Tracking Behavior in Persuasive Apps: Is Sensor-Based Detection Always Better Than User Self-Reporting?

Miyuki Shiraishi
Dept. of Computer Science
Waseda University
3-4-1 Okubo, Shinjuku-ku
Tokyo 169-8555, Japan
s_miyuki@dcl.info.waseda.ac.jp

Vili Lehdonvirta
Helsinki Institute for Information Technology
Spektri Business Park, Pilotti
Metsnneidonkuja 4, Espoo, Finland
vili.lehdonvirta@hiit.fi

Yasuyuki Washio
Dept. of Computer Science
Waseda University
3-4-1 Okubo, Shinjuku-ku
Tokyo 169-8555, Japan
y-washio@dcl.info.waseda.ac.jp

Hiroaki Kimura
Dept. of Computer Science
Waseda University
3-4-1 Okubo, Shinjuku-ku
Tokyo 169-8555, Japan
hiroaki@dcl.info.waseda.ac.jp

Chihiro Takayama
Dept. of Computer Science
Waseda University
3-4-1 Okubo, Shinjuku-ku
Tokyo 169-8555, Japan
takayama@dcl.info.waseda.ac.jp

Tatsuo Nakajima
Dept. of Computer Science
Waseda University
3-4-1 Okubo, Shinjuku-ku
Tokyo 169-8555, Japan
tatsuo@dcl.info.waseda.ac.jp

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Abstract
This paper aims to discuss the roles for the two types of tracking user behavior. Considering these two types of tracking, sensor based recognition has a great advantage when sensing human activity, but it is not always adequate when tracking in the real world. In this paper, we compare the benefits and drawbacks of sensor-based tracking versus self-reported data in persuasive applications called EcoIsland.

Keywords
Self-reporting, Automatic Sensing, Persuasive Technology

ACM Classification Keywords
H.5.2. User Interfaces: User-Centered Design

Introduction
Humans have strong desire to change their behavior to break their bad habits such as smoking, eating to excess or buying too much. Although we know that it is important to keep desirable habits with a great effort, we like to attempt to be lazy and to spend an easy life. Offering appropriate feedbacks to users at the right time is an important role of persuasive applications to change their behaviors. To produce effective feedbacks

for users, persuasive applications have been used their basic personal information including age, sex, location and hobbies. Furthermore, the applications are now starting to use the information about their current behaviors directly [1]. The two main types of tracking user behavior are user self-reporting and sensor based detection. The former is that users' report on their own behaviors by typing texts or by marking a check on a behavior list. The latter is that user behavior is automatically detected by sensors embedded in our environments.

This paper aims to discuss the roles for the two types of tracking user behavior. Considering these two types of tracking, sensor based recognition has a great advantage when sensing human activity, but it is not always adequate when tracking in the real world. From the case study in a persuasive application called EcoIsland, we discuss about the advantage and disadvantage of sensor-based recognition and self-reporting, and clarify the right role of each technique. In the next section, we describe existing persuasive applications and how they track user behavior in them. We then introduce EcoIsland for persuading users to reduce carbon dioxide emissions. After that we present lessons learned from EcoIsland, showing the merit and demerit between the two types of tracking techniques.

Related Work

Dillahunt et al. [3] developed a system that aims to commit users to environmentally responsible actions by providing visual feedback in the form of a virtual polar bear. Participants were shown a Flash-based virtual polar bear on an ice floe that would grow as they committed to environmentally responsible actions and shrink as they chose not to commit to actions. The main objective of the study was to examine to what extent emotional attachment to the virtual polar bear affects test subjects' propensity to commit to positive actions. No sensors were involved and the system was used on a single session only. Afterwards the researchers contacted the participants to ask to what extent they had kept the commitments made during the session. The two biggest problems identified with this approach were 1) the possibility that users were not reporting their actions truthfully when questioned by a researcher, and 2) the lack of knowledge regarding how long the behavior change is sustained.

In sensor based systems, the above two issues are usually less prominent, but other issues appear. Schechtner and Schrom-Feiertag [2] developed a system that aims to influence people's movement patterns within a national park in order to conserve parts of the park. Real-time data regarding the users location is collected using GPS and others sensors, and feedback is provided to the user on a PDA screen. The feedback includes route suggestion and other information designed to influence the user's movement. The effectiveness of the strategy is to be evaluated. The authors expressed that data privacy may be a potential concern in persuasive applications using a sensor based approach. Another issue is that park visitors do not normally carry the necessary devices, the park administration needs to fund and manage a pool of devices and provide the guidance over their use.

Strengers [4] discusses the use of sensor-based energy and water usage data to offer feedbacks on heating, cooling, bathing and laundering to users within a household. The main conclusion of the paper is that using raw sensor data as feedback information is problematic because users did not understand or misunderstand the connections between consumption

data acquired through raw sensors and their own behavior change.

The EcoIsland

Basic Concept

EcoIsland is a game-like application intended to be used through their normal daily activities by a family who wants to behave in a more ecological way. A display installed in the kitchen or another prominent place in the household presents a virtual island. Each family member is represented on the island by an avatar (Figure 1). The family sets a target CO_2 emission level (e.g. national average minus 20%) and the system tracks their approximate current emissions using sensors and self-reported data. If the emissions exceed the target level, the water around the island begins to rise, eventually sweeping away the avatar's possessions and resulting in a game over. Participants can get credits as a regular allowance for saving their island, which are used to buy improvements and decorations to the island, so that green family can

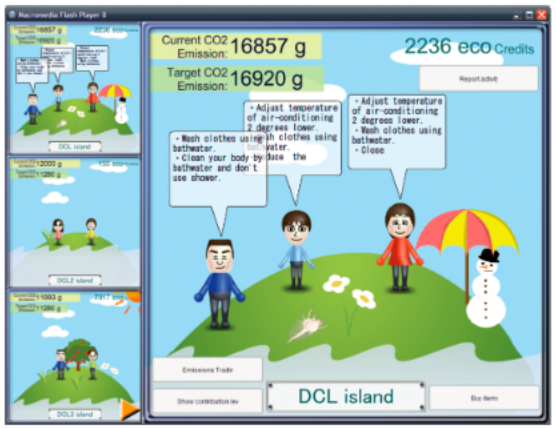

Figure 1. EcoIsland main screen

Sustainable behavior	CO_2 reduction
Use a reusable shopping bag.	-16g
Drive in an economic way.	-80g
Turn off the TV when not watching.	-13g
Instead of car, use bus, train or bicycle.	-180g
Shorten your car's idling by 5 min.	-63g

Table 1. Examples of sustainable behavior list

afford to decorate their island more, while heavy emitters cannot.

On their mobile phones or PC browsers, each participant has a list of actions that the participant may take to reduce the emissions (Table 1). Upon completing an action, a participant reports using the phone or PC, and the water level reacts accordingly. Reported activities are also shown in speech bubbles above the corresponding avatars, which are also shown in a display of another family as a neighbor island's activities.

Persuasive techniques

The general approach from ambient lifestyle feedback systems is to provide a feedback loop for user behavior [1]. The virtual island shown in the display acts as a metaphor and makes the participants conscious of the ecological consequences of their choices and activities. We also tap into social psychology, attempting to exploit social facilitation and conforming behavior to encourage the desired behavior. Social facilitation is the phenomenon where a person performs better at a task when someone else, e.g. a colleague, is watching. Conforming behavior is the desire not to act against

group consensus. EcoIsland's design facilitates these by involving the whole family instead of an individual, and by presenting the participant's activity reports in the speech bubbles and providing contribution charts and activity histories.

Evaluation

For our first user study, we recruited six volunteer families associated with the researchers (20 persons, age 15-58, Male 12 and Female 8) who are interested in environmental issues and lives in a family. The experiment lasted for four weeks. In the first week, we equipped the participant's air heater with a simple electricity usage meter to compare the readings between experiment weeks. In the second week, the system was installed and only one family member from each household was asked to use it. In the third week, all family members used the system. Comparing the results of the second and third week provides insights regarding the social psychological effects. After the experiment, we conducted a survey in the form of a questionnaire asking about changes in the participant's attitudes and feedback.

Results

17 out of 20 participants said that they were more conscious of environmental issues after the experiment than before, and 16 participants said that they acquired more knowledge of environment issue, but only 4 participants tried a new behavior that is not listed in the sustainable behavior list. 9 participants said that the sinking virtual island contributed to a change in their consciousness, suggesting that the metaphor made a good effect. However, the system could not encourage intrinsic motivation, since participants said they felt motivated from reasons stemming from the system, such as saving the sinking virtual island, purchasing items and amassing points rather than using environmental reasoning. It is worth noting that two participants noted that the act of manual reporting itself contributed to the motivation. 11 participants answered that they want to continue using EcoIsland for its amusement or self-discipline to be more sustainable. On the other hand, 7 participants did not want to use EcoIsland any more because of its trouble.

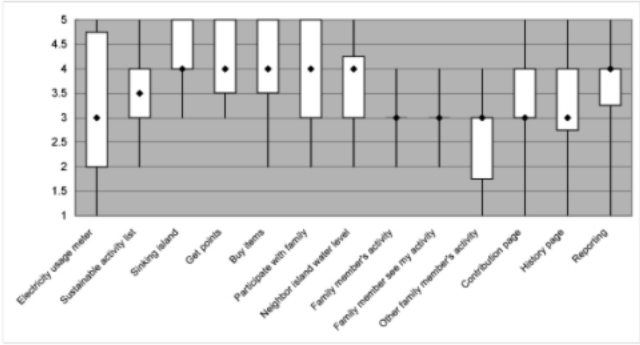

figure 2. Questionnaire: What makes you more sustainable? 1=Less True 5=More True

A log of the reported emission reduction shows that 5 out of 6 participants reported more actions in the third week than in the second week. According to the questionnaire, many participants answered that joining the campaign with their family members contributed to change their environmental awareness. These facts support to the hypothesis that social facilitation and conforming behavior can be used effectively. However, displaying one's and other's activities by a speech bubble seems to make little sense. This is because the font of the speech bubble was too small to recognize in the experimental environments, which was pointed out by 4 participants.

As for the air heater electricity usage, there was no observable correlation with the reported emission reducing activities. While this is an alarming result, it does reflect that the experiment period was short considering ordinary day-to-day variance in electricity use. The time of the experiment (in December and January) was also unusual schedule for them. Also, the electricity usage meter often ran out of its accumulated electric power because of the larger-than-expected power use of participant's air heater, which might affect the strictness of the results.

Discussions

Usability and Privacy

Sensor-based detection has great advantage for timesaving because it is fuss-free. This is because the system gathers user-contexts silently and then users do not have to do any extra operations. On the other hand, self-reporting style applications force users to do extra operations in order to report their own activities. It takes time and might be bothersome. However sometimes it becomes not bothersome. For example many bloggers write articles with fun though they have to type many words. From this lesson, there is a possibility to make self-reporting fun.

Meanwhile, persuasive applications must deal with privacy issues. Sensor-based detection often gathers such user contexts that even users are not willing to inform including privacy of those users. On the other hand, self-reporting style applications allow users to select their activities to be disclosed. This is a great advantage from privacy point of view. However there is a possibility for users to report untrue behaviors, cheating. Unlike general video games, the final goal of persuasive applications is changing users' own behaviors, not defeating others. This point acts as a deterrent against cheating.

Feedback effectiveness

It is important for users that persuasive applications offer actual feelings of what they behave desirably and the sense of accomplishment. Thus persuasive applications must carefully design those feedbacks to users, when the feedbacks should be shown. Also we point that users cannot get the actual feeling without the certainty that the applications surely recognize their behaviors.

If a feedback is given to a user at an inappropriate time, the user must be confused and cannot get the actual feeling. For example, even if a system informs a user that she has done sufficient amount of green actions with her long today's activity list when she come home after a long day at the office, it might be hard for her to get the actual feeling. Oppositely if the system gives feedbacks frequently responding to each action by analyzing real-time sensor data, the user might know what action is effective for our environment. However this must be annoying as the number of her activities comes up because frequent feedbacks interfere her daily activities. If the system introduces 'calm' presentations [10] that do not make her feel annoying, now sense of existence of the system degrades rapidly. Therefore persuasive applications need to engage her attention.

Self-reporting style has power to overcome these problems because the system is able to give feedbacks immediately just after the user reports her own behaviors. While the reporting time is far from actual hours of the behaviors, she can get sufficient feedbacks

of what kinds of behaviors were effective for the environment, which gives the sense of accomplishment.

Learning

As mentioned above, we adopted a self-reporting style in the EcoIsland system, but 4 participants mentioned that it was somewhat bothering to input an activity manually every day. In fact this is true, it is one of the improvements we need to make to facilitate the user inputs, however, that does not simply lead the system to sensor-based detection. This is because that the self-reporting style, which we directly show the desirable activity in activity list to the users, has an educational effect, which has implication.

While main purpose of persuasive applications is to make users take desirable behaviors, there is a case that users do not know about what 'desirable behaviors' are that they can take. In existing persuasive applications, many of the tasks are simply just try doing', or 'not doing' some kind of actions (e.g. not smoking), but in a case similar to EcoIsland, there are many activities that users do not know. In these cases, it is required to show a desirable activity in some way to the users.

Experiment result shows that providing activities in the style of a list was useful for presenting desirable activities. In spite of the fact that we recruited participants who were interested in ecology, most of them did not do any activities that were not mentioned in the activity list. This means that it is necessary to show the users desired activities, and also, 15 out of 20 participants expressed that their knowledge about green activities has increased. In addition to getting interested in environment by using the application, an increase of the knowledge is considered to come from the list shown directly to the users which enabled to educate users about activities they did not know.

On the other hand, if the input is sensor-based, the system senses activity automatically, making users less think and act by themselves, less conscious about desirable activities they can take. In EcoIsland case, it is possible to print out the activities and hand it out preliminarily, but as the number of activities may be quite big, it will not be quite a realistic idea, and educational effect will not be expected without guaranteed to be able to 'see the list every day'.

Although it is not fuss-free and required to think some methods to solve the problem, the system enables users to see the item in the list which includes desirable activities, and every time looking at the list, or reporting the activity, users will be aware that variety of possible activities exists, and act consciously.

References

[1] Nakajima, et al. Reflecting human behavior to motivate desirable lifestyle. In DIS '08: Proceedings of the 7th ACM conference on Designing interactive systems, 2008

[2] Schechtner, K., Schrom-Feiertag, H. Understanding and influencing spatiotemporal visitor movement in national parks based on static and dynamic sensor data. In Pervasive 2008 Workshop Proceedings, pp.95–99, 2008.

[3] Dillahunt, T., Becker, G., Mankoff, J., Kraut, R. Motivating environmentally sustainable behavior changes with a virtual polar bear. In Pervasive 2008 Workshop Proceedings, pp.58–62, 2008

[4] Strengers, Y. Challenging comfort & cleanliness norms through interactive in-home feedback systems. In Pervasive 2008 Workshop Proceedings, Sydney, Australia, May 19-22. (2008) 104–108