Pervasive Displays 2013

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Low-cost public displays are growing in popularity, appearing in our workplaces, in public spaces, and on university campuses. However, due to their pervasiveness, they present many challenges: How do people encounter public displays? What are the key usability and design factors when creating and deploying applications for such displays? How do local communities adopt pervasive displays, and what is the effect of such displays?

Such questions were the focus of the Second International Symposium on Pervasive Displays (PerDis 13), chaired by Roy Want and Bill Schilit, took place in June 2013 at the Google Campus in Mountain View, California. The ACM-affiliated event brought together researchers from both academia and industry interested in the opportunities and challenges of pervasive display systems. For three days, leading researchers from around the world discussed how pervasive displays might be designed, implemented, and used in the future. The symposium program, chaired by Timo Ojala, comprised a paper, poster, and video track showing a variety of research results and works in progress and combining the fields of computer science, electrical engineering, design, and applied arts.

KEYNOTE: PROXEMIC INTERACTIONS

To kick start the symposium, Saul Greenberg presented an inspiring opening keynote on proxemic interactions (see Figure 1). Greenberg gave a brief history of the challenges that arise with interactive ubiquitous computing environments, arguing that the degrees of freedom for interacting with ubicomp environments are greatly increased compared to 2D GUIs.

Moreover, social context becomes central in this interaction. Greenberg presented the notion of proxemics, a well-known concept in social science that studies how the distance between people affects their interaction. He outlined the dimensions for proxemic interactions (distance, movement, location, orientation, and identity) and concluded that these dimensions are fundamental for designing display interaction in a public space.[1]

TECHNICAL PAPER SESSIONS

At the symposium, the technical paper sessions comprised 24 papers and three videos, covering many types of displays—from handheld devices to building-scale projection—and their use in various contexts, such as homes, cars, and public space (see https://dl.acm.org/citation.cfm?id=2491568). The papers were

Figure 1. Saul Greenberg giving his keynote at the Second International Symposium on Pervasive Displays (PerDis 13).
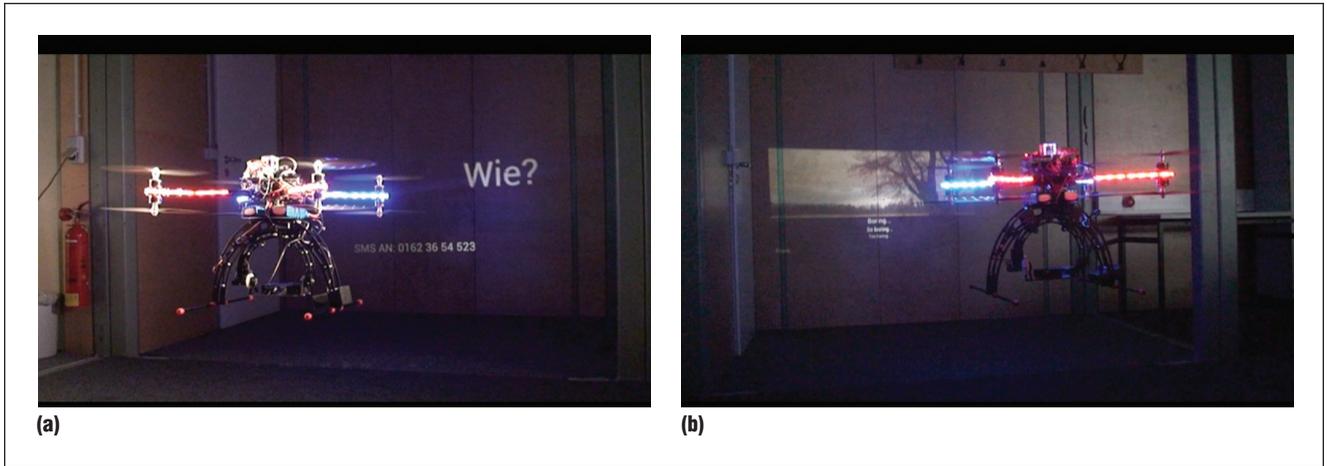
Figure 2. DisplayDrone—projecting user defined content onto arbitrary surfaces.

organized into the following six sessions.

Proxemic Interaction

Following the keynote, Jakub Dostal and his colleagues presented the use of proxemics in a variety of spaces, letting multiple people simultaneously perceive different content. In the next presentation, Marko Jurmu described an observational study for a prototype, which investigated the adoption and user experience of a multipurpose and multimodal public display. Jurmu and his coauthors found that performing mid-air gestural commands accurately is challenging.

Florian Alt and his colleagues presented a prototype designed to investigate the cognitive effects of public display applications and how these effects depend on the situation in which the display is used and whether the display is using interactive or static content. They used an interactive soap bubble application and found that interactivity increases recall and recognition as well as user awareness of the content.

Rainer Wasinger and colleagues presented their Cruiser Ribbon prototype—a wall content-management system that they used to investigate how to demonstrate that a public display is,

in fact, interactive. They argued that interactive public displays must entice users to engage with the display by demonstrating proper interaction.

Applications

Developing applications for networked public displays is still challenging. Sarah Clinch and her colleagues presented Yarely, a software player for pervasive display networks, designed to support media (images, Web, sound, and so on) in an open, extensible, and resilient manner. Their case study uses more than 30 displays to demonstrate robustness and scalability.

Simo Hosio argued that displays will be multipurpose in the future, making service discoverability an issue with public displays. He presented a study measuring "serious" service use and found that high discoverability doesn't necessarily lead to people using the service. He posited that we must further research how different discoverability levels affect service usage in public displays.

Haeyong Chung and colleagues presented a comparison between two display models for collaborative sensemaking. They found that transparency in information, such as intuitive sharing of content, lets people focus on information rather than interaction. Björn

Hartmann and colleagues introduced HydraScope to solve the issues that arise when modern applications are split between multiple displays (such as in a TV control room). HydraScope lets developers adapt existing applications to run on multisurface environments without accessing the source code.

At the end of the session, Roberto Calderon and his colleagues presented the Really Easy Displays Framework, which lets developers create, publish, and maintain multidisplay applications in a simple way. The framework leverages Web technology (HTML, CSS, and Javascript) to allow fast prototyping of walk-up interactive applications.

Projection and 3D

The Projection and 3D session showed a variety of different display technologies containing projection-based drones, 3D displays, and LED curtains. Jürgen Scheible and his colleagues presented Displaydrone (see Figure 2), a flying robot that uses a projector to create interactive pervasive public displays. The system lets users project text, images, or videos onto walls and arbitrary objects in physical space.

Nigel Papworth and his colleagues discussed the lessons learned when a client approached them to make a small trailer for a weather station

more aesthetic to raise awareness about city air quality. They used an LED curtain screen and a Kinect sensor to design an interactive game that presented information about air quality.

Nora Broy and her colleagues presented research into using 3D technology to structure information such that it's easy to perceive on car displays. They found that 3D visual comfort zones vary for each person, but this can be overcome using reference objects, so people should be able to define their own comfort zone.

William Falk and Kim Halskov introduced a series of case studies on allowing any object to be turned into a display. They use virtual models of objects and a projector to overlay information onto the objects. They presented design strategies to help designers turn objects into displays.

Kim Halskov presented a video illustrating the use of projector technology to create 3D tabletops with augmented physical objects using projectors. In their example, when a user moved LEGO blocks on a tabletop display, the blocks changed color according to where they were placed and how they were assembled.

Architecture and Space
This session tackled the challenge of public-display placement. Nick Dalton and his colleagues discussed space syntax, an empirical architectural theory used to predict the best location for design artifacts based on human movement through space.

Moritz Behrens and his colleagues presented research into how network screens influence people's behavior, complementary to architectural elements that occur in space. They analyzed the space around displays to identify the interaction spaces, finding that that the surrounding space and its layout play an important role in the interaction.

Jonna Hakkila and her colleagues introduced a case study connecting two remote spaces using public displays, linked together with a continuous video. They investigated different types of privacy-aware occluding mechanisms for the video feeds and concluded that a symmetric occlusion of the video connection was perceived as the most comfortable and acceptable by their users.

Claude Fortin and his colleagues presented initial discussions about a framework for designing cross-modal interaction with public displays. At the end of the session, Fortin showed a video showcasing some of the technologies used at The Quartier des

> **The GPS Lens uses mobile phone orientation and GPS to turn a mobile device into a wand for remote interaction with building-sized displays.**

Spectacles, an entertainment district in Montreal, and discussed public and developer perceptions of the interactive applications.

Mobile Interaction
One of the most pervasively used displays is the mobile phone. Rui Jose and his colleagues discussed three mobile applications: one that lets people check into places to publish content on displays, another that helps users discover and personalize public displays, and a third that helps users create and retrieve classified ads on such displays. They point out eight key processes that shape the interaction.

Mathias Geel and his colleagues presented PresiShare, an application that lets you share and present content from your mobile phone—such as images, documents, and music—using

QR codes. Petri Luojus and his colleagues introduced Wordster, a game developed to investigate collaborative versus competitive gaming using interactive public displays and mobile phones. They found that the single-player mode created an entertaining social setting, but the multiplayer version didn't entice enough users to be successful.

The last presentation, by Sven Gehring and Christian Lander, introduced the GPS Lens, an application that uses mobile phone orientation and GPS to turn the mobile device into a wand for remote interaction with building-sized displays. Their initial tests indicate that the system is fairly accurate.

Users and Communities
Displays in public spaces have many different users and communities. Niels Wouters and his colleagues presented OpenWindow, a public display only depending on user-generated content, arguing that companies and governments control most of today's content creation. They studied participative content control and found that although people were creative when producing content, they still lost interest in the system, suggesting that content should be both socially and location relevant.

Nemanja Memarovic and his colleagues investigated the implications of limiting access for posting or viewing content in a public display system. They found that tethered content is not only a barrier for inappropriate content but also for lower development costs and support for current interaction practices (such as touch-based displays). In contrast, free-to-roam content reduces the barrier for participation, enables access to multiple devices, and lets researchers investigate how content flows between these devices.

Sandy Claes and Andrew Vande Moere investigated whether urban visualizations can help promote social

change. Based on graphic visualizations they deployed on street signs across a neighborhood, they presented design principles that can help designers create engaging content of social value to citizens.

For the last presentation, Marc Langheinrich and his colleagues discussed the need for a unified ethics process in public display studies. They argued that many countries don't have an established ethics procedure, so they proposed a framework for researchers to use to fill this gap.

DEMO AND POSTER RECEPTION

A reception was held at the Computer History Museum, linking pervasive computing to its past with room-sized computing machines. It featured eight technology demonstrations and six posters, letting attendees try out interactive surfaces, projecting drones, and other applications for pervasive displays (see Figure 3). The interactivity of these demonstrations encouraged participants to explore each display's functionality and features. The poster exhibits also showed the latest ongoing research and initiated many discussions about new projects and potential collaborations.

INTERACTIVE PUBLIC DISPLAYS: FUTURE RESEARCH

To conclude the symposium, Timo Ojala led a panel discussion with researchers of differing backgrounds. In reviewing the challenges of researching interactive public displays, everyone agreed that the community lacks a language of its own and often must borrow terms meant for other media types. Another relevant point discussed was that merging many services (such as online social networks) and other types of media with interactive content is still an unresolved problem.

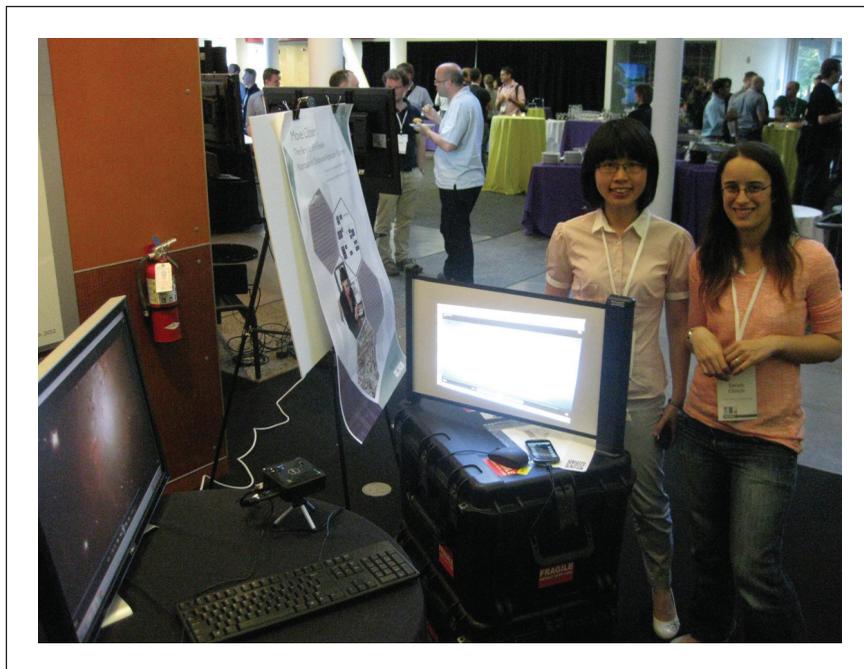The panel also discussed how future research might benefit from the following: identifying some middle

Figure 3. Yu Xiao and Sarah Clinch presenting their work on how public displays can be appropriated for resource-intensive user applications.

ground between the arts and advertising, using public displays to digitally support communities, enabling people to use the technologies presented to communicate with others who have common interests (or who are from the same neighborhood, for example), and finding a way to personalize public displays for particular individuals while still maintaining meaning for passersby.

PerDis 13 offered a forum for discussing a variety of international research into design issues, application frameworks and toolkits, new technologies, and in-the-wild experiments of different types of displays that have become pervasive in public, semipublic, and private spaces. The next iteration of the Pervasive Displays Symposium will take place in Copenhagen, Denmark, and will be hosted by Sebastian Boring. For more information, see www.pervasivedisplays.org/2014. ◘

REFERENCE

1. S. Greenberg et al., "Proxemic Interactions: The New Ubicomp?" *Interactions*, vol. 18, no. 1, 2011, pp. 42–50.

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