Monitoring and Feedback to Increase Awareness of Exercise Activities

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1. INTRODUCTION

Our society has a weight problem. Flegal et al. [5] reported that 61% of US adults were overweight or obese in 1999. The number of quick fixes, like fad diets and expensive exercise equipment, has also increased: Americans spend about \$30 billion a year on weight-loss products and service [11]. However, most people make promises to change, but immediately revert back to their old habits [2].

At another front, individuals are increasingly monitored by technology, but the information gathered from this technology is rarely used to help users with their health and exercise. Instead, the information is given to someone or something else (and in the cases in which the user benefits, the information is used to automate something). For example, smart homes use sensors to automate lighting and temperature settings, so we do not have to get up from our couches. Grocery stores record our purchasing habits and use this information to sell us more food we do not need. Health devices monitor our bodies when we are already ill, instead of helping us with prevention.

Imagine that the information in each of these settings was provided back to the user to help with their exercise goals. Activity information from smart homes can help users prioritize activities. Purchasing habits from groceries can help users assess their eating habits. Physiological data from wearable devices can inform users about the progress (or regress) of their health. The simple retargeting of information about the self back to the self has immediate impact.

We propose the idea of using ubiquitous computing technology to create a comprehensive system that will monitor a person's exercise habits and health and will provide this information to motivate and help them tailor their physical activity. To explore this idea, we present a 5-part framework that delineates what need to be addressed for a successful monitoring and feedback system. The framework consists of the following aspects with their corresponding question:

- Activity: What do we monitor?
- Sensing: How do we monitor?
- Modeling: What information do we get from the sensors?
- Presentation: How do we present the information to the user?
- Effect: How will the information affect the user?

2. MOTIVATION

We have introduced an idea to shift the recipient of monitored information back to the self as a solution to the problem of exercise adherence. This section will address the benefit of the awareness of self on exercise adherence and the role of ubiquitous computing in creating awareness of physical activity.

2.1 Why Awareness?

The awareness of exercise activities that ubiquitous computing can offer provides several benefits. First, awareness can help users make better decisions. Awareness of one's environment has been shown to be critical in decision-making [4]. It is not a leap to think that awareness of one's activities can help with prioritizing and deciding what to do. Begole et al. [3] used patterns of activity to help office workers plan work activities and communication. As an application to exercise, a system can provide the user with patterns of activity and inactivity to help the user regulate his/her exercise.

Second, feedback about exercise can help users prevent problematic behaviors. Discontinuing one's exercise regimen is a common occurrence among people. Martin et al. [13] showed that feedback is one of the several behavioral and cognitive procedures that can enhance adherence to an exercise program. Annesi et al. [2] found that members of a fitness center who received exercise feedback attended the fitness center more and were less likely to drop out.

Lastly, information about one's self can be used as a motivational tool. Paschali et al. [14] used simple accelerometers to track activity among adults with Type 2 diabetes and showed that feedback promoted exercise. Body and environment sensors are here today and more are being created. They just need to be applied to the problem of exercise adherence and their information offered as motivational tools to users.

2.2 The Role of Ubiquitous Computing

Being more aware of an individual's exercise activities seems like a problem for which the individual should be responsible. What role would ubiquitous computing have? First, although people are capable of remembering many events throughout one's life, remembering minor details of everyday activities is difficult. Also, recording one's activities is tedious and can detract from the activity. Many research in ubiquitous computing have focused on the monitoring, storage, and sharing of information between groups of people [1][15]; this can be leveraged and applied to the problem of continuous data of one's physical activities throughout a day, months, and years.

Another problem with people's memory is that people tend to remember negative things [7]. Remembering only the negative aspects of an activity (e.g., remembering how many times one lost in racquetball, instead of the sport's health benefits) can be discouraging. With computers, the sensing of activities is not subject to the person's moods or varying perceptions of what is happening, thus the information about one's activities can be presented more objectively and help the user make better, wellinformed decisions.

Lastly, there are plenty of sensors that can sense things that a human cannot observe. In addition, computing technology can infer information from observation quickly, thus reducing the cognitive load of the user. Various projects have demonstrated techniques for measuring activity. An article by Knapp [10] described a research project that uses GPS (global positioning system) to measure the movement of users. Wearable devices, such as BodyMedia, that monitor physiological information are already in the market.

3. OPPORTUNITIES

We described the role that computing technology can take in helping people be more aware of their exercise activities. This section will describe the different issues in putting together monitoring and feedback to motivate physical activity. We will now use our 5-part framework to outline areas of research and the questions and issues that need to be addressed.

3.1 Activity: What do we monitor?

If we are going to introduce computing technology into exercise, we need to understand the users well. A person concerned with their exercise and health does not need to monitor all activities. What activities are pertinent to determining a person's health? What kinds of activities need the most motivation? Additionally, not everyone needs assistance with being more aware of exercise activities. Previous work of our research group found that advanced athletes understood their bodies well enough that monitoring capabilities are not needed nor desired. Finding the appropriate users and activities will be critical in building an effective monitoring and feedback system.

Surveys are one way to find out which of their physical activities people want to be aware of. Field studies of different populations and activities also provide a way to discover what behaviors people might benefit from being aware of.

3.2 Sensing: How do we monitor?

The physical nature of exercise poses a challenge to the kind of sensors that will be successful in monitoring activity. The sensors placed in the environment and, specially, on the body need to be non- or minimally intrusive. These technologies need to blend seamlessly into the lives of the users. Also, since activity will be monitored continuously for days and weeks, the sensors need to be inexpensive and robust.

Hudson et al. [9] used a Wizard of Oz study to tease out what kind of sensors will be useful for predicting interruptibility. This technique can also be used to discover what kind of sensors will provide the best information about exercise and health. Novel ways of using existing technology and creation of new sensors are also relevant areas of research.

3.3 Modeling: What information do we get from the sensors?

Another challenge is obtaining pertinent knowledge from the monitoring data. The number of steps a user takes is a good place to start to study exercise, but it may not be sufficient to give comprehensive feedback to the user about his/her exercise regimen.

Existing psychological and sociological theories can be used as clues to what kind of information can be gained from people's activities. For example, exercise has been shown to have an antidepressant effect on both men and women with mild to moderate depression [6]. A system that can sense a decrease in an individual's mood can suggest an exercise activity. Another approach is to explore what can be inferred from particular behaviors. For example, research on NEAT or nonexercise activity thermogenesis has shown that lean individuals were more restless and spent two more hours on their feet than heavier individuals [12]. More studies need to be done that correlate various activities with physical fitness.

3.4 Presentation: How do we present the information to the user?

There is plenty of information that can be obtained from people's activities. Providing this information back to the person will be a critical challenge. The first challenge is how to provide the information in a way that is easily and quickly understood. Another challenge is determining the level of detail at which the information needs to be provided to the user. Are patterns of behavior sufficient information or is a higher-level analysis, such as effects of a pattern, required? A crucial challenge is the appropriateness of feedback. Do we present negative information to the person and how?

To address the issues of presentation, different methods for informing the user need to be designed. In addition, we can create taxonomy of methods of disseminating information and determine which applications each method is appropriate for.

3.5 Effect: How will the information affect the user?

Now that the information has been presented, how will it affect the person? This is a challenge in itself, because this will require user studies over long periods of time. What are the best interventions to motivate people or to prevent people from reverting back to problematic behavior? Did they feel like they lost control of self-monitoring? Did the users trust the system? One effect of exercise information to focus on is the results on the emotional affect and mood of the user. Lab studies of feedback about exercise can be performed to learn its emotional effect. Longer studies will need to be done on the effect of feedback on mood. The effect of feedback on motivation, which may be related to emotion, also needs to be addressed.

Another aspect that needs to be understood well is whether information about the self from computing technology will lead to better decision-making regarding one's health.

4. CONCLUSIONS

We have presented the benefit of increased awareness of exercise activity through monitoring and feedback and described how ubiquitous computing can contribute. We also described a 5-part framework, which poses problems and offers opportunities for the ubiquitous computing community to tackle.

Exercise is an exciting domain to study the role of computers in monitoring and feedback, because of the challenges it presents and the impact that a successful technology can make. The components that are needed to make a monitoring and feedback system are already available. Technologies for sensing and monitoring are improving. The sciences of feedback and its effects have been studied extensively. These just need to be put together in appropriate ways, which will provide many opportunities for research.

5. REFERENCES

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