MULTI: Multi-User Laser Table Interface

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ABSTRACT
We present a new system, which consists of an interactive table and several interactive wall displays and is designed to be used by a single person as well as collaboratively. A new kind of interaction device, based on laser pointes, affords both local (i.e. pen-based) as well as remote interaction. The research focuses on interaction techniques for this system as well as research on collaborative activities, in particular collaborative design.

Author Keywords
Distributed Display Environments, Laser Pointers, Tangible User Interfaces, Multi-Display Groupware.

ACM Classification Keywords
H.5.2 User Interfaces: Input devices and strategies, Interaction styles. H.5.3 Group and Organization Interfaces: Collaborative computing

INTRODUCTION
Single-Display Groupware aims to foster collaboration among several people located in front of a single screen. The work in this project aims to improve this concept in several dimensions, as many distributed display systems are often not used by a single person alone, but by a group of persons collaborating on a given problem. However, most distributed display systems allow for only one active user at any given time, even if multiple physical screens are available. This leads to the "driver" problem, i.e. that one person controls the content and collaboration of the meeting – usually the person who is most adept in controlling the system. The point is that frequently this person is not the one contributing the most to the collaborative effort.

In previous work we introduced a system, based on laser pointers as input devices [1,2], which allows multiple people to seamlessly work on several screens. Furthermore, observations have shown that collaboration on single displays (be it an interactive table or wall) is often severely limited by screen space and the fact that only a single *interactive* screen is available, where users can actively interact with the data and not just see a visualization. Furthermore, in collaborative meetings, there is always secondary information that is critical to the task, but not represented on the main visual display. Often this information is available in printouts, but this is clearly not a very interactive medium. Another alternative is various kinds other mobile devices, but all of these are essentially single-user devices and are often poor platforms for collaborative activities. Very few researchers have explored the use of multiple displays for collaboration, and practically none of the proposed systems offer multiple *interactive* screens.

A NEW DISTRIBUTED DISPLAY INFRASTRUCTURE
My research group is currently constructing a large distributed display environment, which includes an *interactive* table and three *interactive* walls that are positioned in a semi-circular arrangement around the short side of the table. This setup has been called MULTI (for Multi-User Laser Table Interface), because it can be used simultaneously by multiple users, due to the use of laser pointers as interaction devices. These laser pointers work also as styli to afford pen-based interaction. The system also includes an efficient form of tangible user interface, based on an optical system, again designed to facilitate collaboration. To avoid issues with shadows cast by user's hands etc., all surfaces are back-projection screens and the projectors project onto these surfaces from behind. The hardware construction will be finished early in 2005 and several research projects are lined up to use this system or will build on it.

The research associated with this novel form of distributed display environment will explore user interfaces for this platform. We will investigate how multiple input and output devices can be used together to provide rich interaction. Furthermore, we will investigate how this platform supports collaboration.

One application area that our research will target in particular is easy-to-use systems for conceptual three-dimensional design, e.g. for industrial buildings, parts of a city, mechanical objects or a home. Many commercial software packages target three-dimensional object creation. However, all of them are single-user and targeted towards

the final stages of design. Senior designers have commented "Recent designs are very beautiful due to the [use of a computer] design tool, but they are very poor, far from the *design* ideal." This means that while all details are perfect, the users of current design tools often do not adequately explore the space of all possible design solutions. Our research in this area has progressed to a state where a real evaluation of collaborative three-dimensional design activities is now possible, as the user interfaces have progressed to an appropriate point – i.e. where all meeting participants can actively use the system, regardless of their "computer" skill level (see e.g. [3,4]). We will to integrate these results into the MULTI setup.

Promising Areas for New Interaction Research

The MULTI system is an ideal platform to investigate the continuum between local pointing and remote pointing, as the laser pointers can be used both as a pen (i.e. a local pointing device) as well as a remote pointing device. Remote pointing devices are often a necessity for any larger screen setup, as it is usually difficult to physically reach every part of the screen due to its size. This problem gets only worse if multiple people and/or multiple screens are present. Hence, one area of research focuses on the issue of local and remote pointing in distributed display environments.

Another issue that we will investigate is the space between pointing-based and tangible user interfaces. Humans often point at objects, but sometimes touch them and manipulate them directly. Again, this issue often occurs in distributed display environment, due to the size of the screens.

Finally, as distributed display environments are often used by more than one person, we will investigate how distributed display environments affect collaboration.

Passive Information Display

The multitude of display surfaces in the MULTI system provides a good platform to investigate the use of passive information display in distributed display environments. In particular, the MULTI system provides screen surfaces that cover a larger field-of-view for a user compared to most existing systems. We plan to investigate this issue, as the screens of MULTI provide a large amount of real estate for secondary information. The system is designed so that the table will naturally serve as the focus of the work, while the wall surfaces will be used as secondary information displays, and are usually passive. However, we believe that users should be able to interact with any kind of displayed information, including passive information displays – even if it is only to get a bit more detail on the displayed information. With the laser pointer devices in MULTI, one can easily interact with any other display surface and work temporarily there, which naturally fits this idea. One particularly interesting form of passive information display in this context is a "radar view" which provides an overview over the larger context to help the user place the current focus area. Speaking more generally, we will investigate how the "focus vs. context" issue works in large distributed display environments.

Evaluation

For the evaluation of the issue of local vs. remote pointing, as well as the space between tangible and pointing-based interface we plan to conduct user studies in the tradition of Fitts' law. However, we will also investigate the effect of orientation of the screens relative to the user in these studies. As MULTI can also be used in "single-user" mode, we plan to investigate screen usage and how users work in such a large distributed display environment.

For the collaborative aspects of the system we plan to analyze the activities of the participants in collaborative work, usually in the context of three-dimensional design problems. We will also investigate how distributed display environments affect collaboration, e.g. by asking participants to design artifacts in different conditions (e.g. only table, table and walls, etc.).

Broader Implications to HCI Research

One important issue targeted by this research, is how large distributed display environments, where a large part of the field-of-view for a user is filled by screen surfaces, affect human-computer interfaces. Given that most office environments are still much larger than most computer displays (including most distributed display environments), this spans a whole spectrum of issues in user interface research, starting from basic Fitts' law tasks to display space management towards collaborative activities. Based on this it may be quite instructive to perform comparisons of space usage in current office environments and compare it to space usage in distributed display environments. If this comparison is based on standard HCI models, one can gain interesting insights into the limitations of these models.

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