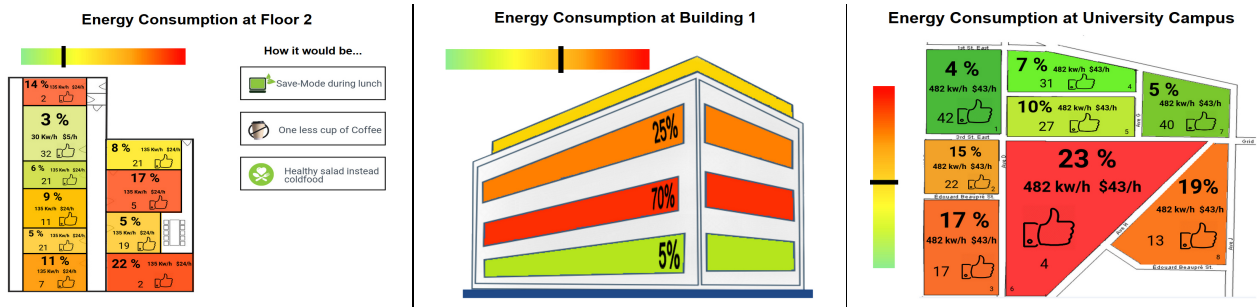
Exploiting Social Comparison using Pervasive Displays and Mobile Notifications for Reducing Energy Consumption

Vito Gentile
Università degli Studi di Palermo
viale delle Scienze, ed. 6 - 90128 Palermo, Italy
vito.gentile@unipa.it

Vasiliki Mylonopoulou
University of Oulu
P.O.Box 4500, Fin-90014
vasiliki.mylonopoulou@oulu.fi



(a) (b) (c)

Figure 1: Multilevel visualization of energy consumption data. Users can see energy consumption data and compare them among rooms in the same floor, floors in the same building, and buildings in the area (e.g. buildings of a university campus).

ABSTRACT

Public displays have been used as a persuasive technology in many prior works. In this paper, we describe a persuasive pervasive system aimed at influencing users' behavior for reducing energy consumption in buildings. This system exploits a pervasive display that visualizes the energy consumption in different levels (rooms, floors, and buildings), exploiting social comparison techniques. Moreover, our system may be extended by means of a mobile application that sends persuasive personalized messages to the users regarding their energy consumption. We then present our evaluation study design, aimed at comparing the effectiveness of three possible implementation of our system: one based only on the use of displays, a second one that relies only on mobile notifications, and a third solution that combines both these approaches.

Author Keywords

Pervasive displays; energy consumption; behavior change; persuasive technology; social comparison.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

PerDis '17, June 07-09, 2017, Lugano, Switzerland

ACM ISBN 978-1-4503-5045-7/17/06.
http://dx.doi.org/10.1145/3078810.3084350

INTRODUCTION & BACKGROUND

During the last few years, there has been a growing interest towards the use of display technologies for changing users' behavior, making pervasive displays a persuasive technology [3]. A persuasive pervasive display can support behavior change through social influence, i.e. influence of other people on our behavior [1]. Social influence and social comparison [2] (i.e. part of social influence [7]) have been exploited in pervasive display research. For instance, in [5] an application for visualizing water consumption on displays has proved to be effective in reducing such waste, as well as for increasing the awareness of these problems among display users. On the same line, persuasive technology using social comparison may lead to positive results in reducing energy consumption. For example, Gulbinas et al. [4] showed that people save more energy when they can relate their energy consumption data to others. However, this research used personal computers to visualize the data.

In this paper, we want to investigate how users' behavior is influenced by the awareness of energy consumption data in three different forms: visualizing data on a public display, sending personalized notifications to users' mobile devices (i.e. hints on reducing their energy consumption), and a combination of these two approaches. Our contribution consists in the design of a multilevel data visualization interface for public displays (see Figure 1), and a system for sending mobile notifications based on energy consumption.

SYSTEM DESCRIPTION

This system is designed to be installed in a campus, i.e. a set of buildings connected under the same company or

organization. Each floor of each building will have a display accessible to everyone, placed at a commonly used place (e.g. entrance of the corridor). The display shows the energy consumption in each room, measured by specific hardware (e.g. Plugwise wireless energy sensors [6]) for each socket. The display also shows energy consumption percentages for all the floors of the building, and the whole campus map (Figure 1).

Colors are used for representing the different levels of energy consumption, along with the relevant percentages. The users can "like" a specific room, and the number of "likes" are shown on the respective room. Moreover, users can choose to see additional details on energy consumption. For example, choosing one of the three options given in Figure 1a may allow users to see an estimation of the difference in energy consumption in case of optimizing the use of the computer, coffee machine, and other utilities. In this way, people should be able to understand which devices consume more energy and how their actions may influence the general energy consumption.

Furthermore, users can download a mobile application though a QR code shown on the display. After the installation, this application asks the users to select the building, the floor and the room where they work, and then remains silent in background. The mobile app will display periodical notifications throughout the day, with personalized tips based on the energy consumption in the users' room.

EVALUATION: STUDY DESIGN

We designed a relational study for evaluating how the social comparison based visualization of energy consumption on a display and the use of personalized notifications can contribute in changing users' behaviors. In particular, we focused on three possibilities: i) one that uses only displays for visualizing the data, ii) one that uses only a mobile application for receiving personalized notifications according to energy consumption data, and iii) one that uses both approaches.

In order to compare these three solutions, we will deploy them in different buildings of the same campus (splitting it in three parts, one per each approach to be tested), during the same period of the year. The data collection will be done during months where temperature will not vary, in order to minimize the effect of temperature in the energy consumption. One week before the installation will be sufficient to record the normal energy consumption trend, while after the installations we will record energy consumption data for two months, in order to get over the novelty effect. Then, we will compare the recorded energy consumption data before and after the installations.

We envision an initial novelty effect, which may cause an initial decrease immediately after the installation day. Then, the energy consumption should decrease in time. For any peaks and valleys in the recorded energy consumption, we will send short questionnaires immediately after the deployment to all the employees, in order to investigate the reasons of each fluctuation.

Semi-structured interviews will be conducted for deeper understanding of quantitative results (both energy consumption trend and questionnaires). The semi-structured interviews will be focused on the following areas:

- Have the employees been informed about energy savings during these periods?
- Was there any exceptional situation, e.g. strikes, department, travels or conferences attended by many people, weather changes, etc.?

FUTURE WORKS

We plan to implement a working prototype system and deploy it in a real scenario (e.g. a university campus), in order to conduct a long-term evaluation.

ACKNOWLEDGMENTS

We would like to thank the UBISS 2016 organizers, Nigel Davies and Sarah Clinch for their course and advices that allowed us to build this idea. A special thank goes to Ahsan Manzoor for his contribution in the initial interface design.

This work has received funding from the European Union's Horizon 2020 research and innovation programme – the Marie Sklodowska-Curie Actions grant agreement no. 676201 - CHESS - Connected Health Early Stage Researcher Support System.

REFERENCES

1. E. Aronson, The Social Animal, Macmillan, 2003.
2. L. Festinger, «A Theory of Social Comparison Processes,» *Human Relations,* vol. 7, n. 2, pp. 117-140, 1954.
3. B. J. Fogg, «Persuasive Technologies,» *Communications of the ACM,* vol. 42, n. 5, pp. 27-29, 1999.
4. R. Gulbinas and J. E. Taylor, «Effects of real-time eco-feedback and organizational network dynamics on energy efficient behavior in commercial buildings,» *Energy and Buildings,* vol. 84, p. 493–500, 2014.
5. S. Kuznetsov and E. Paulos, «UpStream: motivating water conservation with low-cost water flow sensing and persuasive displays,» in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '10)*, 2010.
6. Energy management systems of the 21st century | Plugwise: 2017. *https://www.plugwise.com/*. Accessed: 2017- 04- 07.
7. A. Stibe, «Towards a Framework for Socially Influencing Systems: Meta-analysis of Four PLS-SEM Based Studies,» in *International Conference on Persuasive Technology*, 2015.