Designing Ubiquitous Computing Technologies to Motivate Fitness and Health

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Abstract
Physical inactivity in the western world is leading to a range of serious health problems and many health organizations are attempting to address this through new ways of motivating people to have more active lifestyles. This paper suggests using *ubiquitous computing technologies* to motivate fitness and health. We describe an initial qualitative study of exercise motivation among active individuals as well as an activity tracker that motivates exercise through social involvement. Finally, a research strategy is outlined in terms of technology development and evaluation studies.

1. Introduction

There are many ways mechanical technologies can measure and support exercise; treadmills and exercise bikes enable stationary and controlled movement, where pedometers for example measure the collective amount of walking or running activity. Computing technologies have already been implemented into many of these tools in order to process measurements and tailor exercise sessions. There are, however, still numerous unexplored aspects of technologies in terms of location-based services, social software systems and mobile devices that can potentially motivate and provide better awareness of fitness and health. We envision that ubiquitous computing technologies will be able to contribute towards many aspects of exercise, both in the gym and in people's daily lives.

Studies show that obesity is a major problem in most of the western world and it is often highlighted that more exercise and higher levels of physical activity could counteract trends of overweight and related illnesses [14]. It is estimated that only 30 percent of the UK population for example, get their recommended half hour of moderate exercise five days of week [1]. Many approaches to increase people's level of health are therefore focusing on increasing moderate activity level on an everyday basis [14, 18]. Social support in particular is a main factor for people's inclination to increase activity level; sharing information and collaborating to work out together has influence on people's activity level [5]. Social computing technologies have already been shown to support promotion of personalized health [17] and motivate activity by for example tracking and sharing details of physical movement [4, 16]. However, few fitness applications have taken full advantage of the new possibilities of ubiquitous computing. In particular, many systems depend upon users entering information or otherwise changing their routines to make use of new technology.

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This paper presents initial research and development from an ongoing interdisciplinary project applying technology to fitness and health. The goal is to increase awareness and motivation of exercise and general daily level of activity by way of ubiquitous computing technologies.

2. Fitness and Health Awareness

2.1 Motivation

Numerous studies and theories within sports science and health literature have explored how to motivate people to increase their level of activity, both in terms of moderate activity throughout the day and specifically targeted exercise. For example, social cognitive theory predicts exercise level based on the individual's internal values (e.g. the need to be social) rather than external values or stages of change.

The social cognitive theory focuses on increasing the individual's self-efficacy in relation to keeping fit. The theory is based on studies that show how intrinsic motivation (enjoyment, feeling good about the exercise) rather than extrinsic motivation (external pressures or immediate rewards) increase the likelihood that the person will stick to a routine [11, 14]. Experiments for example show that personal services are successful in promoting increased physical activity among middle-aged and elderly compared to a control group [7, 8].

Other research has addressed social aspects of sharing activity information and found that this can also motivate people to become more active; the light competition that occurs can make people increase their activity level [16]. Similarly, when people receive tailored information that is personally relevant, it is more likely to stimulate change, adding to their self-efficacy and outcome expectancy [18].

Behavior change is difficult to promote and many health researchers point to the unique combination of internal and external influences that are complicated to trace. One critique of the physical activity literature for example is that they do not distinguish between individual level values (such as age, social class, health status) and social level values (such as family, school/work and community) [6]. Although the social cognitive theory addresses such aspects of community, it still focuses on internal values as the main motivator to increase individuals' level of exercise. Indeed, social factors such as poverty and neighborhood have been found to highly influence the levels of exercise individual's do [6]; it is reasonable to conclude that exercise is affected by the behavior of the individual's surrounding group alongside individual values. Our goals in our project have thus been to focus on social and communal aspects of exercise; the pressure from the surrounding community is a great motivational factor not to be underestimated in relation to intrinsic motivational factors.

2.2 Technologies

Numerous activity measuring technologies have been developed and are commonly used, such as heart rate monitors and speedometers. Typically, heart rate monitors are used for medical purposes and in-the-gym measurement of general fitness level but wrist-worn monitors are becoming more common, making it possible to use outside. Another tool is the pedometer, a small device that measures each stride the wearer takes. Indeed, recent research indicates that just the presence of the pedometer can motivate people to be more active [16] and that sharing this information with a small group of friends was both satisfying and motivating for the participants compared to a control group [4].

A new commercial technology in this area is the BodyBugg, which measures an array of values such as temperature difference between skin and air, steps and acceleration, in order to estimate how many calories the wearer is burning [3]. It has been shown to work reliably in controlled tests for measuring burnt calories (an accuracy of between 89 and 98 % in various tests), however, it showed to have more difficulty determining actual context of the wearer [10]. The disadvantage is that it has to be worn on the upper arm for 24 hours a day, and can therefore easily collide with everyday clothing, in particular among women who tend to wear tighter clothes than men.

Alternatively other applications have relied on GPS data, such as Rundo [13]. It measures speed, distance, altitude and calculates the number of burnt calories on this basis. However, GPS based applications rely on constant view of the satellites (usually at least four) making it inefficient for cityscapes where satellite shadows appear frequently and the device naturally does not work indoor.

Finally, some experimental technologies are using multimodal sensors to infer patterns of behavior, such as the one developed at Intel Research, Seattle [9]. This sensor board uses data from audio, 3-axis acceleration, barometric pressure, temperature, humidity, compass heading and light level. This data enables the sensing box to distinguish between ten types of activity such as sitting, walking, jogging and riding a bicycle. A small box containing the sensor board is equipped with Bluetooth and wireless networking, which has to be worn on the user's body. However, the sensor board is specially built and not commercially available.

One of the problems with the systems described above is their applicability to daily life. A pedometer is to be worn on the person's body at all times (preferably at hip height) similar to the arm-worn bodyBugg and the heart rate monitor which needs to be strapped tight around the chest. Such body attachment is intrusive to everyday activities, making it less usable for people who want to use such a device everyday. The least intrusive one of the activity measuring technologies though, is the pedometer; the weakness is that it only measures strides, not the intensity of the strides. This has tremendous effect on the actual level of activity of the individual since the body uses different force to for example walk uphill than straight or slowly versus fast. One of the aims of this project is therefore to design and develop a new type of activity tracking that is more suitable for daily life than the ones above. Its preciseness was important; however, since the measurements are meant to provide fitness awareness to individuals rather than medical measurements, the users' understanding of it was more important than the numerical accuracies.

2.3 Methodological Considerations

Through combining theories from social science, in particular sports medicine related issues, with methodologies of technology design we are aiming to design, implement and trial innovative fitness technologies. The project is taking an interdisciplinary stance, relating research to both social and technical theories; in the tradition of human-computer interaction we use ethnographic methods for pre-design and evaluation studies so as to gain better knowledge of how technology can be utilized to motivate fitness. The methods include qualitative inquiry and analysis of important factors in relation to for example active people's motivation and experience of fitness and health. A first pre-design study has been conducted, which reveals concerns and motivations for people in relation to specific exercise.

3. A Pre-Design Study of Exercise

The study used in-depth interviews and respondents were selected through purposive sampling, allowing us to select information rich cases. All ten participants were active or very active getting specific exercise between four and six times a week. Their age range was between 24 and 54 and six were males, three were females. The study revealed issues in relation to three themes: (1) how the participants got their exercise and how active they were, (2) how they motivated themselves to be active and (3) what they found de-motivating.

3.1 Doing Many Types of Exercise

One of the characteristics of the participants was that each of them got exercise from a combination of different types, such as cardiovascular exercise at the gym, swimming, running in the park, climbing and hiking. Each exercised between two and five times a week doing various things, only two did all their exercise at the gym, one 32 year old male who had started exercising six months earlier and one 28 year old female who mainly went to exercise classes such as aerobics. Despite them all being quite active, most still said that they did not feel they got enough exercise and would like to increase their level of everyday activity.

3.2 Motivations

One of the characteristics of the highly active participants was that they often exercised with other people, either friends or acquaintances. Eight of the ten participants had 'workout buddies' that they worked out with most of the times. They said it motivated them more. One female participant, age 54, would even go running with another woman who were not running as fast as she, because of the company. She knew she did not get as much out of the exercise as if she was running alone, but the company motivated her more. Another factor was friendly competition. A male participant, age 24, who could mainly cycle because of an injury would go to the gym with a friend and compete on the stationary cycle. It was still difficult to stay motivated in the gym though. One female interviewee, age 28, found the gym boring but took spinning classes to be social: "I prefer exercising with other people. It gives you more motivation and it's more fun. […] The gym is so boring, you know, I think there are some people that like the gym[…], [but] I just find it very, very dull". She had realized that she could not motivate herself on her own and therefore relied on specific exercise classes.

Half of the participants brought music players to the gym and felt that they got motivated by the beat of the music. When running outside on the other hand, only three of the seven runners would occasionally bring a music player. Finally, performance related motivations such as wanting to look good, run a marathon or being able to play football well were mentioned.

3.3 De-Motivations

Despite the participants being highly active people and doing many different types of activities, they also had problems motivating themselves once in a while. There were obstacles from within, such as participants who said they sometimes skipped a work-out because they just did not feel like going (but consequently felt bad about it) but also injuries leading to certain types of activity being restricted and thereby making exercise sessions less motivating.

Once in the gym there were also issues of de-motivation. An issue raised in relation to the gym machinery, in particular the treadmill, was that they are often positioned in front of a full-length mirror. A 24 year old male interviewee found the treadmill the most boring of the machines. He associated this with the fact that the treadmill was placed in front of a mirror: "so the majority of the time you are just looking at a reflection of yourself". The control panels for the gym machinery were given much critique; one participant, age 32, could not work the controls for the stationary bike and consequently never used this for exercise. Others covered it with a towel so they did not have to watch the progress of the exercise so closely.

One of the problems with cardiovascular gym exercise is that these are activities taken from outdoor practice (running, cycling etc.), and then placed in a uniform, sterile gym environment. Gyms have introduced stimuli such as music and TV but these are ineffective and detrimental if they prove not to be to the exerciser's liking. The majority of the participants were motivated by social factors, such as friendly competition and working out in pairs or groups and this often added to the experience. Although this is not the case with everyone; some people are not motivated by social factors, we found the sharing of experiences to be important. Our further research is therefore focusing on social aspects of exercise and promoting exercise by way of social systems.

4. Shakra – An Activity Tracker

Shakra was developed considering the findings from the study above. It was important to motivate people by social technologies on an everyday basis. It is pointed out that many people do not get their recommended 30 minutes of moderate activity a day [12] and that just minimal increase in moderate activity improves health [15]. We therefore designed and developed and activity tracking and sharing device.

The Shakra application uses fluctuation in GSM signals and neighboring cell information to determine the pattern of how a mobile phone is moving. After training by the user in his/her own area, the system can accurately track a user's mobility. To train the system the user indicates what activity is being performed when starting something new (walking, running, bicycling or driving). It can then distinguish between being still and walking briskly (moderate intensity walking), driving in a car or on a bus/train. The system depends on movement, fluctuation between cell ID, and therefore does not detect stationary movement such as walking on a treadmill. The technical details are presented in [2] where testing and accuracy is also described. The application can in theory be adapted to run on any mobile phone, however the current version is developed for GSM phones with a windows operating system. Because many phone manufacturers limit the access to cell-data, the application can only run on certain high-end phone; we used the iMate sp5. In contrast with pedometers, which can merely tell the wearer how many steps he or she has taken during a time period, Shakra can also measure the intensity of the movement. Where other body tracking devices as the ones mentioned above have to be worn on the body, sometimes on the skin, the application here is simply an add-on part to the user's mobile phone.

The user can continuously view his/her own current activity and status as well as see their previous week in a graph as shown in figure 1. The data is continuously being uploaded via GPRS to a central server and is made available to specified friends of the user. The user can then compare their amount of activity with their friends, both on a daily and on a weekly basis. See figure 4 for this function.

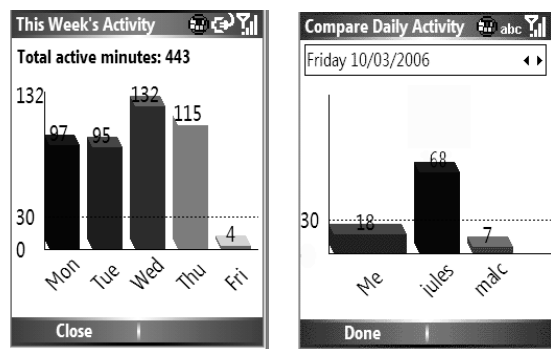

Figure 1: The user's previous week and comparison to his/her friends' activity.

Shakra was tested over a week with three groups of friends (two, three and four people in each group) The study investigated the experience of using the application and its applicability in the real world. The data collected was the system log, showing how much activity the users do and what they looked at (comparing to friends or themselves). The participants also filled in a diary every night about their use and in the end we interviewed them about their experiences with Shakra. All participants were positive and found it motivating to increase their activity. Where some participants did not necessarily increase their activity during the week, they all became more aware of their activity levels. One participant for example, said that he was very surprised about how 'lazy' he in fact was and that he wanted to do something about that. The study being analyzed presently and will be reported in a future publication.

5. Discussion and Future Research

The project described here addresses the demand for motivating exercise and providing increased awareness of people's general activity level. However, the benefits to research go beyond just increasing general level of health. The project also applies new types of technologies to an area that ubiquitous computing and social systems have yet to embrace. In the area of fitness, computing technologies have often been put on top of other technologies (such as gym equipment) although not always in a well-considered fashion. Applying new technologies such as fluctuations in GSM signals to detect movement is a novel way of using traditional data transmission technologies and we hope to provide research results that can be relevant to other areas than fitness and health.

Social issues have been emphasized as an important part of motivating exercise. The goals of the technologies within the project will be threefold: Firstly, the aim is to use technology to increase awareness of fitness level, secondly the technologies should motivate people to increase their amount of moderate exercise. Finally, the goal is for the technologies to motivate people to maintain their exercise routines. This paper has described our first application, Shakra, which gives users an awareness of their fitness level as well as aiming to motivate exercise. The plans are to continue refining Shakra and develop more and different applications, for example based on gym equipment. The evaluation of these applications should lead to a better understanding of how technology and in particular ubiquitous computing can provide us with tools to assist exercise and healthy behavior. Essentially, design of this kind is an iterative process and each technology and design approach needs thorough evaluation in order to inform researchers about the possibilities (as well as disadvantages) of computing technologies in the area of fitness and health. Finally, we hope that this information leads to a general improvement in health among the population.

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