Pervasive Displays

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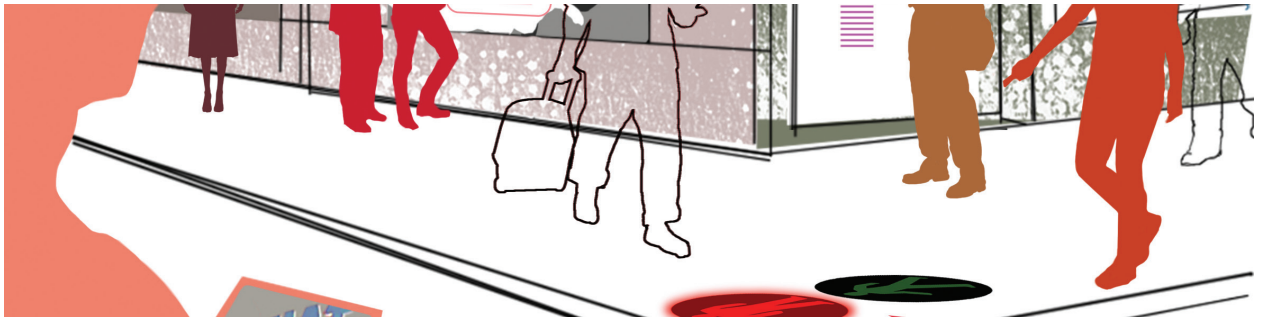
The falling cost of display hardware has led to a proliferation of screens of varying sizes, shapes, and forms in public and semipublic spaces. These displays have traditionally been used as digital signage—providing electronic equivalents of paper advertising and information boards. However, researchers in the field of *pervasive displays* are now exploring how the same hardware can form part of future ubiquitous computing environments. As existing digital signage systems evolve toward more sophisticated pervasive display networks, the introduction of personalized, interactive content on public displays could engage viewers and promote social interaction like never before.

The Nature of Pervasive Displays

Pervasive displays have a number of interesting characteristics as a communications medium.[1]

The first is that they offer *push-based distribution*—viewers don't need to make an active decision to access content on a typical pervasive display. Rather, the content shown is often something that the users wouldn't actively seek out; it's something that others want them to see—advertisements being of course the canonical example. However, this ability to push information to viewers has applications beyond advertisements—for example, in areas such as information dissemination or emergency announcements.

Second, such displays offer *context-specific content*. The fact that displays are physically embedded in the world means that the content they show can (and indeed should) be related to their physical context. This is in contrast to many other communications media in which information is often presented out of context—typically when the user can't actually act on the message.

Another interesting characteristic is the ability to display *multimedia content*. Unlike traditional paper signs, pervasive displays can include a wide range of media types.

Pervasive displays also provide *new opportunities for sharing* among viewers, because the content shown is visible to multiple people in a physical space. This is in contrast to information shown on a personal mobile device, which is often targeted at a single user.

Finally, pervasive displays are *easy*

out by the graphics communities (especially research focused on creating video walls) and the ubiquitous computing community. Indeed, Weiser's original ubiquitous computing vision included large displays ("yard-scale devices") as an integral part of the world he foresaw.[6] In addition to this

advertising content that is broadcast regardless of the current user set, so it's rarely tailored to individuals viewing the display. As a result, viewers tend to assume that the content being shown isn't relevant to them and thus exhibit what is called "display blindness."

For a much more detailed introduction to the research field of pervasive displays, see "Pervasive Displays: Understanding the Future of Digital Signage."[1]

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to update and offer an efficient use of physical space. Traditional signs require a worker to physically visit them to update their content. In contrast, pervasive displays can be updated many times a day, from thousands of miles away, and for a minimal cost. This enables display screen real estate to be shared at a very fine temporal granularity, enabling more efficient use of the potentially valuable physical space occupied by the display.

These characteristics of pervasive displays are enabling the development of entirely new applications for pervasive display networks, such as situated displays that generate their own content[2] and open display networks that can accommodate applications and content from multiple sources.[3]

Related Pervasive Displays Research

Displays have a rich heritage in pervasive computing research. Early work focused on using displays as tools for communication and collaboration—principally driven by interest in computer-supported cooperative work.[4] More recently, researchers have started investigating a much wider range of applications for display networks (for example, as a replacement for a classified notice board).[5] Today's displays research community spans many disciplines. Technical work is often carried

technical work, pervasive displays are also studied in the social sciences, and they attract significant interest from the commercial sector.

Of course, pervasive displays aren't without their shortcomings. Compared to Web-based content, it's difficult to understand how many people actually see any given pervasive display (consequently, supporting business models based on the number of impressions or views a piece of content receives is also difficult). Furthermore, there's no pervasive display equivalent of a user "clicking through" on a piece of content. This makes measuring the effect of pervasive display content by tracking user actions—something trivial on the Web—extremely challenging.

Another difficulty with pervasive displays is encouraging viewers to see and interact with content. Indeed, the creation and distribution of engaging content is key to realizing the potential offered by the installation of digital displays in public spaces. Currently, despite their prevalence, public engagement with digital displays in their environment is typically very low—viewers have become skilled at ignoring them. Research has shown that many passersby look at public displays for less than two seconds.[7] Typical commercial display deployments are dominated by generalized

In This Issue

In this issue, we present five exciting articles that cover a wide range of topics on pervasive display systems. In "A Survey of Pervasive Displays for Information Presentation," Sarah Clinch, Jason Alexander, and Sven Gehring provide a survey of key pieces of research in three different classes of pervasive display systems—traditional displays, urban deployments, and novel display hardware—identifying emerging cross-cutting trends. The article will be of value to researchers starting out in this field or to those looking to understand the synergies between different aspects of the field.

Encouraging user interaction with displays is always challenging, and in "Toward Meaningful Engagement with Pervasive Displays," Simo Hosio, Hannu Kukka, Jorge Goncalves, Vassilis Kostakos, and Timo Ojala build on their extensive experience with a display network in Oulu to consider the challenges in supporting sustained engagement between viewers and pervasive display systems.

Engagement is also the focus of "Developing a Networked Public Display System," by Nemanja Memarovic, Ivan Elhart, and Elisa Rubegni. The authors describe their experiences with a long-term campus deployment.

Specific techniques for user interaction with pervasive displays are explored by Jouni Vepsäläinen, Petri Savolainen, Jouni Ojala, Antonella Di Rienzo, Matti Nelimarkka, Kai Kuikkaniemi, Sasu Tarkoma, and Giulio

Jacucci in "Web-Based Public Screen Gaming: Insights from Deployments." Their work focuses on how mobile devices can be used in conjunction with pervasive displays, and the topic is explored in the context of two week-long deployments of pervasive games. While much pervasive display work has focused on general public spaces, there are also many opportunities in specific niche areas.

In "Pervasive Displays in Classrooms of Children with Severe Autism," Monica Tentori, Lizbeth Escobedo, Carlos Hernandez, Aleksandar Matic, and Gillian R. Hayes explore the use of pervasive displays in an educational setting and report on how the technology can be used to increase behavior awareness and social interactions.

The issue also includes a Spotlight department, "Displays as a Material: A Route to Making Displays More Pervasive," that illustrates how readers can prototype their own next-generation pervasive displays.

The key challenge for designers of future display systems will be to create innovative new systems that deliver real value to passersby. The research presented in this issue showcases some of the challenges—and potential solutions—in making pervasive displays more useful and user-friendly. As new display and sensing technologies become available to better support such innovation, pervasive displays might yet emerge as one of the core components of our future ubiquitous computing infrastructure. ℙ

ACKNOWLEDGMENTS

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