Eco-Avatars: Visualizing Disaggregated Home Energy Use

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ABSTRACT

This paper presents Eco-avatars, a tool aiming to promote long-term energy conservation behaviors across householders. It takes advantage of the emotional links that can form between humans and avatars, or personal digital personifications. The application represents each member of a household as an avatar situated in a shared graphical environment that reacts according to individual consumption activity and shows collective performance. This paper argues that playful visualizations that let users observe the impact of their consumption behaviors on a personal virtual representation, and contrast this with others in their household, will provide support and motivation for engaging in long-term sustainable behaviors.

Author Keywords

Avatars, Sustainability, Home Energy

ACM Classification Keywords

H5.2: User Interfaces: Prototyping.

INTRODUCTION

Motivated by the environmentally sound goal of reducing resource use, eco-feedback technology aims to make users aware of their personal consumption. Smart meters, one of its most established forms, have been shown to promote significant savings by simply presenting basic information such as watts consumed, costs accumulated or CO_2 emissions produced [1]. However, the long-term impact of such visualizations is less profound; after acclimatization to new sources of feedback, relapse to prior consumption patterns is common [2]. One solution to this problem is the creation of more evocative, engaging and individual visualizations that are more capable of sustaining prolonged user engagement. Avatars, embodiments of users residing in a virtual world, are one mechanism for achieving this; studies have shown that users can form attachments sufficiently strong that they feel damage to their virtual representations as damage to themselves [3]. Indeed, promising avatar eco-feedback systems have been deployed in scenarios based on monitoring travel behaviors [4] and on committing to sustainable behaviors [5].

This paper extends this work and describes a prototype application that aims to promote sustainable energy conservation behaviors in a household composed of multiple members by highlighting both individual and group consumption levels and by forging affective links between the user and their impact on the environment.

DESIGNING ECO-AVATARS

The energy consumption of most homes is collective; all occupants contribute. Correspondingly, energy feedback, be it in the form of bills, or smart meters is aggregate, summing the usage of many users over a substantial period of time. Theories of motivation suggest that this lack of individual impact and the temporal delay between consumption activities and feedback represent significant motivational challenges. Essentially, it is hard for users to understand or care about the impact of their actions when this is obscured by the input of others and obfuscated by significant delays in receiving feedback.

The application in this paper attempts to address these problems. It is based on the idea that each member of a household can be represented by an avatar in a shared graphical visualization. Specific consumption activities are then associated with each user, and their avatar rapidly and immediately alter its depiction to represent the users individual actions in the wider context of those performed in the entire household. The goal of this is to allow every member of a household to understand their personal and collective consumption patterns and to encourage them to consume less. Two main motivational strategies informed the design of the system: social pressure and humanization.

Social pressure is inherent in the system in that it shows individual and group behavior. One design goal was that it is immediately clear from the visualization which avatars, and by inference users, are behaving more or less sustainably. By directly observing such contrasts, we argue that understanding the consumption impact of particular activities and individuals will become clear. Social pressure present in normal family dynamics may then provide a motivational foundation for optimizing consumption and saving energy.

Humanization or strengthening the connection between householders and their avatars was also a key design objective. To achieve this the avatars was designed to express feelings from happy to sad using a pre-defined set of facial and bodily emotions and textual messages. To further, this metaphor, the avatars were also able to interact with one another, turning to face each other and communicating and commenting on each other using simple textual messages.

PROTOTYPE

Eco-avatars was implemented in Adobe Flash and runs on the Adobe AIR runtime hence allowing the quick deployment across different platforms and devices. Aggregate and disaggregate consumption information is computed using a bespoke Non-Intrusive Load Monitor (NILM) system [6] that can be installed on a homes' main electric supply and remotely queried by the avatar application using standard TCP socket connections. The NILM system is capable of analyzing changes to overall electrical load in order to deduce what specific appliances have been turned on, off or adjusted.

Operations

Eco-avatars has three modes: 1) configuration, 2) consumption and 3) environment. In the configuration mode the users create a family of avatars (one per family member) and customize each individual avatar by naming it, and selecting a gender and appearance (from a set of 10 options). They also manually associate a specific set of home appliances with the avatar. These associations are used to attribute consumption to particular users in the consumption and environment modules described below.

Consumption module

This module displays a picture of a family member's avatar and a comparative chart of individual energy consumptions (kW/h or projected costs) so that family members can contrast each other's performance. It also displays general energy saving tips and consumption goals and is designed as a fairly typically eco-feedback display. Figure 2 (top) shows a screenshot of the consumption module.

Environment module

The environment module (Figure 1, bottom) shows an expressive and personal view of consumption activities. It incorporates a number of features to highlight consumption and sustainability issues. Firstly, it consists of a static forest background, populated with all the avatars from a family. The background shows a healthy forest (right side of Figure 1, bottom) gradually transitioning to a desolate, deforested landscape (left side). Avatars are positioned against this background according to the consumption activities of their real world counterpart; high consumption results in a leftward drift towards the polluted area of the scene.

The avatars also have more direct and immediate feedback mechanisms. They show happy to sad expressions and have a lightly glowing aura, which changes color from red to green in response to specific low consumption actions, or goals and commitments met. Finally, the avatars can interact with one another by commenting on each other's performance. They achieve this by turning to look at each and using captions to express messages (see Figure 1).

Figure 1. Eco-avatars working modes: consumption (top); environment (bottom).

CONCLUSION

This paper presents Eco-avatars, a system designed to help a household reduce their energy consumption by revealing and contrasting individual usage levels via playful, expressive characters. Future work on this system will involve deploying and evaluating its effects in a field study. Future development of the application will focus on improving the quality of the media and introducing gamification techniques with the objective of capturing and maintaining users long term attention and engagement.

REFERENCES

1. Parker, D. et al. How Much Energy Are We Using? Potential of Residential Energy Demand Feedback Devices. Solar Energy, (2006), 1665-06.

2. Peschiera, G., Taylor, J.E. and Siegel, J.A. Response–relapse patterns of building occupant electricity consumption following exposure to personal, contextualized and occupant peer network utilization data. Energy and Buildings, 42(8), (2010), 1329-1336.

3. Benyon, D. and Mival, O. Landscaping personification technologies: from interactions to relationships. Ext. Abstracts CHI 2008.

4. Froehlich, J., Dillahunt, T., Klasnja, P., Mankoff, J., Consolvo, S., Harrison, B. and Landay, J.: UbiGreen: investigating a mobile tool for tracking and supporting green transportation habits. In Proc. CHI 2009.

5. Kimura, H. and Nakajima, T. EcoIsland: A persuasive Application to Motivate Sustainable Behavior in Collectivist Cultures. In Proc. NordiCHI 2010.

6. Pereira, L. and Nunes, N.J. Low cost framework for non-intrusive home energy monitoring and research. In Proc. SmartGreens 2012.