Gamification of Exercise and Fitness using Wearable Activity Trackers

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Abstract. Wearable technologies are a growing industry with significant potential in different aspects of health and fitness. Gamification of health and fitness, on the other hand, has recently become a popular field of research. Accordingly, we believe that wearable devices have the potential to be utilized towards gamification of fitness and exercise. In this paper, we first review several popular activity tracking wearable devices, their characteristics and specifications, and their application programming interface (API) capabilities and availabilities, which will enable them to be employed by third party developers for the purpose at hand. The feasibility and potential advantages of utilizing wearables for gamification of health and fitness are then discussed. Finally, we develop a pilot prototype as a case-study for this concept, and perform preliminary user studies which will help further explore the proposed concept.

1 Introduction

Smart watches, smart glasses, gesture controllers, health monitors, and activity trackers are all part of the emerging landscape of wearable technologies, which are believed to change our lives. The number of wearable devices has seen a significant growth since 2011[3]. Activity and fitness related devices are one of the most dominant categories of wearables and attract a significant amount of research and development [11, 19–21].

On the other hand, gamification, which is the process of utilizing games for tackling particular problems, has become a popular field of research due to increased capabilities and ubiquity of smart phones and PCs [22, 14, 18]. Since exercise and fitness are often physically strenuous, alternative motivators such as entertainment and encouragement through games are considered effective ways for appealing to a wider audience [8–10, 13]. We believe gamification of health and fitness can benefit both novice and professional users alike, and result in short-term engagement as well as long-term improvement through intelligent game-based objectives.

In this paper, we suggest that wearable technologies are suitable platforms as sensing and communication portals for interacting with gamified health and fitness applications and software. In other words, this work proposes and explores the overlap of three different fields, namely digital games and gamification, health and fitness, and wearable technologies. This concept is illustrated in Figure 1. Following a review of activity tracking wearable devices, we present an

analysis and discussion on application programming interfaces (API) of existing wearables as APIs play a critical role in order for gamified fitness and health applications to be popularized. Subsequently, as a proof of concept, we design and prototype an exercise game, which utilizes wearable devices for interaction. We perform a preliminary user study, and demonstrate the validity of our proposal.

Fig. 1. The three general fields that relate to this work are illustrated. The target field is presented as the overlap of the three fields shown in white

2 Related Work

2.1 Gamification of Health and Fitness

Gamification is defined as the process of utilizing games or game-like reward and penalty, competition, and goal-based systems in order to increase engagement, incentivize users and popularize particular activities [12]. Lately, the use of gamification in different fields related to exercise, fitness, and health in general, has become common. An evidence for this is the availability of many applications under the category of health and fitness in the application stores of iOS, Android, and Windows, with some aspects of gamification [6].

In the past few years, researchers have also devoted considerable attention to games for exercise, fitness, and health. For instance, Nenonen et al. [17] proposed the use of heart rate as an interaction method for video games. They suggested that heart rate interaction could be utilized in different exercises as users found the concept interesting. In [4], Buttussi and Chittaro proposed a user-adaptive game for jogging, in which they combined the use of a GPS device and a pulse oximeter worn on the user's ear. Their user study results showed that the game

motivated users, while having other benefits such as training users to jog as a cardiovascular exercise. Mokka et al. [15] introduced a cycling fitness game that users could play in a virtual environment. Their pilot user test showed that virtual environments could be a motivating factor for exercise. Finally in [5], Campbell et al. focused on everyday fitness games and indicated that for applications that people use in their everyday lives, designs should be fun and sustainable, and adapt to behavioural changes. They applied this idea to the design of a game.

2.2 Wearable Technologies

Generally, wearable devices are technological gadgets worn by users, and activity trackers are wearable devices that monitor and record a person's physical fitness activity [7]]. They are fundamentally upgraded versions of pedometers and similar devices [16] and use accelerometers and altimeters to calculate distance and speed, estimate the overall physical activity, calculate calorie expenditure, and in some cases also monitor and graph heart rate and quality of sleep. Some more advanced wearables monitor muscle activity through electromyography, measure body's hydration, estimate lactic acid production, and more [1].

Most of the popular wearable activity trackers provide an API for third party developers. Resource API refers to the access to user resources (read or modify). Subscription API is a set of functions through which the third party applications could be notified when user data changes, which allows applications to have the user's latest data without having to implement a polling or scheduling system to retrieve users' data. Bluetooth API refers to the authorization of third party applications for communicating directly with the device via Bluetooth without the need to synchronize over the web. These three types of API are considered to be critical for developers in order to build applications. Table 1 presents a summary of the availability of different types of API for several wearable devices that can be utilized for the purpose at hand. As we can see, most of the devices provide web-based resource access and subscription API that allow third parties to build applications while Bluetooth APIs and software development kits (SDK) are only provided by few devices. An SDK is generally a collection of tools and functions provided for building new applications on a particular platform[2]. Accordingly, it is generally easier to develop applications for devices that provide an SDK.

3 Application Design

To further explore the notion of fitness-related games with wearable devices as interaction mediums, we prototyped two different applications on the iOS platform. The first game is a realistic type of game where users can select either a running or cycling mode. Accordingly, an avatar of a running or cycling subject is depicted on the top half of the screen, while an opponent is depicted on the bottom half. The opponent can either be programmed to complete a course over

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	Resource API	Subscription API	Bluetooth API	Android SDK	iOS SDK
Fitbit	✓	✓		✓	✓
Nike Fuelband	✓	✓	✓		✓
Pebble	✓	✓	✓	✓	✓
Samsung Gear Fit	✓	✓	✓	✓	
Jawbone Up	✓	✓		✓	✓
Garmin Vivofit	✓				
Misfit Shine	✓	✓			
LEO	✓	✓	✓		

a fixed period of time (single-player) or correspond to a real user playing in real-time (multi-player). When the multi-player setting is selected, the number of opponents can be entered by the user. Finally, upon completion, the winner is announced, and race metrics are presented in a post-workout summary page. The metrics include duration, distance, maximum speed, average speed, and calorie expenditure among others. Simulated screens from the prototype are presented in Figure 2 (a).

The second game is a more abstract and cartoony application in the form of a goal-based game. In this game, a flowerbed is illustrated, where faster and more consistent exercise on a daily basis results in a more rapid blooming and growth of the flowers. Abandoning the routine for a few days will result in the death of the flowers. Users can unlock higher level and different types and number of flowers when certain goals and milestones in terms of distance, duration of time, speed, calorie expenditure, acceleration, and others are achieved. Similar to the first game, data and summary screens are presented after each session. Figure 2 (b) illustrates simulated screen from this game.

Generally, the first application is a more serious and realistic game, which will potentially engage more professional and athletic audiences, while the second one is more geared towards novice and younger users. While both games enable users to post their results online to social media such as Facebook, the former is mostly expected to leverage athletic competition, while we believe the latter is mostly suitable and attractive for its social network component.

Finally, we mentioned that both games enable two modes: running and cycling. Accordingly, while for running both arm and leg-based wearable devices can be utilized as interaction devices (since there is sufficient arm movement during running), for cycling, an arm or wrist-based device cannot be utilized. This is because on stationary bicycles, the arms/wrists do not have sufficient motion for the device to estimate the overall motion of the body and physical activity. As a result, leg-based wearables will be required for the cycling option of both games.

Fig. 2. The general design of application prototypes 1 and 2 are presented in (a) and (b) respectively

4 User Study and Discussions

4.1 User Study

We performed pilot user studies on the mock-up of the two games. Five users were invited to use this app and fill a five-point Likert scale paper-based questionnaire. Three were males and two were females, with the average age of 26 and standard deviation of 2.3 years. In order to evaluate our proposal, three main questions were asked (see Table 2). The questions are meant to evaluate the likelihood of subjects using the games, whether the application motivates subjects to exercise more, and understand the overall satisfaction with the application. The results for this study are presented in Figure 3. The responses were rating values from 1 to 5.

Table 2. The major questions used to assess the usefulness of the proposed approach.

Question 1	Do you find this kind of application motivating to exercise?
Question 2	How likely are you to use this application again?
Question 3	How would you rate your overall satisfaction with this application?

4.2 Discussions

The number of subjects in the user study was not sufficient to make concrete statistical conclusions. Nonetheless, the study provides some insight as to whether the approach is successful and one that would motivate users or not. According to the results of the study, both games received average ratings of higher or equal to 3/5 on all counts of motivation, engagement, and satisfaction. The

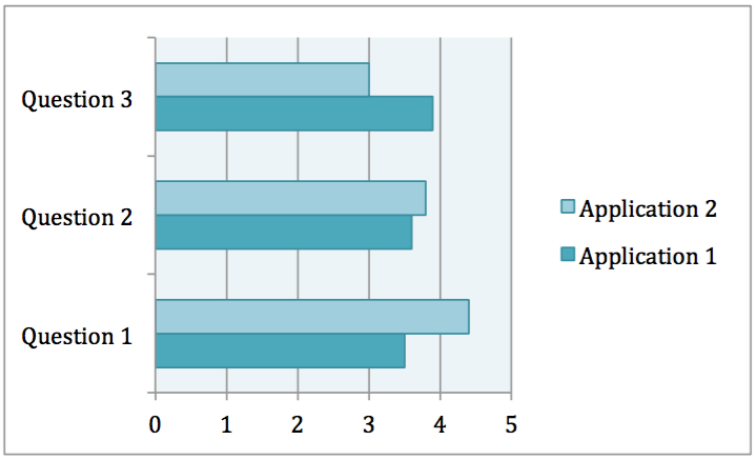

Fig. 3. The general design of application prototypes 1 and 2 are presented in (a) and (b) respectively

second game is more likely to motivate users to exercise (4.4/5 compared to 3.5/5 respectively), while also being more engaging (3.8/5 compared to 3.6/5). Interestingly, the first application has a higher overall satisfaction score (3.9/5 compared to 3/5).

The overall results suggest that both player vs. player and goal-based games are feasible approaches to gamification of exercise and fitness, and possess the potential for being utilized in conjunction with wearable devices for this purpose. When further explored the notion of player vs. player as opposed to goal-based games, some subjects suggested that they were in favor goal-based games in order to avoid competitive factors during exercise. These subjects mentioned that the rewards that they would receive when achieving a goal is a sufficient motivator for them to exercise more frequently. On the other hand, some subjects stated that only competition could motivate and engage them to exercise more frequently.

5 Future work

Future work includes optimizing the design and implementation of the applications as well as integration of the apps with two wearable devices of different form-factors (for e.g. arm-based and leg-based) will be carried out. The games will be played with multiple subjects, and more details regarding usability will be compiled and statistical conclusions will be drawn. The effect of factors such as leg-based vs. arm-based applications, goal-based vs. multi-player games, animation and graphics, the activity/sport (running, cycling, or etc.), and several others will be studied. Finally, the implications and usefulness of the approach

including both short and long-term effects in terms of exercise habits, motivation, and fitness will be studied.

6 Conclusion

In this paper we proposed a novel approach for gamification of exercise and fitness, where wearable technologies are utilized for interaction with exercise games. We first reviewed the general status of some activity trackers and their API capabilities and availabilities. We then designed and prototyped a player-vs-player as well as a single-player goal-based game. Finally, pilot user studies on the applications were reported followed by a discussion on the feasibility and potential advantages of utilizing wearables for gamification of health and fitness. Results show that based on existing technologies and user needs, the idea of employing wearables activity trackers for gamification of exercise and fitness is feasible, motivating, and engaging.

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