics. Finally, we describe how the application provides some motivational reading material for patients on health-related topics to help users to improve their lifestyle choices and thus their recovery.

1.1 Available features

The application design is carefully considered to make sure that it is suited to cardiac rehabilitation patients. To this end, a focus group was formed of 26 participants with the age ranging from 46 to 82 year and their feedback was carefully considered while designing the application. Participants were drawn from a community exercise-based CVD rehabilitation community programme entitled MedEx Wellness[3]. Three main design design considerations were identified from the focus group: exercises, feedback on progress and reading material on health-related topics.

1.1.1 Exercises. The application is designed to motivate the user to exercise. There are three options for exercises within the application – see Figure. 1(a). A patient can do the exercise provided in the application, and this option gives the user feedback on the progress

[1]http://www.shimmersensing.com/products/shimmer3
[2]https://www.fitbit.com/ie/charge2
[3]See: https://www4.dcu.ie/shhp/Medex-Newsletter.shtml

Figure 2: MedFit screen displaying my exercise information

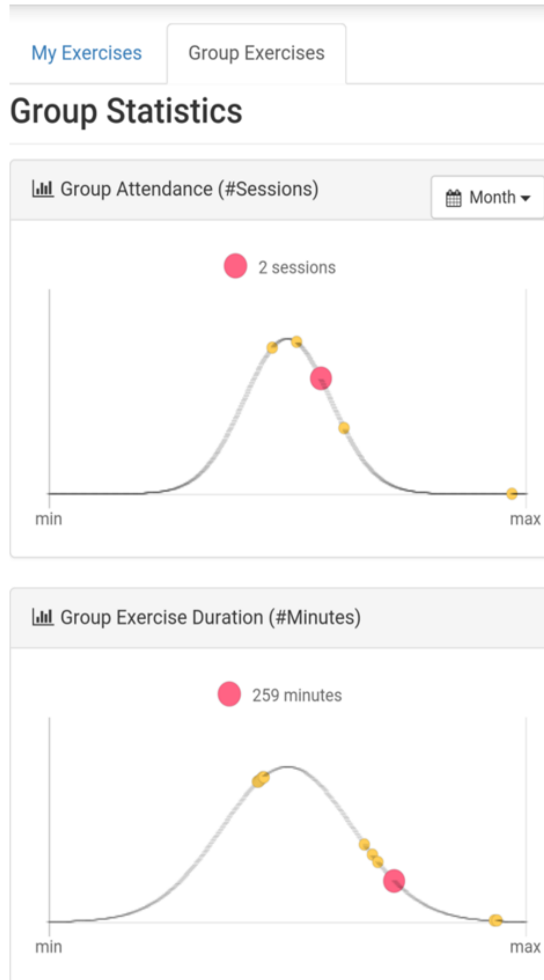

Figure 3: MedFit screen displaying group exercise information

of the exercise – see Figure. 1(d). If the user is being active by doing some other activities, e.g. walking or swimming, there is an option to manually log the exercise. The third option allows users to test their level of fitness by performing a walking test which is a standard physical activity health test [5]. If the user chooses to perform an exercise provided by the application, there is a list of classes that are personalized to the user based on an automatic evaluation of his/her previously completed exercises. The classes are presented to the user based on their duration with a variety of extra options (see Figure. 1(b)). The list of exercises is shown to the user after selecting a class and it usually consists of three phases: warm-up, main-phase and the cool-down (see Figure. 1(c)). The feedback is integrated only for the Local Muscular Endurance (LME) exercises [2] and it provides the user (in near real time) with the number of repetitions achieved during the exercise. A repetition in this context means the correct biomechanical performance of the exercise. A machine learning approach is used to identify a successful repetition. Patients are required to wear a Shimmer3 IMU sensor (a 9-degrees-of-freedom inertial sensor) while exercising. The sensor is interfaced directly with the MedFit application via Bluetooth. The details of the machine learning approach to repetition recognition will be published in the future. The results from the machine learning algorithms are displayed on the exercise screen after completing each exercise in the class. The performance of the exercises and the completed classes are logged in the database and the data is used to provide the user with the information about their progress in the *Progress* section of the application.

1.1.2 Progress Section. Knowledge of performance history is important to patients as it allows them to self-monitor their progress along with the completion of the rehabilitation program [7]. The progress section of the MedFit application provides the user with

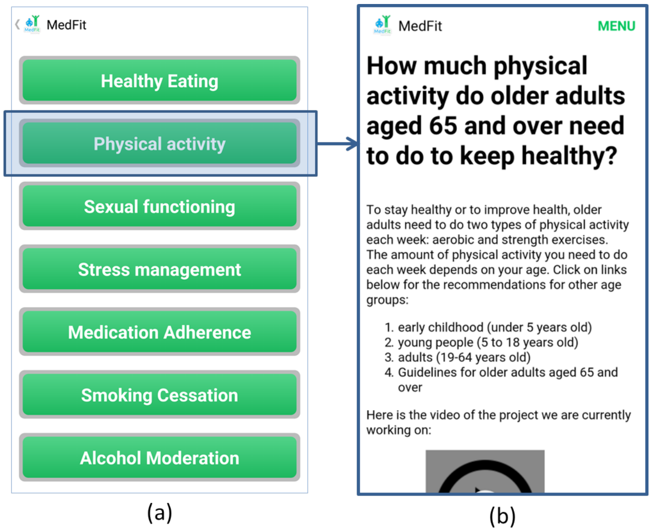

Figure 4: List of topics related to the recovery from CVD

insights about the physical activities performed in the past and comparison to current performance on a daily, weekly or monthly basis. there are two groups of statistics available to the user: personal statistics as seen in Figure. 2 and the group statistics as can be seen in Figure. 3. The statistics are given to the user as four measurements collected during a period of time (day, week or month): 1. number of minutes spent active; 2. number of exercises classes completed; 3. Number of steps walked; 4. average heart-rate recorded during activities. There are six different forms in which this data is presented to the user. Figure. 2 top to bottom shows a week's data. First, the number of active minutes during each day in a week is displayed as a bar-chart. Second, the number of steps completed per week when compared to the weekly goal is shown. The goal is taken from the daily recommendations of the FitBit community[4]. The heart-rate is an important indicator of the recovery progress for CVD patients. Therefore, the third statistic shows daily rates that are extracted from the FitBit sensor. The next view-box shows the progress of the user as compared to the goal that is set for him by the medical personnel (or the default goal if the input from a doctor is not available). The fifth box shows the number of exercise minutes per period of time as compared to the previous achievement in the same amount of time (e.g. this week as compared to the previous week). The last statistic shows the total number of classes (sessions) completed.

In addition to the personal statistics, as can be seen in Figure. 3 the users can compare their progress with the other users in the same exercise group to similate the group-based nature of a community rehabilitation programme. There the activity minutes and the number of sessions are shown on the Gaussian-curve (shown in red) together with other users (shown in yellow).

1.1.3 Healthy Lifestyle. In addition to the exercise options and feedback on exercises available to the user, the application also provides interesting material to read on lifestyle topics important for a patient's recovery. The list of topics can be seen in Figure. 4(a). At registration stage, users are asked to enter their preferences on the topics. These preferences are stored in the MedFit database and used to order the list of topics presented to users. Each user will be presented with the topic list ordered according to his/her preferences. The user is also able to modify the topic preferences at any stages by access the settings on the MedFit application. When users are presented the list of healthy lifestyle topics they can read articles by tapping on the preferred topic (Figure. 4(a)). The material of the topic is carefully selected by behavioral change psychologists to ensure the material is relevant to the patient group.

2 CONCLUSIONS

The MedFit application is about to be deployed to end users as the technology enabler for a month long lifestyle intervention study with approximately 80 patients recovering from CVD. We propose to demonstrate the operation of the entire system at the MM Health 2017 workshop via a short presentation on the intervention study (i.e. motivation, study design, outcome measures, etc.,) and by and a walkthrough of the usage of the MedFit application by a typical user during the study. We will demo how to navigate the application and how adherence is automatically monitored via the two wearable sensors and the associated feedback.

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