Improving User Engagement by Aggregating and Analysing Health & Fitness Data on a Mobile App

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Abstract. Nowadays, health, fitness and contextual data can be ubiquitously collected using wearable devices, sensors and smart phones and be stored in various servers and devices. However, to engage users in active monitoring of their health and fitness, it is essential to personalise the monitoring and have all the relevant data in one place. It is also important to give users control on how their data is collected, analysed, presented and stored.
This paper presents how those important features are integrated in myFitnessCompanion®, an Android Health and fitness app developed by our team. The app is able to aggregate data from multiple sources, keep it on the phone or export it to servers or Electronic Health Records (EHR). It can also present the aggregated data in a personalised manner. A mobile app such as myFitnessCompanion® is a solution to the personalisation, interoperability and control issues that are key to user engagement.

Keywords: Connected health, Wearable devices, Wireless sensors, Health and fitness apps, Chronic disease management.

1 Introduction

The fast adoption of wearable devices comes at a time where chronic diseases are increasing in developed countries and where those countries struggle with their healthcare budgets. Chronic disease is an increasing problem and, for most cases, some hospitalization or doctor visits can be avoided by prevention and self-monitoring. Wearable devices are becoming part of normal life and are able to collect some data needed for the self-monitoring. Other health data is collected using medical grade devices such as wireless blood pressure monitors and blood glucose meters.

There is an abundance of health and fitness apps available from the Apple store and Google Play. At the time of writing, there are 40,000 health related smartphone apps [1] and HIS [2] forecasts that the sales of wearable technology that can link to the Internet or work with mobile apps will grow from $8.6 billion in 2012 to almost $30 billion by 2018.

Physical activity promotion is a priority and a lot of research and mobile Apps address this issue and focus on motivating users towards a more active and healthy lifestyle (e.g.: [3-5]). Many Apps use a specific sensor or only deal with a particular chronic condition. (e.g. Asthma Coach). Mobile apps like Fitbit and Jawbone UP [8] only support their own activity trackers and mainly display data that is collected from their devices. Data collected from these wearable devices are stored on separate servers. Some fitness servers such as Google Fit claim to be an aggregator of health data but are limited to fitness data only, which makes them unsuitable as a complete Electronic Health Records (EHR) system. Government controlled EHR systems, on the other hand, focus on health data provided by health professionals. There is a need to combine these 'informal' fitness data and 'formal' health data in one system and make it easily available to the users.

For chronic disease patients, there is often a need to monitor several physiological parameters and not just their activity level or calories burned. Lack of device interoperability, and the presence of data silos prevent these users from obtaining an overall view of their health. To engage these users in active monitoring and controlling their condition, it is important to have all health & fitness data in one place and give them a personalized overview on trends and progress.

Several mobile apps already exist to play the role of health data aggregator. They have been named the *'connected mHealth app elite'* by Research2Guidance [6], a consultancy and market research company focussing on mobile app economics.

myFitnessCompanion® developed by our team is in the top five list of this exclusive group of connected apps'. It interacts with a wide range of sensors (20+) and wearable devices (e.g. MIO link, Polar, Zephyr) and aggregates data from third party apps and connects with public servers such as Microsoft HealthVault, Google Fit, Fitbit, Jawbone, Withings, and iHealth, as well as non-public EHR systems. It offers a user-centred solution and analyses and presents the aggregated data in a personalised and engaging manner.

This paper is structured as follows: Section 2 describes how we collect and aggregate the data from a variety of sources. Section 3 presents how the data is analysed and presented to the user. Section 4 concludes with a discussion on our work in progress and open issues.

2 Health and fitness data aggregation

myFitnessCompanion® collects health & fitness data from different sources. It uses wearable devices and wireless sensors but also manual entries by the user. It gives the user the possibility to aggregate data from different sources and stores it on the mobile device and in the cloud using one or more servers as illustrated in Fig. 1.

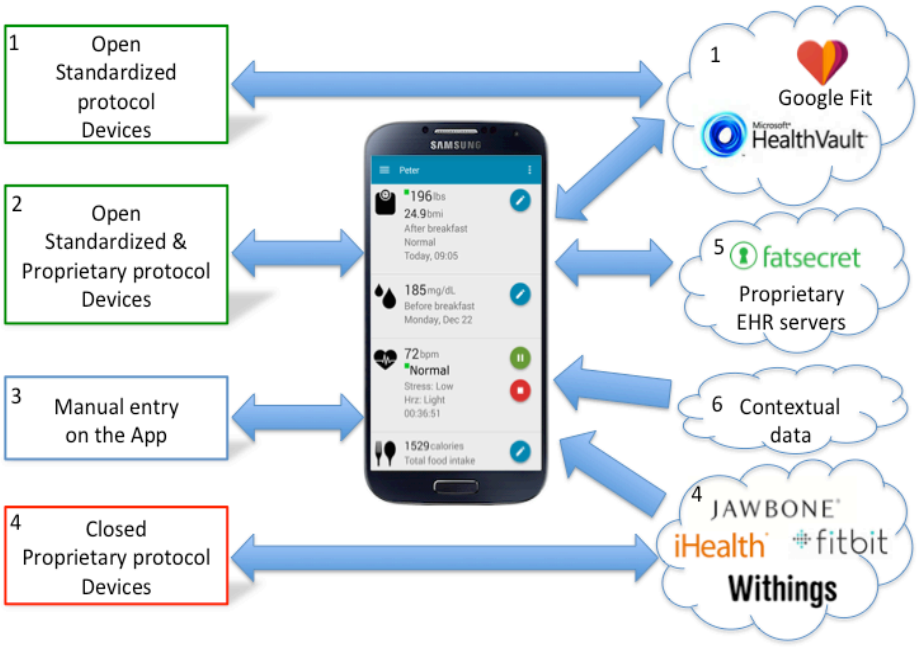

Fig. 1: myFitnessCompanion®'s eco system

myFitnessCompanion® collects data from wireless devices supporting open standard protocols such as the Google Android Wear smart watches and fitness trackers that allow third party developers to retrieve the data directly from the device (Fig.1, box 1). They are open in the sense that they use standard open protocols to transfer health data using either Bluetooth or ANT+. These devices are connected a server such as Google Fit and can then be retrieved by myFitnessCompanion®.

myFitnessCompanion® can also collect data from devices paired with the user's mobile device (Fig.1, box 2) via Bluetooth or ANT+. These include Bluetooth Smart heart rate monitors and blood pressure monitors. The devices implement an open standard and work seamlessly with myFitnessCompanion® without making modifications for a specific vendor. Unfortunately, the majority of wireless devices implement a vendor specific protocol. Sometimes the vendor makes the protocol available which allows the integration but, for each device, specific software has to be written to communicate and interpret the data transmitted by these devices.

Closed and proprietary wireless devices (Fig.1, box 4) do not allow third party developers to communicate directly with the device. Although those devices use standard Bluetooth to communicate with a mobile device the actual protocol and data format are not public. This makes it near impossible for third party developers to integrate the device directly in their mobile app. Fitbit, Jawbone, Withings and many other vendors follow this strategy and only allow third party developers to obtain the data via their server through an open API.

Websites such as myFitnessPal and Fatsecret collect health data by allowing users to input data directly or via their mobile app (Fig.1, box 5). These sites then allow third party developers to retrieve the data via an open API. Some servers like

Microsoft HealthVault allow 2-way communication whereas others like Withings do not allow uploading data from a third party app.

The objective is to collect as much relevant data as possible in order to offer the best overview for a user regarding his/her chronic condition. In future versions of myFitnessCompanion® we will also collect contextual data (e.g. location) that can be useful to offer more fine-grained analysis (Fig.1, box 6). For example, an asthma user could benefit from a pollution forecast for his/her area to take preventative action.

The users are in control of the data they want to collect and how it is collected. They can enter data manually into myFitnessCompanion® (Fig.1, box 3). This is the case when they have a non-compatible device or conditions for which no sensor exists (e.g. ostomy or stool tracking). Users can annotate a reading by adding comments and contextual information, such as extra coffee consumption or performed activities before and after a blood glucose measurement. They can also manually enter health data in Microsoft HealthVault, Google Fit and others, which is then automatically imported into myFitnessCompanion®.

3. Data analysis and presentation[1]

myFitnessCompanion® analyses health & fitness data in real time and presents the personalized information to the user. We opted for a user-centred approach where the user is in control of the way the data is analysed and presented.

myFitnessCompanion® deals with a wide variety of users. Some only need to monitor their weight and blood pressure whereas others suffer from asthma or obstructive sleep apnoea. Presenting the data is a major challenge, especially taking into account that some users exhibit the white coat syndrome when taking a reading. Based on feedback from customers and health professionals, we do show all data collected in various formats.

To accommodate this user variety, myFitnessCompanion® allows enabling or disabling analysis in real-time. If real-time analysis is activated, threshold levels can be set for several biometric monitors. The assessment for several health metrics such as blood pressure and blood glucose adhere to internationally accepted guidelines. For other health metrics, such as heart rate, the user can set max and min thresholds based on advice from a health professional or personal trainer. Some monitors such as stool and ostomy offer a more discreet feedback and do not show all details.

The analysis is performed on the mobile device and instant feedback is given to the user using either voice, textual or colour rating. Assessment is currently available for weight, blood pressure, blood glucose, oxygen level, asthma, heart rate (training zone, stress level), respiration, body temperature and urine osmolality.

Depending on the user's choice, we display the 'live' data, the user's history, the activity summary or a trend analysis. The live data is presented to the user on the dashboard and some data can be displayed on the smart watch. An important feature of myFitnessCompanion® is exercise monitoring using a heart rate sensor. Showing the heart rate zones, together with other exercise information gives the user instant

[1] Screenshots can be viewed on myFitnessCompanion.com

insight on how he or she performs. At the end of an exercise the data is analysed and presented in heart rate zones and it allows them to stay in their targeted heart rate zone.

Users can see their history under the form of tables and graphs. The data is colour-coded. Colours ranges from light green (good) to dark red (severe problem) and comes together with a description (e.g. normal, prehypertension, stage 1 hypertension etc.). Similar feedback is provided to obstructive sleep apnoea users using myFitnessCompanion®. Using a pulse-oxygen device (e.g. Nonin WristOx2) they record heart rate and oxygen saturation level during a night's sleep.

Other powerful features include the activity summary and the trend analysis of the collected readings. Users can quickly see how they progress over a certain time frame. Users can export or print the data for later viewing by health professionals and personal trainers.

4 Conclusion: future work and open issues

The ultimate goal of myFitnessCompanion® is to empower users and help them monitoring their health and fitness a personalised way with a clear overview of their data and activities. There are a lot of benefits in aggregating the health and Fitness data especially for chronic disease users, as their condition needs a long term monitoring and depends on a complex set of factors. With the aggregation, the silos can also be limited and users, their carers and health professionals can get more control on their health and fitness data.

Our objective is to keep adding new wearable devices and sensors as they come on the market, as well as, connecting to more health and fitness servers. In particular, there is a gap in the market for secure and well-designed EHR that combine health and fitness data. Companies are jumping on this market segment and we are currently integrating myFitnessCompanion® with these types of servers since it can deal with 'informal' and 'formal' health and fitness data.

The context of a user can be important and one of the challenges is to identify and collect the data that is important for a particular user and provide timely feedback. An example, for users with asthma, myFitnessCompanion® will capture location-based information about the Air Quality Index (AQI), alert the user when the air quality deteriorates (AQI > 100) and raise an alarm if it gets hazardous (AQI > 200). A similar approach will be taken for the pollen level since the information is widely available and using the location of the user a tailored advice can be given.

Location-based information such as the likelihood of flu, rheumatism and migraine is already available from various websites. The data can be used together with the health data collected to provide a more detailed analysis and alert the user if needed.

In future versions, we will use data mining and data analytics to offer a more personal and accurate assessment for each user. We are interested in making correlations between context and conditions (e.g. altitude, weather and blood pressure or location and stress level). We also looking at the possibility to make an assessment

based on several input parameters (e.g. calorie intake, activity level and blood pressure).

Currently, myFitnessCompanion® stores all data locally on the mobile device or on a server chosen by the user. However, for more complex data analysis we will need the data to be stored on a server in order to provide more intelligent feedback based on long-term user's history and possibly comparing it to other users with similar conditions. Some users will accept that in order to get better insights while others will opt for less feedback and keep their data private. We will cater for both.

There are a lot of wireless sensors and activity trackers (e.g. Fitbit, Jawbone UP, Withings) on the market with different quality and accuracy. Many health professionals discard self-collected health and fitness data due to the unreliability of the data and prefer to use their own data for diagnosis. We believe that over time more health professionals will accept the data if the source is properly tagged so that they know which device, or which app, generated the data.

Apps like myFitnessCompanion® have the potential to change healthcare by empowering users and by helping them taking control of their health. This could lead to fewer visits to the doctor and fewer additional measurements. It also has the potential to give health professionals an overall view on their users' health and fitness data and help them making a more accurate and personalised assessment.

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