

Towards Designing Persuasive Ambient Visualization

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ABSTRACT

This paper discussed a new contextual phenomenon in current ambient information systems, which can be coined as ‘persuasive visualization’. It investigates a recent evolution of ambient display’s main purpose, from informing people over augmenting awareness towards modifying human behavior through subtle forms of visual persuasion. This analysis is initially based on environmental contexts, from spatial installations towards the more personalized and human behavior-driven realm of ubiquitous and wearable computing. More specifically, several issues involved in designing and evaluating so-called persuasive ambient visualizations are discussed as a potential new research direction. Accordingly, meaningful applications could be developed that are able to augment our awareness and positively modify our behavior as an answer to socially relevant issues.

Keywords

persuasive technology, ambient display, information visualization, wearable computing

INTRODUCTION

The concept of *ambient visualization* or *ambient display* is often defined as a sort of data representation that conveys information in the periphery of attention. According to Mankoff’s [11] evaluation model, an ambient display ideally needs to adhere up to eight different heuristic principles that qualitatively seem to closely relate to a well-defined design rationale founded in functionalism, effectiveness and aesthetics. An ambient display is different from classic data visualization in that it can be quite *ambiguous*, in so far that it “must be incomprehensible”, although “it may not be immediately understandable” [16]. Accordingly, by including *ambiguity* in its design [4], multiple, potentially competing, interpretations can be created, that provoke intrigue and user engagement [4]. It is clear that ambient display thus aims for a more artistically inclined and emotionally engaging way of data representation, that goes beyond simply ‘informing’ people of specific abstract data patterns.

Instead, ambient display tends to be a calm and non-obtrusive representation that shows non-critical information to only those persons that are interested. Due to this intrinsically informational, non-intrusive but still highly emotional connection, this paper claims that ambient display might be an ideal persuasive technology that could motivate and influence people. From sustainability and health to social relationships and trust, various contemporary social issues currently exist that are directly supported and determined by data and directly aim to induce more positive human behavior and attitudes. As will be shown, several current forms of ambient display already contain *persuasive* characteristics, although are motivated by more informative or artistically motivated purposes.

Therefore, this paper investigates the current evolution of ambient display from relatively large-scale spatial installations over physical computing artifacts, towards the realm of ubiquitous and wearable computing. More specifically, it discusses the need for a different design considerations in what could be coined as *persuasive visualization*, a potentially new sort of ambient display that aims to modify human behavior by directly augmenting the awareness of people in an engaging way.

SPATIAL AMBIENT VISUALIZATION

Generally, ambient display takes form as a large-scale installation within a spatial, public context, representing dynamically changing, non-critical information such as the actual weather [7], bus schedules [11], and so on. Next to the obvious use of dynamic projections or screens, such displays are often more architecturally inspired and include the stimulation of alternative human senses such as sound (e.g. data sonification, tempo changes), touch (e.g. wind fans, temperature changes) or smell (e.g. odor emitters) [17]. Figure 1 shows two typical spatial ambient display examples, developed and built as part of an undergraduate design studio course at the University of Sydney [14]. Both installations depict different time-varying datasets: on the left, the actual sales at the local coffee shop are depicted as a collection of flowers that relate to the country of origin of the products sold at that moment; on the right, organic-style wallpaper patterns calmly adapt keep a visual history of the real-time networking usage and environmental parameters of four computer labs, while rhythmically changing light bulbs convey the actual waiting time of the printing and plotting devices placed below.

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Figure 1. Spatial ambient display examples [14]. Left: a plant display showing the traditional country flowers in relation to what products people buy in a coffee shop (Designers: Mitchell Page et al.). Right: a wallpaper style display capturing real-time environmental parameters in three computer labs (Designers: Huong Nguyen et al.).

Most spatial ambient displays aim to ‘communicate’ onlookers non-critical but contextually-relevant information. For instance, by looking at the displays, shoppers become more aware of the relative amount of foreign products that are bought, whereas students are informed about the actual occupancy rate, networking speed and sound levels in our computer labs. However, unknown to most onlookers, such displays can have implicit design motivations that aim beyond just providing contextually valid information, and implicitly aim to modify human behavior. For instance, the shopping installation was founded from a concern for more sustainable shopping considerations: by increasing the awareness of foreign products, it was expected that the customers would choose more local products that require less transportation costs and have less environmental impact. Similarly, the wallpaper concept hoped to influence the decision process of students of which computer lab to go to, for instance the one that is the most quiet, least occupied, and has the fastest network. However, these concerns were not clearly translated in the final prototypes, and became diluted due to design concerns about the physical adaptation to their environmental context, the general acceptability by people and a typical desire for originality and artistic value. If human behavior modification would have been the main aim, would these installations have looked differently?

AMBIENT VISUALIZATION ARTEFACTS

A more recent direction in ambient display seems to be focused on producing data-driven *physical artifacts*. Although these objects still follow most ambient display heuristics, they also show close affinities with physical computing, product design and electronic gadgetry. Such designs have only become recently possible due to the appearance of community-driven physical computing platforms, such as Arduino and Processing, that aim to reduce the technical complexity for the enthusiastic interaction designer.



Figure 2. Ambient display artifact examples. Left: an egg shaped USB device that wiggles and moves in reaction to emotions communicated during online chat conversations (Designer: James Kim); Right: a working computer mouse that changes temperature hot/cold depending on the input of textual humans emotions (Designer: Irene Chen).

The most famous ambient visualization artifacts might well be the weather information driven Ambient Orb made by Ambient Devices Inc., or the robotic plant display that conveyed the recycling behavior of people [8]. Figure 2 shows two more explorative examples designed and prototyped by our postgraduate students: on the left, an egg-shaped ambient light device wiggles and rocks as different interpretable motion typologies in direct reaction to the human emotions depicted during online chat conversations; on the right, a working computer mouse becomes hot or cold depending on human emotions detected in textual documents in use on the computer.

These examples show how most ambient display artifacts aim for alternative, especially non-graphical (or non screen- or projection-based) ways of communicating complex information (e.g. human emotions, weather, human habits). These objects can be interpreted as explorations in alternative visualization methods that are inspired by digital, interactive art: they are highly technological, engaging, as well as informative. Real data communication falls into the background. Instead, the dataset becomes a tool, a real-world context and justification for a larger, more imaginative message than just the information alone. Does these displays’ aim for a higher form of reasoning correspond to an according level of awareness? And can such awareness augmentation potentially lead to behavior modification? Would users become more aware of their emotional chatting style, and change accordingly? By deliberately experimenting with human’s cognitive perceptive capabilities through motion, light, temperature or an ‘infotropic language’, these displays expect a close, personal interpretation. The time, effort and joy required to decipher the hidden message seems reminiscent of some techniques used in advertising. So, is ambient display an effective tool to communicate abstract messages in a personal way, potentially inducing possible behavior changes?

WEARABLE / UBIQUITOUS AMBIENT VISUALIZATION

The most recent advances in ambient display seem to target the *ubiquitous / pervasive* paradigm, or the use of computational devices that enhance the experience of everyday life by interfaces that are embedded within the physical environment [5]. Several potential benefits of ubiquitous computing have already been described that demonstrate how technology can support activities and values that are fundamentally different from those that are existing today [3]. Whereas most ubiquitous computing efforts seem to be focused on sensor analysis and context recognition, we propose instead to investigate the externalization / visualization of such information. Accordingly, a natural combination of ambient display and wearable computing can be made, which can be coined as ‘*wearable visualization*’, or the use of wearable computing to visualize information. As will be shown, wearable visualization is highly inspired by the ambient display paradigm and its heuristics principles.

Instead of large-scale installations or small-scale artifacts, wearable visualization focuses on the design of data representations that use small computers which can be continuously worn on the human body. It enables the visual communication of abstract data, either to the wearer herself, or to other people in the wearer’s vicinity. It differs from more common visual applications on mobile devices in that wearables are specifically designed to be unobtrusively integrated within the user’s clothing. By merging visualization with fashion, clothing is then considered as a sort of public display that is meant to ‘signal’ an interpretable meaning [10]. By representing specific information, and thus making people ‘aware’ of aspects that were normally hidden from view, a wearable display potentially can alter the experience of wearer or other people present in her immediate vicinity. Moreover, this awareness augmentation is straightforwardly contextualized on the wearer and her direct environment, and therefore at least theoretically ideal for investigating behavior modification through visualization.

Figure 3 shows two recently accomplished wearable visualizations: on the left, *TeamAwear*, an electronically-enhanced basketball jersey that is capable of displaying publicly available sports data related to the wearer (e.g. fouls, score, time clocks, etc.) [13]; on the right, a fashion-neutral wearable device that slowly creates fabric folds depending on environmental data of the wearer, such as the amount of movements, sounds and social contacts over the time span of a day [15]. Both are examples of experimental visualizations inspired by the ambient display concept: they both attempt to convey information through “subtle changes in form, movement, sound, color, smell, temperature, or light” [17], are based on ‘non-critical’ dynamic data streams, can be observed in the periphery of human attention, are meant for a non-expert audience, and are designed with attention to visual aesthetics. In addition, both projects subtly aim to alter human behavior. The

TeamAwear’s original design hypothesis consisted of providing sufficient information to the players so their in-game offensive and defensive decisions would become more informed, hereby enhancing the whole game play experience. Instead, it were mainly the referees, coaches and audiences that reported the highest impact, and relied their behavior on the information shown. The folding display aim to induce increased social interaction. The display was specifically designed to become understandable over time, only for those people that had extensive exposure to the display, or were personally informed by the wearer about the used data mapping algorithms. Here, the design used ambiguity and aesthetics to ‘encrypt’ the data in time and effort for obvious privacy reasons.

Both projects show a desire for communicating information literally as close as possible to the user. From building facades and spaces to small objects, from mobile devices to electronic fashion, information access seems to be reaching the borders of technology’s miniaturization. At the same time, the used datasets become more personally related, more socially relevant and thus more behavior dependent.



Figure 3. Wearable ambient visualization. Left: a light-emitting basketball jersey showing game-related information (Designer: Mitchell Page, [13]); Right: a wearable folding device conveying activity information (Designer: Monika Hoinkis, [15]).

PERSUASIVE VISUALIZATION

In this information society, people are concerned about the continuous and ubiquitous access of information. Similarly, several socially relevant phenomena are emerging that directly rely on actual data, and aim for positive human behavior modification. Sustainable living, energy conservation, water management, healthy eating, interdisciplinary collaboration, trust, ethics, and knowledge exchange, are only a few obvious examples of contemporary, socially relevant concepts that have foundations in various real-world measurements and data analyses. Imagine being able to (ambiently) represent, the true environmental impact of products, the energy consumption of activities, the health risks of food items, and so on, exactly when relevant human decisions are made. These are just a few simple examples of data that is theoretically widely available, but still hidden for most

common people, especially when they would need them the most. Imagine becoming aware of this information while choosing to buy specific products, eating fast food, taking a shower, choosing the stairs or the elevator. By directly incorporating ambient visualization in the daily activity of people, would decisions become better informed? Would people make decisions differently, or make the identical decisions in a more informed way? How can human behavior modification be objectively assessed?

Background

Several projects already exist that directly or indirectly aim to encourage human behavior modification, and could be classified under “persuasive visualization”. For instance, the original Bus Schedule visualization was evaluated by measuring whether more students were logging off the university computers in tact with the bus schedule after the display was installed [11]. DiMicco et al. [2] conducted a behavioral study to examine how a shared graphical display of individual speaker-participation rates impacted the behavior of a group during a collaboration task. Gyllensward [6] visualized the power consumption of radiators to help people understand and reflect upon their energy usage. Jacobs et al. [9] promoted energy awareness through creative design interventions in public space, increasing awareness and provoking responses and discussion. A short evaluation study of the robotic plant display developed by Holstius et al. [8] showed that an ambient display could influence the recycling habits of students in a positively way. Morris [12] recently developed a social network visualization with sensor and self-reported data, to foster awareness and empowerment of social health. Other researchers at the same company developed a semi-graphical mobile phone application to encourage physical activity [1].

All these examples prove the recent attention to externalize socially relevant information as directly and as close as possible to the user, aiming beyond simply augmenting awareness. The specific designs rationales show a strong desire for user engagement, who is then obliged to reflect and respond, possibly by a positive behavior adaptation.

Design and Evaluation Considerations

The goals and expectations of persuasive visualization require that the current assumptions and heuristics of ambient display need to be reassessed. For instance, the concern about aesthetics should reach beyond the simple adaptation to its environment and the fact whether people enjoy it or not. Instead, persuasive visualization could be assessed on how ‘convincing’, ‘encouraging’ and ‘motivational’ it conveys data, augments awareness or leads to ‘reflection’, ‘responses’ and ‘discussion’. Unfortunately, it still seems unknown how the interplay between increased awareness, human cognition and personal motivation leads to true behavioral change.

New evaluation methods might be required to objectively measure behavioral changes. Traditional long-term

behavior capturing methods include self-monitoring techniques such as diaries and reporting. They either require physically carrying around a diary or the retrospective completion of reports at the end of the day. The effort of carrying around a diary results in a low long-term user compliance. Retrospective reporting is relatively unreliable due to recall bias and cognitive errors. Self-monitoring ultimately might even influence the behavior change itself, either positively or negatively. Traditional surveys, interviews and questionnaires might ultimately reveal the real purpose of the display. Cross-over investigations with control groups might be able to accurately assess whether a display truly induces and maintains behavior change. As novelty and curiosity might easily drive behavioral changes at first, longitudinal studies are required to assess compliance and sustained changed behavior.

Ethical Considerations

Persuasive visualization is different from common ambient visualization in that people have an increased concern to rely and fully trust the information shown. Whereas all visualizations in general should be trustworthy, little harm will follow when an ambient weather diagram or a bus schedule are either based on wrong data, or are correct but miscomprehended by people. Naturally, this ethical concern shifts when people are prepared to modify their personal behavior based on what they understand from the display, for instance by buying specific products, conducting a more sustainable lifestyle or make social contacts. This issue becomes even more apparent for personal data, such as health data, identity information or sports performances. Here, such device can communicate a false message, taking over the control of a person own projected image in the environment.

CONCLUSION

This paper discussed a new contextual phenomenon in current ambient information systems, which can be coined as ‘persuasive visualization’. It identified a recent tendency of ambient displays to become smaller, more personal and literally closer to the intended users. It also showed that some ambient displays aim beyond simply informing people. Instead, visual displays seem to be increasing their relevance, significance and justification by representing socially relevant data. By presenting this information in an engaging, convincing and motivational way, persuasive visualization intends to augment the awareness of people, in order to alter human behavior in a ideally permanently and positive way.

However, what are the design considerations of such persuasive ambient displays? And how can they be accurately evaluated?

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