Tangible Visualization

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ABSTRACT
In this paper, I propose that visualization should escape the traditional constraint of the screen and embrace the physical environment to realize more tangible interactions for manipulating digital information.

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Visualization, Tangible User Interface

ACM Classification Keywords
H.5.4. Hypertext/Hypermedia: User Issues. H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Human Factor, Design

INTRODUCTION

Information Visualization (Infovis) is the study of the visual representation of complex information, and the use of graphical techniques to help people understand and analyze data. Tangible User Interface (TUI) is the practice that allows a person to interact with digital information through the physical environment. Because of the popularity of visual display technologies and the improvement of computing power, a lot of Infovis research is done on the computer screen. The successful use of graphic elements in Infovis and previous attempts converting fundamental GUI components into the physical space inspire me to ask if we can visualize data in the physical world to accommodate user interactions more naturally while preserving the benefits of being digital? In other words, if we bring digital visualizations to the physical space and manipulate them directly, will it make people rethink the relationship between the representation of digital information and our physical environment?

BACKGROUND

The visualization in my thesis is defined as the formation of a tangible representation of an abstract concept. Therefore, the visualization applications I want to explore are interactive visualizations that exist in our physical environment. They include interactive art installations that show abstract data, interactive tabletop displays that have more interactions than traditional vertical LCD/CRT displays and interactive ambient displays that designed for specific purposes. In fact, when we introduce TUI to Infovis, we also broaden the methods of interactions between human and the digital information, e.g. interactions through tactile, acoustic, or olfactory input and feedback. In my research, I tentatively categorize these applications as **Tangible Visualizations (TanVis)**.

Some of the related research falls in the category of ambient displays, which are devices that improve our ability to multitask. Because people interpret images well (a picture's worth thousand words), visualization has been used to convey low to medium-priority information to people, while residing in the periphery of their attention. The calm technology proposed by Weiser allows people move easily from the periphery of their attention, to the center, and back. Ishii's idea of ambient media uses sound, light, airflow, and water movement for background interfaces with cyberspace at the periphery of human perception. He thinks ambient media enables users to be aware of background bits in a space.

EXAMPLES

The Tangible Tracking Table [2] combining the effectiveness of digital displays and advantages of interactive surfaces realizes my vision of TanVis inherently. An installation that visualized the energy consumption of a skyscraper by Ullmer et al. [4] introduced visualization in another form. This particular visualization designed for specific tasks allows users to read information without using a traditional computer interface. Tangible Menus and Interaction Trays are Ullmer et al.'s [3] attempts to manipulate digital data without needing to switch to a GUI. The modular hardware architecture allows implementing a variety of tangible and embedded interfaces.

The Weather Lamp is my attempt to explore how a tangible ambient display with lifelike quality can be used to convey complicated information through an everyday object. It uses modularization to show multivariate data. Also, it uses color, shape, sound and animation to convey the most information to users with a single glance. It is a lamp that changes its shape according to the data and changes the way it represents data by physically manipulating it. The design goals of the Weather Lamp include:

Abstract: I want to present weather data in a form (based on color, size or shape) that is not numerical but relates to the value of specific data.

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Non-intrusive: I want to present data in the background that does not require frequent attention of the existence of this display.

Aesthetic: This display will be part of a living environment, rather than sitting in a laboratory. It has to be aesthetically pleasing to fit into our living space.

Public and Isotropic: This display intends to be part of a living space. Ideally, users should get all information within a glance. Its cylindrical shape will show the same information to users viewing from all possible directions.

Tangible: Unlike most ambient displays that demonstrate data from some information space to the user unidirectionally, I want the Weather Lamp to have an interactive surface that accepts tactile inputs as well.

Modular: Most ambient displays are standalone devices with no communication capability to talk with their kinds. I want the Weather Lamp to be modular so that it can be assembled to express multivariate data.

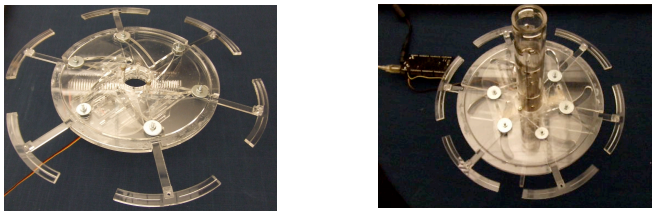

Figure 1. The left figure shows the Tangible Visualization Module (TVM) of the Weather Lamp. The right figure is the Weather Lamp with one module installed. A finished Weather Lamp will have three TVMs.

The Weather Lamp contains three Tangible Visualization Modules (TVMs) that each of them uses a servo motor to change the module's size and an RGB LED to control the light. The module is controlled by a wiring board connected to the Internet. The module changes its color and shape according to the data retrieved from the Internet. It also accepts tangible input when the user squeezes the disc. Several input types were discussed in the brainstorming session in the lab's meeting. Yet, I believe, more interaction models will be discovered in the future user evaluation.

There are some common properties within TanVis and the related work of ambient displays. The data represented is non-critical or casual and the design is aesthetic and environment appropriate. They use not only visual displays but also ambient media such as shadow, sound or air flow. Moreover, some TanVis applications are designed for a specific task and deliver limited information. Therefore, combining several modularized devices expands the number of information channels.

EVALUATION

To examine TanVis applications, related evaluations on ambient displays point toward a direction we can start with. Mankoff et al.'s [1] heuristics for ambient displays adopt five of Nielson's original heuristics with seven new heuristics for ambient displays. These heuristics help uncover major design problems based on the knowledge of the experts. An in situ study will give us more feedback about the application in a real world situation. The in situ evaluation can be either a task-oriented study that guides subjects through the function of the application or an exploration without given tasks. The advantage of case studies is that they reflect users in their natural environment doing real tasks, showing real world feasibility. The disadvantage is that they are time consuming, and not all results can be replicable and generalizable.

SUMMARY

TanVis applications should convey information in a way that satisfies simplicity, aesthetics, and interactions.

Some fundamental Infovis tasks can be solved naturally using tangible design, e.g. a user can simply change her position to see the overview or different angles of an object. Exploiting basic graphic elements in 2D graphics could improve the data-ink (data-object in TUIs) ratio of TanVis if applied appropriately, since the perception is not only visual but can be tactile and aural. Specifically designed TUIs are not comparable to scientific visualization tools that are designed for general purposes on some tasks. But they work better on specific tasks and are easier to use.

While the ambient media proposed by Ishii focuses on the seamless transition of the user's attention from the foreground to the background. The TanVis emphasizes on the visual representation of data and encourages users to manipulate the object directly. While most ambient visualizations remain bound to the screen, TanVis proposes designers to embody their ideas in the physical space with digital media.

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