Factors In Designing Effective Ambient Displays

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ABSTRACT
We introduce guidelines to govern the design process of ambient displays, stressing the importance of involving the user in the process during the initial stages. We suggest that ambient displays should be site-specific. In our framework, the site is used to determine the information which will be displayed, and this information is in turn analyzed via a set of questions in order to guide the design of the display.

Keywords
Ambient display, design theory

INTRODUCTION
Ambient display is a growing part of Human-Computer Interaction. Many different types of displays have been built out of various mediums. A heuristic evaluation technique [3] and a comprehension-based evaluation framework used to judge the success of these displays have been developed [2]. There has also been work concerning design guidelines [1], but it focuses on what properties the results of the process (i.e., the interface) should have. The heuristic evaluation technique [3] outlines abstract principles which should be met in order to have a successful design, but these principles have yet to be connected to the initial stages of the design process. Rather than designing a display, evaluating it, and then redesigning, we propose that it would be useful to link the abstract qualities which the design should possess (e.g., intuitiveness) to site-specific conditions. We put forth a series of questions that can be asked about these conditions in order to guide the process from the very first step. We anticipate that a design produced in this manner will perform more successfully in evaluation. This will serve to work towards a comprehensive methodology which governs the entire design process.

WHAT MAKES A DISPLAY SUCCESSFUL?
Although ambient display seems to be an ideal way to saturate a user's environment with more information while simultaneously keeping the cognitive load on the user low, few resoundingly successful displays have been developed. This seems to be due to the fact that determining *what* information should actually be displayed is difficult. Although many groups stress the importance of involving the user in the design process, this is usually done after important decisions about the display have already been made. Because the success of a display depends on the usefulness and appropriateness of the information, it is essential that the information itself be the driving force behind the design process. Although this might seem to be a fundamental notion, it is often overlooked.

WHY SHOULD INFORMATION GUIDE THE DESIGN PROCESS?
Choosing the information which will be displayed should be the first step of the process, and this step should be done with user participation. Naturally occurring sources of ambient information are in a sense ideally suited for their situation. The sound of rain can only be heard when you are outside, or close to it, because the information is most relevant in those places. This information is not transmitted to people in caves or inner rooms of their homes, as it would be superfluous there. Using this as a cue, we propose that the site of the ambient display should be chosen first, and then the information should be tailored to it. The site itself could be static (e.g., a room) or mobile (e.g., a car), or it could be an abstract situation (e.g., a group of friends) rather than a concrete location. Regardless, the designer should go observe and interact with the users in their environment and see what sort of information would be suitable for display. By watching the natural patterns of the user interacting with their environment it will hopefully become clear what kinds of information the user could absorb peripherally. The ambient display should fill a need, however subtle, rather than attempt to generate a new one if the goal is to reduce cognitive load on the user. If the information is extraneous the user will be more inclined to ignore it altogether.

HOW DOES INFORMATION GUIDE THE DESIGN PROCESS?
Once the information is chosen, its characteristics should then be analyzed. There are several questions which should be asked about the information. Their answers can then be used to make decisions about the features of the ambient display.

Is the Information Specific to a Certain Group?
When choosing the site for the information, this will often restrict the intended user base as well. This allows the

designer to exploit certain group specific attributes (e.g., a shared semantic) in order to make comprehension of the display feel more natural.

How Quickly Does the Information Change?

A display which undergoes large changes too rapidly will distract the user, while a display which changes too slowly or too subtly will go completely unnoticed [4]. This means that the rate of information change must be determined and then adapted to the method of display so that the speed and degree of change are at acceptable levels. If the information changes quickly, then the display should be less sensitive, i.e., it should change in small ways. Likewise, if the information is slow to update, then the display should reflect each change in a larger way.

Does Past Information Persist in the Present?

Sometimes the information will only need to reflect a current state, and so the display will be memory-less. Other types of information might be aggregated over time, and so the display must be capable of gracefully merging past states with the present. Usually this would imply that the complexity of the display is increased.

How Does the Ambient Information Relate to Other Information at the Site?

When the information to be displayed is well chosen it should seamlessly integrate with all aspects of the site including the other information which is being transmitted. The display should strive to preserve this property. Thus the display should not target one of the user's senses that is already heavily loaded.

Is the Information Itself Site Specific?

If the information is inherently wed to the location in which it is being displayed it would be wise to exploit this fact. Other studies [4] have shown that user comprehension was greatly increased when the display somehow incorporated actual features of the site and its physical relationship to it.

If so, is the Site Mobile or Static?

If the site is mobile, using site-specific information becomes more challenging and more exciting. It necessitates a more robust way of incorporating context-awareness on the fly. At the same time, it provides a new level of input to help guide the structure of the display.

Is the Site Cohesive or Fragmented?

If the site is actually composed of several smaller sites (static or mobile) the display cannot be perceived all at once. In this way the display taken as a whole is inherently lossy. However, this can be one method of reducing the amount of overall change in the display. If individual pieces change rapidly but the user perceives only a subset of those pieces the display will seem to change more slowly. Furthermore, each piece of the display can be taken as an individual display and re-analyzed with these questions.

Is the Information Already Displayed in Some Way or is it Intangible?

Some types of information are already perceivable (e.g., current weather) but some types are abstract (e.g., stock values). A designer should not try to completely reinvent the wheel when dealing with information that is already in some way tangible. Rather, they should draw on this existing mode of presentation and somehow incorporate it into the design. If a designer tries to force a user to contradict their previous perceptions of a certain kind of information, they will most likely be met with resistance. If, on the other hand, the information is intangible, the designer still does not have free reign on the way to display it. Many basic concepts (e.g., increase/decrease) that are part of the information a designer might want to relate already have some standard modes of display, and these should not be overlooked.

Is the Primary Purpose of the Display to be Aesthetic or Informative?

Sometimes the need which the designer will see as the primary candidate to be filled is mainly an aesthetic one. In this case the need to preserve the quality of the information as much as possible can be relaxed in favor of artistic liberty, although these guidelines should still be considered.

CONCLUSIONS AND FUTURE WORK

These guidelines present a way of approaching the design of ambient displays which is closely tied to user study. By considering the display to be a site-specific item, the design process becomes more manageable. The pitfall of trying to invent the killer-app for ambient display which can result in gross over-generalization can be averted by focusing on the details of the site and the users. This bottom-up approach will hopefully make filling the already established requirements for a good interface easier. We look forward to creating a display through this design process and evaluating it with the aforementioned techniques.

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