

# Ambient and Artistic Visualization of Residential Resource Use

Johnny Rodgers\*

Lyn Bartram†

Simon Fraser University, School of Interactive Arts + Technology

## ABSTRACT

Supporting sustainable resource use in the home requires a range of feedback techniques to enable informed decision-making. These techniques can include traditional screen-based interfaces, but these tools often require too much effort and attention from already-busy residents. An alternative approach is the provision of ambient and artistic visualizations integrated into the domestic environment. This method reduces the attention required of residents, increases aesthetic interest and coherence with the home, and enables situated and timely feedback on resource use. We present the theoretical basis of our research, discuss how we have applied it to the development of prototypes in two green home projects, and detail our ongoing efforts to evaluate techniques within this domain.

**KEYWORDS:** Aesthetics, ambient visualization, residential resource use, sustainability.

**INDEX TERMS:** H.5.0 [Information Systems: Information Interfaces and Presentation — General]

## 1 INTRODUCTION

Supporting sustainable resource use in the home requires a range of feedback techniques to enable informed decision-making. Sophisticated sensing and data collection mechanisms are making a wealth of information about resource use available to residents. Visualizing this data in ways that are meaningful and contextually appropriate will help to bridge the gap between data and decisions about how to sustainably use resources in the home.

However, as others have pointed out [1][12][13], and as we have argued previously [2], we cannot just import established visualization techniques to non-work environments. Contextualizing visualization for these environments means considering a range of user attention from ambient to attentive, appropriate placement of displays to support daily activities, and balancing aesthetic appeal and usefulness [13]. After all, we cannot expect residents to refer to graphs on their computer every time they make a resource use decision. By integrating ambient and artistic feedback into the home, we can increase awareness of resource flows subtly and beautifully.

## 2 CONTEXT

Our work in this area has grown out of two high-profile sustainable housing projects. The first, North House, is a net-zero home that placed 4<sup>th</sup> at the U.S. Department of Energy Solar Decathlon 2009, an international competition to design and build the most energy efficient solar-powered home. We designed and built the Aware Living Interface System (ALIS), an interactive visualization, control and social networking system to support informed energy and water use choices in North House. It includes embedded displays with both passive and interactive modes, web-accessible tools, mobile visualizations, and ambient



Figure 1. Clockwise from top-left: The *Power-Aware Cord* glows and pulses as electricity passes through it [4]. *The Ténéré* depicts a tree that dynamically changes to indicate power use [8]. *7000 Oaks and Counting* conveys carbon footprint as a kaleidoscopic artistic visualization, with trees mapped to low consumption and electronics to high [5]. *Nuage Vert* visualizes the energy consumption of a region of Helsinki. Decreased demand leads to a larger ‘green’ cloud projected onto the emissions of the local power plant [3].

informative art.

West House, our second and current project, is a small footprint sustainable laneway home developed in partnership with the City of Vancouver and displayed at the Vancouver 2010 Olympic Winter Games. The second implementation of ALIS for West House includes new prototypes in informative art and ambient displays informed by our experiences with North House.

## 3 RELATED WORK

Significant research has been done to understand ambient and artistic approaches to information visualization. Pousman and Stasko state that ambient information systems “display information that is important but not critical; can move from the periphery to the focus of attention and back again; focus on the tangible (representations in the environment); provide subtle changes to reflect updates in information (should not be distracting); and are aesthetically pleasing and environmentally appropriate [11].” Ambient approaches make up one facet of *Casual InfoVis*: “the use of computer mediated tools to depict personally meaningful information in visual ways that support everyday users in both everyday work and non-work situations [12].” Pousman et. al. draw attention to the potential *Casual InfoVis* represents for users outside of the traditional InfoVis paradigm, allowing practitioners to “develop for [the] idiosyncratic, private [...], and delicate nature of people’s lives outside of focused episodes of work [12].”

Examples include Miller and Stasko’s InfoCanvas, which artistically conveys peripheral personal information in order to

\* e-mail: jgr3@sfu.ca

† e-mail: lyn@sfu.ca

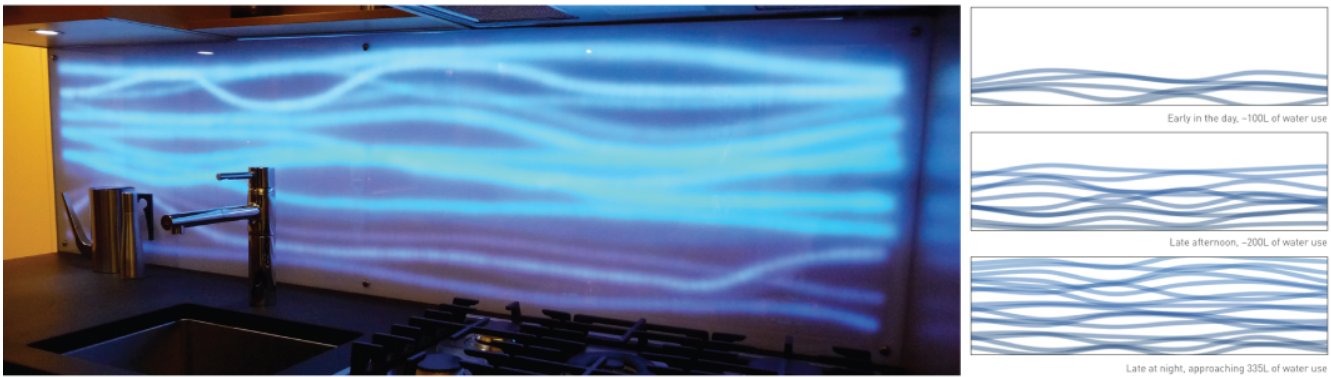


Figure 2. The Ambient Canvas is an ambient artistic visualization, pictured here embedded in the kitchen backsplash in West House. The canvas conveys relative levels of resource use in the home, as compared to past averages. As shown at right, one mode of display visualizes water use over time. Using the metaphor of a volume filling with water, the LED strings are lit and ‘fill’ the canvas over the course of the day as residents use water.

reduce information overload [10], and Skog et. al.’s informative artworks [7][13]. Skog et. al. highlight the importance of balancing aesthetic appeal and practical usefulness when applying these techniques. Along with Pousman et. al. [12], they note that traditional methods of evaluating the effectiveness of a display — typically considered in a work context — may not be the most important criteria to use when evaluating artistic displays. They argue that aesthetic factors and ‘calmness’ may be just as relevant, as these visualizations will be “lived with rather than used [13].”

We also draw on Kosara’s distinction between artistic and pragmatic visualization. Where pragmatic visualization focuses on enabling the exploration and analysis of data sets, artistic visualizations primarily aim to “communicate a concern, rather than to show data [7].” Artistic displays may not be immediately recognizable as visualizations, and may require a period of learning to read accurately. Holmquist has proposed a framework for evaluating the comprehension of ambient displays over time, progressing from awareness *that* information is being visualized, to understanding *what* is being communicated, to finally comprehending *how* to make sense of that information [6].

#### 4 PROTOTYPES

Existing instances of ambient and artistic feedback on resource use have informed our approach [see Figure 1]. We have explored a variety of concepts in this design space during the development of ALIS, including ambient indicators embedded in smart appliances, informative art applied as thermo-chromatic ink to interior surfaces, digital photo frames displaying dynamic landscapes, and light-based feedback on water use.

Our first major prototype is an embedded display combining artistic and ambient approaches that we call the Ambient Canvas [Figure 2]. Embedded in the kitchen backsplash, the display combines LED lights and a transmission medium (Corian®, acrylic, or glass) for diffusion. Feedback on energy, water, and natural gas use is conveyed through shifting patterns and varying intensities of light. Baselines of resource use are gathered from logged system data in order to compute averages and convey relative levels of use to residents.

#### 5 EVALUATION

The next step in our research agenda is formal evaluation of these techniques. Anecdotal feedback received during the Solar Decathlon and Olympic Games made it clear that visitors were drawn to the ambient feedback prototypes. Reactions indicated aesthetic appeal and curiosity, but also demonstrated the importance of carefully mapping data to representation to support understanding. For example, during public demonstrations, the

Ambient Canvas in West House was fully lit. In our model, this would indicate a high degree of resource use — something to be avoided! However, visitors remarked on the appearance of this mode, indicating that they enjoyed the look of it when fully lit. This suggests that our model may be backward: visually active states should perhaps be mapped to low resource use in order to encourage conservation. These and many other questions remain to be explored.

We are currently translating the Ambient Canvas to a software emulator environment in order to study how different approaches using this format are perceived by participants. In a lab setting, we will not be able to assess the effectiveness of these approaches in reducing resource use. However, we will be able to assess the visualization’s perceptibility in different conditions, and collect data on participant’s impressions of the prototypes.

In addition to experimental evaluation in the short term, our research agenda includes plans for longitudinal studies. Now at its permanent location, West House provides us with the opportunity to study the effect of these techniques on resource use in the home over time.

#### 6 CONCLUSION

Ambient and artistic visualizations represent a promising approach to the provision of feedback on residential resource use. The examples we have discussed address some of the drawbacks of traditional visualization methods in this domain, enabling cohesive integration with residential spaces and increased aesthetic appeal while supporting informed decision-making. Our ongoing research aims to identify and evaluate successful techniques within this design space and situate them within a larger ecosystem approach to supporting sustainable living.

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