Smart Tablecloths - Ambient Feedback of Domestic Electricity Consumption

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ABSTRACT

In this work we discuss the topic of ambiently informing individuals of their home electricity usage, with the ultimate goal being to induce positive change and reduction in users' energy usage. We believe that simple ambient feedback, integrated into the surroundings as the colour of a home textile, may provide a powerful motivator in better raising awareness of electricity comsumption. This demonstrator shows the use of an illuminated colour-changing fabric to provide feedback on realtime energy use.

Categories and Subject Descriptors

H.4 [**Information Systems Applications**]: Miscellaneous; D.2.8 [**Software Engineering**]: Metrics—*complexity measures, performance measures*

General Terms

Design, Experimentation, Human Factors

Keywords

home energy monitoring, ambient feedback, smart fabrics

1. INTRODUCTION

It is becoming increasingly evident that a subtle change in end user behaviour can reduce overall energy demands [6, 2] and thereby eventually help control national energy dependencies. Indeed the HCI community are now beginning to focus on this topical area of research as evidenced by papers in CHI this year [1, 3]. In our work we have found that IHD (in home display) and/or web page information is not enough to increase awareness within the 20 domestic households we have instrumented regarding their electricity usage.

We investigate exposing individuals to information on their electricity consumption in an ambient fashion, through everyday textiles that the user regularly sees in the home.

CHI iHCI, Ireland

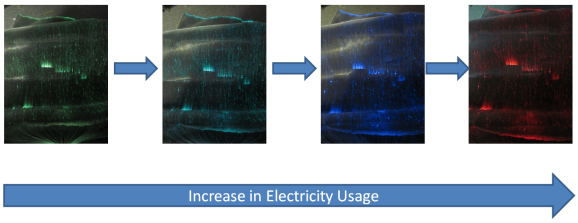

Figure 1: Overview of fabric which changes colour based on domestic electricity consumption in comparison to personalised baseline levels

Colour is an important factor in all aspects of design – in fashion it can serve as a form of expression while in interior design it can affect the mood of those within a space [5]. New developments in textile technology have presented designers with illuminated fabrics and flexible displays which can be used to transform the garments we wear [7] and the textiles in our homes. This year leading design houses Chanel and Jimmy Choo each developed high heel shoes with integrated lighting effects. There is an increasing acceptance of such "smart" textiles both as a functional and aesthetic product which is evident through the increasing emergence of consumer products in this realm.

To realise a method of providing ambient energy consumption feedback, we require material science expertise in designing suitable and smart fabrics to integrate into household items. Engineering and signal processing expertise is also necessary to ensure the reliable transfer of information to the smart fabric, in addition to computer science and HCI insights. Our demonstration system is of a smart cloth which changes colour based on the real time energy consumption in a given environment, seen in Figure 1.

2. SYSTEM DESIGN

We now describe the design of our system including collecting electricity usage data, selection of suitable smart fabrics, data communications and selection of appropriate colours to provide user feedback.

2.1 Domestic Electricity Monitoring

To monitor electricity consumption in the home, we use an EpiSensor ZEM-30[1] data logging unit illustrated in Figure 2.

[1]http://www.episensor.com/products/wireless-nodes/zem-30/

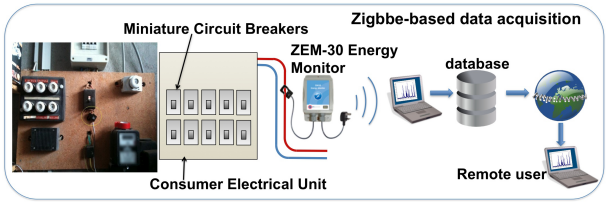

Figure 2: Overview of capturing home electricity usage data and uploading to a central server

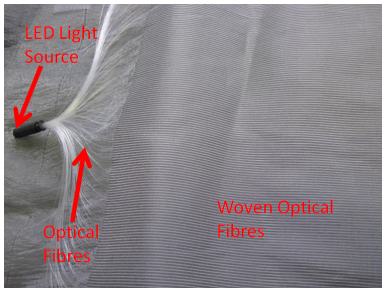

Figure 3: Fabric Light Source

The ZEM-30 measures a variety of parameters which are relayed across a local Zigbee network to a local PC/laptop which logs the data onto a relational database, before regularly sending it to a central web server. This setup has now been active across 22 homes where 66,922,802 parameter readings have been recorded over a period of one year.

2.2 Tablecloth Fabric Selection

The fabric chosen for this demonstration is light-emitting woven plastic optical fibre textile manufactured by Luminex[2]. A tablecloth-sized Luminex(R) fabric with black background and an RGB LED (Roithner Lasertechnik B5-4RGB-CBA) coupled to the optical fibres, shown in Figure 3, is used. This allows any colour of the visible spectrum to be displayed by the fabric. The RGB has 4 pins, a common anode and 3 cathode pins to control the red, green and blue LEDs.

2.3 Communications Module

Data is transmitted wirelessly between the PC and the fabric using Xbee modules. A base station Xbee module connected to the PC transmits the real time energy use of the home. An Arduino Duemilanove, a single board microcontroller, with an Xbee shield is used to control the fabric colour. This reads data from the PC through its connected Xbee receiver. Three digital outputs of the Arduino microcontroller are used to control the Red, Green and Blue pins of the LED. The driving circuit which used to control the current flow to each pin of the LED is shown in Figure 4.

2.4 Colour Selection Algorithm

The importance of presenting information in context to users through personalised baselines or reference points has been noted [4]. We construct a personalised model of the typical electricity consumption of each domestic setting by calculating the average value (based on past usage) for each of the 168 hours in the week. Based on whether the current

[2]www.luminex.it

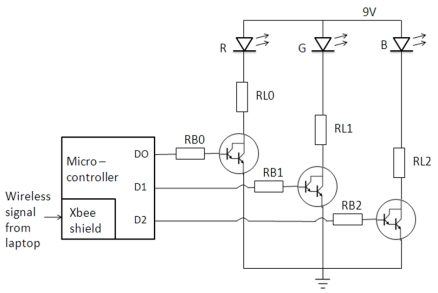

Figure 4: Driving circuit used to control the RGB LED

recorded electricity consumption is $< x\%$, $\pm x\%$, or $> x\%$ of the expected value, we change the colour of our smart fabric – thus providing ambient feedback.

3. DEMONSTRATION

For our demonstration we take a selection of household appliances and monitor their energy consumption using an Episensor ZEM-30. Our laptop records those electricity consumption readings, and if more energy is consumed than expected, our smart fabric will change to red to provide real-time always-on ambient feedback. Similarly if less energy is consumed, then our fabric will change to green. We believe explorations into the psychology of motivating consumers to reduce their energy consumption requires a multi-faceted solution, with ambient feedback playing a key role.

Acknowledgments

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4. REFERENCES

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