ResearchWave: An Ambient Visualization for Providing Awareness of Research Activities

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ABSTRACT
The goal of a research institution is, ultimately, to share and disseminate knowledge. Yet the sheer volume of information produced by large institutions makes it challenging to keep track of the vast knowledge within. Information on who knows what is often scattered across multiple sources and media. Expertise tracking systems allow users to search for people who know answers, but do not support serendipitous discovery. To help visitors and researchers alike develop awareness of research activities, we have designed ResearchWave—a large-display ambient visualization, installed in the social spaces of a research institution. ResearchWave represents information on research activities in a lightweight and aesthetically pleasing manner. ResearchWave is based on a "walk up and use" approach: it uses multiple levels of visual encodings to engage people while allowing them to learn more with each novel encounter. In this paper, we report our design process, first prototype and lessons learned from initial user feedback.

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Ambient visualization, activity awareness, case study

ACM Classification Keywords
H.5.2 Information Interfaces and Presentation: Miscellaneous

Introduction
Academic and industrial research institutions produce a huge volume of information in form of technical papers, reports, videos, and other media on a daily basis. This flood of data can make it difficult to discover the breadth of research activities, or to learn how they are related to each other. Yet at these organizations, there can be great opportunities for researchers to learn from each other, and for outsiders to discover how the research applies to their own skills. While on-site employees and researchers might be aware of the work of their immediate colleagues, they might not know of relevant activities of different research divisions. Similarly, outsiders might have a hard time gaining an overview of the scope of research activities. Expertise findings (e.g. [1]) can only get so far: they help answer explicit questions, but cannot help users find connections they do not know to look for. Using the real-world example of Microsoft Corporation, an international organization with a large corporate research division, we explore information visualization as a means to provide activity awareness to a broad audience. Ambient information visualization has been explored as a medium to convey information at a glance in everyday environments [8]. Recently, public institutions such as libraries, art galleries, and corporations have started to make use of large-display visualizations as a means to represent an overview of their activities internally as well as to the public [3, 4, 9, 10]. Inspired by these systems, we developed ResearchWave, a visualization prototype to enhance awareness of research activities within Microsoft Corporation. With ResearchWave we explored solutions for three design challenges: (1) engaging multiple audiences: on-site employees, researchers, and visitors, (2) designing for walk-up-and-use, and (3) making the scope and richness of institutional research activities understandable. Here, we describe our motivation and design process that led to the first prototype of ResearchWave, and discuss how insights from initial user feedback will shape future iterations.

Real-World Scenario & Design Goals
The work of Microsoft's research division (MSR), is broadly applicable to activities across the rest of the company. MSR's output consists in the main of technical papers, which are published in journals and conferences. Presenting research activities on a more informal level might allow them to be more seamlessly integrated into people's everyday agendas. Three different groups in particular would benefit from learning more about MSR's activities.

- *Non-Research employees* at Microsoft may find surprising topics linked to their needs. The core operating systems team, e.g., may not realize that there is research on design implications of responsiveness in user interfaces. They might not think of specifically investigating the user interface group's "show-and-tell" sessions.
- *Visitors* to MSR may only know about the specific research conducted by their hosts. Learning more about the breadth of projects carried out at MSR can help them find possible future interactions with Microsoft.
- *Researchers* at Microsoft know about their own research, but may not be aware of, e.g., research at remote Microsoft branches. Thus, some projects might be repeated

across the company and researchers doing complementary work might miss opportunities for collaboration.

Addressing these three distinct audiences, our goal was to create an information visualization that enhances the social spaces of Microsoft by enabling serendipitous discovery of relevant ideas during breaks or informal meetings and, at the same time, provide a brief overview of research activities happening at MSR. The design of our visualization was particularly oriented toward the following goals:

(A) Engaging User Experience. The visualization should engage our audience by evoking curiosity without, however, being distracting and prevent other use of the space. It should offer casual passers-by a small amount of information about MSR where repeated visits can lead to more insights about MSR's projects and research focuses.

(B) Walk-up-and-use Comprehension. The visualization should be comprehensible without elaborate instructions. Ideally the meaning of visual elements should unfold in front of the viewer, becoming clearer over time.

(C) High Information Capacity. Research activity can be analyzed from very different perspectives, including research topics, projects, people, collaborations, and development over time. Our design should allow us to show many perspectives on the whole dataset and still be meaningful.

(D) Informative without Interaction. While we consider interactive capabilities for future iterations, we first focused on designing a visualization that would be informative without user input to make it suitable to a variety of spaces and technology, and be available to a large audience at the same time.

Related Work

Our project is located at the intersection of research on ambient displays in workspaces and ambient information visualization. Communal displays have been used to improve awareness of activities and interactions within a workplace [2, 5, 13], usually showing structured textual data. Ambient visualizations have been used to display non-critical information (see [8] for examples). These often apply an abstract encoding, assuming that the audience will be trained on the visual mapping of data. Our design is meant to appeal to first-time visitors who do not have a need or desire to learn our encoding. We therefore chose a symbolic visual encoding based both on text and familiar visual elements such as timelines and tag clouds [11].

Several data visualizations have been developed to provide a narrow slice of data across large institutions, e.g., [3, 4, 7]. Our work is inspired by these examples that evoke curiosity and attention of a broad audience; however, it speaks to research, rather than a newspaper [3] or library [4].

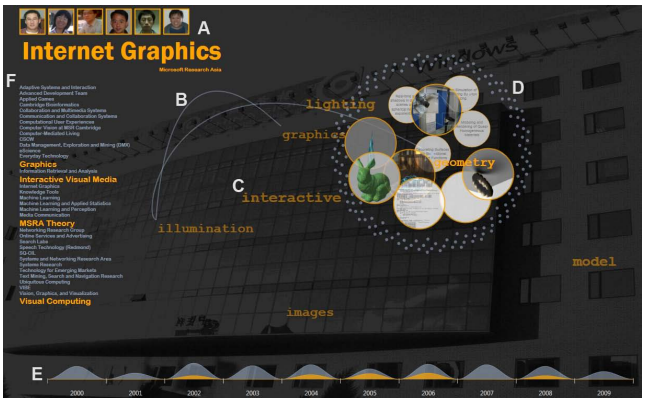

Figure 1. The ResearchWave prototype, showing a research group (A), major keywords (C), and papers on the topic of geometry (D). See text for more description.

ResearchWave

Our process of designing the first prototype of ResearchWave (see Fig. 1) was driven by discussions with members of our three audiences: visitors, employees, and researchers at MSR. We asked them what they would want to know about MSR; what kind of information they would find interesting. We inspired our design process by asking about the metaphors they would use to describe MSR's activities. We particularly found metaphors of "ideas flowing" to be both recurrent and evocative. Based on these discussions, we decided to base ResearchWave on MSR's research publications that represent the breadth of its activities, research topics, and temporal development. To reduce the massive amounts of information that can be extracted from publications, the visualization focuses on one research group at a time showing activities along temporal and contextual dimensions before moving on to the next group. Despite this focus, a large amount of information is on display at a time. We use animation to guide the visual exploration and to show contextual relationships within visual elements without providing instructions. On an aesthetic level, the constant movement within the visualization conveys a dynamic look and feel—an impression that can attract people's curiosity.

Identifying a Research Group

The general layout of ResearchWave resembles a poster. The top left corner contains information on the research group in focus, while the rest of the view represents its research activities and collaborations. Each "information cycle" for one particular research group starts with an animation that brings in the title element showing the group's name and pictures of its group members (see Fig. 1(A): the "Internet Graphics" group). It also indicates the group's geographic location through a label and a background picture representing the research building the group is located in.

Conveying the Group's Activity over Time

After the title element has faded in, a keyword cloud gradually develops as the center part of the visualization (see Fig. 1(C): research topics of the Internet Graphics group). The keyword cloud is based on a ranked list of keywords generated for each group from all its publications over the past ten years. A blue ray (see Fig. 1(B)) swirls across the screen, revealing keywords one by one. By focusing on each keyword one by one, the ray helps to guide the viewer's eye from keyword to keyword and, at the same time, conveys a dynamic look and feel to the visualization. Keywords are ranked based on their number of occurrences in the group's articles, reflected by font size and the order of appearance.

Figure 2. ResearchWave prototype installed in an MSR common area.

The most recent keyword is vividly colored while previous ones fade into background. The spatial arrangement of keywords is based on contextual similarity. Keywords that appear in the same publication are drawn more closely to each other using a force directed graph algorithm [6]. The keyword cloud provides an evolving overview of the group's major research themes.

Publications. With each keyword brought up in the keyword cloud, a paper cluster appears showing a visual representation of all publications of MSR that have been published under this particular keyword (see Fig. 1(D)). Publications by the research group in focus are represented through circles with an orange outline showing images extracted from the publication or the publication title. The circles are spatially organized in a phyllotactic pattern which allows for a compact placement of large amounts of visual elements in an aesthetically pleasing way [12]. Publications from other MSR groups appear as small blue dots on the periphery of the paper cluster. In this way, the involvement of the group in focus in a topic becomes visible compared to other research groups at MSR. Fig. 1(D) shows that the Internet Graphics group has produced more than ten papers on the topic "geometry" while other MSR groups (blue dots) have published even more on this topic. The color scheme used for the paper cluster (orange for the highlighted, blue for all other research groups) is consistent throughout all visual elements of ResearchWave.

Temporal Development. The timeline located in lower part of the visualization shows how research activity on particular topics has evolved in the past ten years (see Fig. 1(E): temporal use of the term "geometry" in publications by Internet Graphics (orange) and other MSR groups (blue)). Fading in after the according keyword and associated paper cluster have appeared, the timeline is based on a variation of a stacked bar chart. It represents the number of publications of the highlighted group (orange) against publications throughout MSR. The smooth curve (instead of standard bars) continues the organic theme.

Conveying Collaboration. An important aspect of any MSR group is its collaboration with other groups which is represented by the group list element (see Fig. 1(F)). The group list appears with the timeline, presenting the names of all research groups that have published on the highlighted keyword. Groups shown in a larger, bright orange font have directly collaborated with the group in focus through publication. All other groups that have published on the keyword but not collaborated with the highlighted group are listed in blue. Fig. 1(F) shows that the "Graphics" and "Interactive Visual Media" group have collaborated with the Internet Graphics group on publications on "geometry"; other groups (blue) have also published on this keyword but not collaborated with Internet Graphics.

Providing an Overview. After the complete keyword cloud has been revealed, all keywords are highlighted once again with the timeline representing all publications on these keywords. The system then moves on to show activity on the next research group.

Information on Demand. ResearchWave allows people to take home information of interest. As the visualization cycles through research groups, employees can "swipe" their badges using a device close to the visualization screen. ResearchWave sends a screenshot of all information on the research group currently on display to the employee's email address, including links to the group's website and papers.

User Experience

We installed the ResearchWave prototype on a large display in two social spaces of MSR: a kitchen area and the MSR building's atrium (see Fig. 2) to gather preliminary feedback on this first iteration. We tracked all badge swipes on ResearchWave and sent a brief survey to employees associated with these badges asking for their comments on ResearchWave. During the deployment, many people walked up to the display and lingered for time periods ranging from a few seconds to several minutes. In addition to this *in-situ* feedback, we conducted five focus groups where we asked participants to discuss and interpret the content represented by ResearchWave without previous instructions on visual encodings. We coded the discussion amongst participants for the correct recognition of visualization elements, aspects that caused confusion, and insights they gathered from the visualization. Each focus groups consisted of three participants; both senior and junior/visiting researchers participated.

Results

Most in-situ users and focus group participants quickly understood that the visualization showed the activity of a given research group based on publications, and remarked on the attractive appearance of the interface. Focus group participants identified the meaning of both the timeline and the keyword cloud, and used the animation to identify relations between visual elements. Participants also worked out some of the subtler elements: several noticed that the appearance of a new keyword in the keyword cloud was linked to changes in the timeline, which helped them to understand that the information in the timeline directly related to the most recent keyword. Participants focused on familiar information in

the visualization to decode the meaning of visual elements. The representation of collaboration (the group list element) caused more difficulties to decode: the color coordination between different groups was too subtle. In future iterations, it may be useful to indicate collaborating groups by placing their representation in proximity to each other.

Several in-situ users commented on the usefulness of the visualization. One replied, "*I get down there [to the atrium] to get a coffee, and, here it is, I just swipe to get the information and web links on this group. Getting the same thing on the [Microsoft] website takes far more time*". Both in-situ users and focus group participants in general were taken by the idea of showing a visualization of research activity within the social spaces of MSR. Several participants were impressed by the number of MSR groups, the amount of publications on certain topics, and research topics of particular groups.

Both in-situ users and focus group participants criticized the lack of control over the information shown on the display, and expressed the desire to actively select the research group in focus. They were especially interested to see their own group in the ResearchWave representation. Users also wanted to explore information in more detail via direct touch. This shows that the ResearchWave prototype triggers a lot of interest and even motivates interaction. We will follow up on these comments by exploring combinations of an automatic information display to trigger the interest of people, with interactive features that enable information on demand without turning the visualization in a large "single user" display.

Discussion & Conclusions

We have presented ResearchWave—a visualization aimed to provide information on research activity for different audiences within a large research organization. Past research on ambient visualization systems has largely required users to be trained in the visual encoding. ResearchWave allows users to become familiar with the encoding rapidly by looking at nearly-familiar data: information about topics they understand. This and the timed animation of visual elements allowed them to rapidly interpret more of the interface.

Preliminary feedback from our potential audience shows that the general idea and approach of ResearchWave is promising. The visualization and its content triggered considerable interest (Design Goal (A)). Designing for walk-up-and-use comprehension (Goal (B)) was successful with some visualization elements, in particular due to the use of animation. There are opportunities to improve the system in future prototypes and experiments. In addition to animation timing, contextual relations between visualization elements need to be made more clear, e.g., through their position or visual elements such as arcs to indicate collaboration. Despite of these, our idea to show different perspectives on research activities from a group perspective found approval among our audience (Goal (C)). People were able to interpret the visualization in meaningful ways and to relate information to their own activities (Goal (D)). In future iterations we will explore the use of interactive features to provide people with some control over the content shown by the visualization.

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REFERENCES

1. M. S. Ackerman and T. W. Malone. Answer garden: a tool for growing organizational memory. In *Proc. of the ACM SIGOIS and IEEE CS TC-OA conference on Office information systems*, pages 31–39, 1990.
2. A. Grasso, M. Muehlenbrock, F. Roulland, and D. Snowdon. *Public and Situated Displays: Social and Interactional Aspects of Shared Display Technologies*, chapter 11: Supporting communities of practice with large screen displays, pages 261–282. Springer, 2003.
3. M. Hansen and B. Rubin. Movable type. http://www.earstudio.com/projects-/moveable_type.html, 2007.
4. G. Legrady. Making visible the invisible. http://www.mat.ucsb.edu/ g.legrady/glWeb/Projects-/spl/spl.html, 2005.
5. J. F. McCarthy. *Public and Situated Displays: Social and Interactional Aspects of Shared Display Technologies*, chapter 12: Promoting a sense of community with ubiquitous peripheral displays, pages 283–308. Springer, 2003.
6. L. Nachmanson, G. Robertson, and B. Lee. Drawing graphs with glee. Technical Report MSR-TR-2007-72, Microsoft Research, 2007.
7. Z. Pousman, H. Rouzati, and J. Stasko. Imprint, a community visualization of printer data: Designing for open-ended engagement on sustainability. In *Proc. of CSCW*, pages 13–16, 2008.
8. Z. Pousman and J. Stasko. A taxonomy of ambient information systems: Four patterns of design. In *Proc. of AVI*, pages 67–74, 2006.
9. J. Stasko, T. Miller, and Z. Pousman. Personalized information awareness through information art. In *Proc. of UbiComp*, pages 18–35, 2004.
10. F. Viégas, E. Perry, E. Howe, and J. Donath. Artifacts of the presence era: Using information visualization to create an evocative souvenir. In *Proc. Of the Symp. On Information Visualization*, pages 105–111, 2004.
11. F. Viégas and M. Wattenberg. Tag clouds and the case for vernacular visualization. *ACM Interactions*, 15(4):49–52, 2008.
12. H. Vogel. A better way to construct the sunflower head. *Mathematical Biosciences*, 44(3–4):179–189, 1979.
13. C. Wisneski, H. Ishii, A. Dahley, M. Grobet, S. Brave, B. Ulmer, and P. Yarin. Ambient displays: Turning architectural space into an interface between people and information. In *Proc. of CoBuild*, pages 22–32, 1998.