Motivating Children to Increase Physical Activity by Means of Reward

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Abstract. The paper describes the concept and its prototype realization named Move2Play aimed at averting the prevailing trend of decreasing participation in physical activity observed in children and adults alike. The concept is based on the idea of tracking, personalized recommending, evaluating and rewarding physical activity. While age-agnostic at the core, we have developed the concept further to specifically target children where motivation plays an important role. We also provide an overview of the methods used in tracking activity and motivating children. The means of guidance and recommendation in physical activity are also discussed.

1 Introduction

Over the last few decades, overweight and obesity became a problem of global proportions. Insufficient amount of physical activity and unhealthy dietary habits have been cited as its primary causes. While measures that need to be taken have been known for a long time, their execution has been hindered by a lack of motivation present in all age groups.

Tracking activity is an important step towards improvement. Movement tracking has become significantly easier due to the widespread availability of sensors such as GPS receivers, accelerometers and gyroscopes in mobile phones. Coupled with statistics and recommendations, it is a powerful source of motivation. However, unlike adults, children are not easily motivated by figures and charts. A different approach to motivation is necessary. Our solution is based on rewarding, a natural and effective way to motivate.

Being physically active requires a certain extent of knowledge on the right kind and amount of activity. Not enough activity may result in no improvement while too much activity may be harmful [3]. It is therefore vital that users are advised on these matters. Our solution provides the user with advice and recommendations.

Much like motivation, advising children requires some additional consideration. Animated pedagogical agents have proven to be effective in capturing children’s attention [6]. With the help of such agents, good results have generally been achieved. We propose an animated character (avatar), which is fully customizable in terms of appearance.

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While the general concept of our solution is not limited to a specific age group, we have chosen to target children as our primary focus group. There are a number of differences in the approach that needs to be taken with younger users. Moreover, experience suggests that if any measurable progress is to be achieved, the involvement of parents in the process is necessary. For that reason, we specify means for parents to oversee their children’s progress and interfere when and where appropriate. Parents are also the primary source of rewards, which provide children with the necessary motivation.

2 Related Work

In recent years, a number of innovative solutions have been developed aiming to tackle the problem of sedentary lifestyle. Current solutions can be divided into three categories: Informative, Direct and Indirect.

Informative solutions provide information such as guides to increase the activity level or lists of sports grounds in selected areas. An example of such an application is Kid Fit, which contains a list of exercises. These solutions generally lack any kind of motivation.

Direct solutions actively motivate users to increase their physical activity level. One of the simplest approaches is based on tracking one’s daily step count. Research has shown that even this single piece of information can provide enough motivation to increase the daily step count for both adults and children [5].

A commonly used means of motivation is competition through games. One example, which builds upon this kind of motivation, is NEAT-O-Games [4], where users can compete against each other. The rules are fairly simple – be more active than your opponent. Activity is measured in steps and the winner is awarded points, which they can afterwards exchange for hints in Sudoku. Unfortunately, these solutions are rarely developed by skilled game designers, and thus cannot compete with popular game titles played by hundreds of millions of people.

Indirect solutions are generally not developed to increase physical activity. Most notable examples are gaming consoles such as the Xbox 360 with Kinect or the Nintendo Wii, which are very popular these days. Games for these consoles incorporate physical movement, which is a great supplement to other activities such as walking or jogging.

3 Concept Overview

The core concept behind Move2Play is centred on motivating people to be physically active. To that end, we use activity tracking and rewarding. Unlike the implementation described in the following sections, the concept is not limited to a specific age group.

Physical activity is tracked using the sensors of a smartphone. The tracked activity is aggregated, evaluated and compared with other users. However, since most people do not have enough information on the right amount of daily physical activity they need to participate in, guidance and recommendation constitutes a major part of the solution. In particular, we introduce the concept of a daily plan.

We use a social networking model to incite competition among friends in order to provide an even stronger source of motivation [1]. In conjunction with competition, motivation is also achieved through engaging data visualization, which provides an overview of the accomplished progress.

Rewarding is also a very powerful means of motivation. However, while competition and progress visualization are not age-specific, rewarding cannot be implemented in an age-independent manner.
4 Activity Tracking

There are numerous ways to track activity, which involve a number of different kinds of measurement devices. Stand-alone pedometers, for instance, are widely available, but only a few can be connected to a computer for further data analysis. However, surveys and sales of this kind of device suggest that people in general do not want to carry a stand-alone single-purpose measurement device [2]. Children, our focus group, are even less inclined to carry a pedometer. People also do not have the time or will to sync their devices with a computer, which is essential in order to obtain useful results. This implies that any viable solution should be integrated with a device most people already carry, that is, the mobile phone.

The most commonly found sensor in the current generation of smartphones is a three-axis accelerometer. We use the accelerometer to track walking and running steps. It is, however, not possible to rely solely on the accelerometer if we want to use a rewarding system to motivate children. Even some of the most sophisticated pedometer applications are easily tricked into counting shaking the phone held in hand as steps. To prevent this, we use an additional device, the GPS receiver. When several steps have been identified, it is logical to expect that GPS coordinates have changed.

When using sensors, battery life becomes a concern. While most current phones are capable of sustaining the usage of the accelerometer or the GPS receiver for significantly longer than the recommended duration of daily activity, all-day usage is currently not possible. However, phone battery life is expected to improve in the following years. To work around the problem, we use a longer update interval for both sensors, which is dynamically adjusted as activity is identified. The main problem with this approach is that several steps can be missed before activity tracking takes place. A more sophisticated and efficient solution is the use of GSM signal strength fluctuation. This way, the usage of the accelerometer can be deferred until a large enough change in signal strength is detected, which implies a change of location. However, the current Windows Phone APIs we use do not provide access to this information.

Our GPS tracking algorithm collects geographic locations (latitude, longitude, altitude) with timestamps. We then calculate the distance between two successive locations using the haversine formula. To keep measurements accurate, we needed to solve two main problems – position inaccuracy and movement in vehicles.

Position inaccuracy is present mainly while moving inside a building. Horizontal accuracy is obtained through the Windows Phone 7 Geolocation API. Average horizontal inaccuracy while moving outdoors is between 7 and 12 meters, inside a building it is usually more than 100 meters. We exclude all locations with a horizontal inaccuracy greater than 30 meters as measurements with a higher deviation become very unreliable.

To prevent counting movement in a vehicle as activity, we use the speed of movement associated with every location change. We split the measured data into groups, where each group consists of successive locations that represent either a speed-up or slowdown. Using a predefined speed threshold for different types of activities, we decide whether a group is valid or invalid. If any location in a group has speed higher than the threshold, we mark the whole group as invalid. Additionally, we also use data from the accelerometer. For instance, if the GPS data suggest that the user is walking at a speed of 3m/s, but accelerometer reports no movement, we do not count this activity as walking or running.

5 Avatar as a Means of Motivation

We believe the key problem with lack of physical activity is motivation. The main motivations for children are benefits, in-game bonuses, pocket money and others, which the child can get for being physically active. Move2Play communicates with the child via an animated pedagogical agent called an avatar.
We designed the avatar as a cartoon character, whose look can be changed according to the child’s preferences. The reason for this kind of personalization is that the child should identify with the avatar, which can be seen as an interface between the child and the system, resulting in better communication. The avatar informs the child about bonuses which can be gained and it also shows how well the child fulfils his or her daily plan. The avatar can show several kinds of emotion according to the child’s progress. If the child fulfils the plan of his or her physical activity well, the avatar’s facial expression is positive. In case of insufficient activity, the avatar looks sad.

If children fulfil their activity plan very well or complete a task given by the avatar, they are awarded an achievement. Achievements are visualized by medals that can be seen within the application. For example, this could be a medal for having fulfilled the plan 3 days in row.

Children can compare their own avatar with the avatars of their friends. Specifically, they can compare its visual appearance and facial expression, but also their awards. We believe that children are naturally competitive and thus motivated to keep their avatars happy and get as many rewards as possible.

Education is an important feature of the avatar. We consider teaching children to lead a healthy lifestyle very important. It has been shown that habits learned during childhood usually persist into adulthood. Our educational model is influenced by several inputs. The goal is to choose the best quizzes and advice and educate children in areas of healthy lifestyle. We are tracking all children’s answers and if there is an area in which a child does not succeed, we put more emphasis on it. We also consider the child’s interests and hobbies. For example, if we see that the child is interested in football, we put more emphasis on quizzes and advice connected to football.

Children spend a lot of time together and thus influence one another. We use this fact and model quizzes and advice according to the interests and trends among friends. If a child has a friend who has difficulties in some area of healthy lifestyle, we put more stress to this area and educate both friends. Some of the advice or quizzes are specific to daytime. We show these quizzes in the time with the highest probability of affecting the child. For example, it is much more efficient to give advice on healthy sleep in the evening that at lunch time.

There are children with certain diseases such as diabetes or the coeliac disease. These children need a large amount of information on these diseases, and some kinds of advice, which are useful for healthy children, can be dangerous for them. For this reason we select quizzes and advice according to the health state of the child.

The way children think changes with their age. Our design reflects this in that we formulate different sets of quizzes and advice for different age groups.

Everybody needs acclaim for their effort. We provide positive motivation. Move2Play praises the child for their successes through the avatar. Thanks to this, the child is better motivated and is more likely to listen to the avatar’s advice.

6 Concept Implementation: Move2Play

We developed a prototype called Move2Play. As shown in Figure 1, it is based on a standard client-server architecture, where the client side is represented by a mobile application for children and a parent application running in the browser. The server side is responsible for storing, processing and communicating data back to the client side. Our system also involves a component provided to external online games, in order to facilitate rewarding of the child by in-game bonuses.

Children who have a mobile phone equipped with an accelerometer and GPS are enabled to use the mobile application. Using these sensors their activity is tracked in logs, which are stored locally and sent to the server when connected to the Internet. Summarized logs and information on the fulfilment of the recommended plan is shown to the parents. The tracked activities are transformed into points or enable the credit paid for by the parent. Points and credit can be exchanged for rewards and in-game bonuses in the virtual market. In addition to this, the mobile
application integrates other motivating tools such as comparison with friends and a pedagogical agent mentioned above.

The parent application allows to create an account and link it to the mobile device of the user’s child or the user themselves. After this, the transferred data of tracked activities from the phone are visualized in illustrative charts and compared with the recommended daily plan. Parents of children with no mobile phone are still able to use this application by manually entering records of activity. To motivate the child, parents set rewards in the virtual market here. Moreover, parents may choose to buy credit using a credit card and set daily limits on the credit to prevent immediate spending by the child. The application also supports features such as adjusting the recommended plan, recording physical attributes in order to monitor changes over time and notifications of important events.

All of the logical components of the parent application are deployed as web services on the server. The services are a mid-layer between the database and the client applications and are responsible for processing data and providing results to the front-end applications. The advantage of this approach is that the services are accessible for other developers to be used in their desktop or mobile applications. Another important server component is an activity evaluator, which estimates the recommended daily plan for the users according to the history of the tracked activities. This means that the plan is calculated automatically every day without user intervention.

To implement the client applications we have chosen Microsoft Silverlight technology. The mobile application is developed specifically for Windows Phone 7 devices. The application for parents is a browser application, with all its advantages such as no installation requirement and instant access from anywhere. The deployed services and other modules as well as the component provided to external games are implemented using the .NET Framework.

7 Evaluation

To evaluate our solution, we have established cooperation with the Pediatric Clinic of the Children’s University Hospital in Bratislava. We have on-going plans to deploy mobile phones with our application preinstalled to a select group of overweight or obese children. In addition to their parents, we will also provide data to the doctors, which will then be used in the treatment of the children. A control group will also be comprised of physically active children to put the obtained results into perspective.
8 Conclusion and Future Work

We described the novel concept of motivating children to increase their daily physical activity level. Our concept addresses issues that are essential for achieving sustainable improvements in child activity habits:

- Lack of motivation, as we incorporate both the intrinsic and extrinsic kind of motivation. Intrinsic motivation is achieved through challenge by recommending the right amount of activity, competition, cooperation and recognition by both friends and family. Extrinsic motivation is accomplished by means of achievements given by the avatar and rewards – tangible or intangible – given by parents, for achieving good results.
- Mostly intrusive activity measurement, as we took advantage of modern smartphones and turned them into activity measurement devices. As children keep their smartphones with them most of the time, they present an ideal choice over external devices such as a pedometer, while achieving comparable accuracy.
- Insufficient involvement of parents, as we created a separate application for them and involve them in both motivation and recognition of their children’s achievements. We also provide detailed statistics on children’s activities, which can be further consulted with doctors.

Using smartphone sensors we are at the moment able to measure only a few types of activity, such as walking and running. Other kinds of activities have to be entered into the system manually by children and confirmed by parents. In the future we would like to incorporate other algorithms, which would allow tracking of additional activities, along with the integration of automatic data transfer from popular game consoles such as the Xbox 360 and the Wii Fit. Also, preventing cheating is a difficult task, which requires additional careful consideration, as it is very hard to distinguish between actual activity and someone trying to trick the sensors.

Move2Play takes a new, unique approach to solving the problem of sedentary lifestyle. It brings together several ideas and concepts such as activity tracking, motivation through rewarding, motivation through competition, activity recommendation and, specifically for young users, an animated pedagogical agent and the involvement of parental guidance.

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References