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User Centered Design of a New Eco-Feedback Device Based on Life Cycle Audit and Augmented Reality Technology

S. Yin Kwok, D. Harrison and S. Qin
Brunel University, UK

Individual behaviours are responsible for a significant portion of society's impact on the environment. Design for sustainable behaviour (DfSB) is an emerging research area under the banner of sustainable design. Recent research has been done in understanding human behaviour patterns and theorising design intervention strategies for sustainable behaviour. However, implementation and evaluation of these design intervention strategies is still a relatively underdeveloped research area. Few 'behaviour-changing' devices have been prototyped and user-tested to evaluate their effectiveness related to the use of DfSB strategies. Eco-feedback devices have become a focus of human-computer interaction (HCI) and ubiquitous computing (UbiComp) research for several years, yet the performance in usability and engagement remains a major challenge.

This research aims to identify the requirements for the development of a new ubiquitous eco-feedback device, based on enabling technologies and design intervention strategies, to aid decision making for more environmentally beneficial behaviour. This paper will explain the rationale behind the device, and present results from four empirical studies which will prepare the design and development of a working prototype of the device.
A background literature review introducing DfSB and the state-of-the-art development of a range of enabling technologies is reported. We will present a comparative survey of existing ubiquitous eco-feedback tools largely based on mobile phone apps, and discuss the limitations and challenges of these tools, and relate them to relevant DfSB strategies and technological viable solutions. Opportunities in design for sustainable behaviour are identified with the application of key enabling technologies, namely augmented reality (AR), a novel human-computer interaction tool that overlays context-sensitive information on the real world environment, the Internet of Things (IoT) and Life Cycle Assessment (LCA).

This paper continues with the results from four empirical studies on user requirements for an eco-feedback device, temporarily named as the 'eco-value indicator'. The main feature of the 'eco-value indicator' is to display the value of environmental impacts associated with a wide range of everyday activities, objects and consumptions.
The studies reported in the paper are:

- An interview with an expert in DfSB conducted to consolidate the design concept of the 'eco-value indicator'.
- A questionnaire survey conducted to identify daily activities which have significant environmental impacts, and to identify the key aspects of sustainable behaviour to be focused on by the 'eco-value indicator'.
- A focus group study canvasing people's opinions and expectations for the 'eco-value indicator'.
- The development of paper prototypes of the device's software interface, and a usability test of the software interface (paper prototype) carried out with a second focus group.

The results from the above studies will inform the design and development of a working prototype of the 'eco-value indicator', and a design specification of the device will be outlined as a conclusion to the paper.