

## Pervasive Displays 2014

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The International Symposium on Pervasive Displays brings together researchers from different disciplines who share an interest in the opportunities and challenges raised by the emergence of pervasive display systems as a new communication medium for public and semipublic spaces. PerDis proved an engaging and exciting conference for this emerging research community. Some symposia and conferences boast about their low acceptance rates as if this were the only metric for evaluating a conference's quality. PerDis doesn't attempt to define its quality by an acceptance rate but rather by the amount of follow-up work the conference enables—the new research avenues that PerDis opens up and the impact felt far beyond the proceedings. PerDis 14, organized by Sebastian Boring and Aaron Quigley (a coauthor here), accepted work that's inspiring and useful for people in the field with an aim to nurture and grow this emerging area (see Figure 1).

This single-track conference started a day early with a boat tour on the Nyhavn Canal. Overall, 30 papers were presented, mixed with video presentations (see [www.pervasedisplays.org/2014/](http://www.pervasedisplays.org/2014/)). Here, we summarize some of the conference highlights.

### KEYNOTE: LARGE-SCALE MEDIA FACADES

The conference started with an evocative keynote by Peter Dalsgaard, an associate professor of interaction

design at Aarhus University. In his talk, Dalsgaard discussed the design of large-scale interactive media facades and the challenges and potential they present. By drawing on his experiences from many projects, such as Aarhus by Light, Climate on the Wall in Aarhus, and the Danish Pavillion at the 2010 World Expo in Shanghai, he described some of the key challenges involved with such large projects. For example, media facades often must be integrated into existing physical environments or

newly built structures, which requires managing potentially heterogeneous stakeholders and existing work practices and schedules.

Due to their highly customized nature, media facades often involve the development of new interfaces and new forms of content for such a medium. Dalsgaard demonstrated that media facades as a form of pervasive displays can engage, inform, educate, and illuminate the public but require developments, deployments, and



Figure 1. The organizers behind PerDis 14: Aaron Quigley (program chair) and Sebastian Boring (general chair).



**Figure 2.** A free-floating midair display concept presented by Jürgen Scheible. (Photo courtesy of Florian Alt; used with permission.)

considerations far beyond a simple user interface design. The keynote helped provide some of the underlying themes for the conference in terms of interactive media facades, artistic deployments, deployment challenges, and engagement opportunities with pervasive displays.

### ART AND AUDIENCE

Large public displays and artistic media facades received additional attention during the first session with Claude Fortin's presentation of *Mégaphone*, a site-specific architectural-scale art installation designed as a digitally augmented "speakers' corner," where people can freely express their opinions and listen to fellow citizens. The installation, or "digital agora," primarily relied on sound input—the speaker's voice—which was amplified and transformed into a building-scale visual experience. The spoken words were separated and individually displayed on a media wall along the side of a building.

According to Fortin and her colleagues, media facades can have important roles in emerging digitally augmented public spaces as self-publishing

tools and social media platforms. During the next day's poster and demo session, Fortin further illuminated what was involved in realizing this platform and showed how it was appropriated over time to augment city life.

In many situations, display installations can augment activities in public spaces, but in some situations, displays can influence and even disrupt usual activities. To measure the impact of display installations and how they can change the way public spaces are used, Julie R. Williamson created an evaluation tool that captures pedestrian traffic using a computer vision technique. Williamson argued that simple metrics such as walking speed and distance can be used to capture the influence of public displays on pedestrian traffic and help evaluate new display installations in a wider context of the surrounding public spaces.

### NOVEL DISPLAYS AND INTERFACES

This session focused on unusual ways of using pervasive displays, covering novel form factors and interaction modalities. Jürgen Scheible started the session by

presenting a free-floating midair display concept, where a small display is attached to a copter drone (see Figure 2). The "anytime, anywhere" display concept avoids the limitations of static displays by allowing information to be brought to the user, potentially for outdoor sports, emergency situations, or guided tours. Scheible noted the challenges involved with midair displays, including dealing with noise, a limited carrying capacity, and restricted flight time of the copter. The interaction modalities also must be reconsidered.

Scheible also reported on a user study of the readability of the midair displays in different conditions—such as whether the display and user are standing or moving. While a moving display didn't significantly decrease performance, a walking user did, leading to the conclusion that the midair display should adapt to the user state (such as standing or moving).

Nora Broy gave a presentation on stereoscopic head-up displays (HUDs) for cars, which can increase safety and comfort by giving driving information in the driver's visual field (see Figure 3). Broy pointed out that the third dimension allows better augmentation of the real world by, for example, showing a navigation arrow directly at the location of the next junction. Broy reported on two user studies: one for exploring the comfort zones for single and multi-depth layer cases, and another for determining the depth judgment accuracy. A single layer allows higher comfort limits than two layers, but introducing a third layer did not significantly decrease the comfort area from the two layers, which is an important design factor. Visual tagging was more precise when the virtual screen distance of the stereoscopic HUD was closer to the physical object distance. Broy proposed a distance of between 5 and 8 meters as the optimal virtual screen distance for cars.

### DISPLAY APPLICATIONS

This session presented different applications for public displays. Insights

into potential applications for public displays was given by Constantin Taivan in his talk about application diversity in open display networks. Taivan made an analogy with the success of today's app stores for mobile phone ecosystems and foresees a similar trend emerging for multipurpose public displays. Taivan and his colleagues categorized 75 mobile applications from the Google Play app store into six categories relevant for public displays. They also defined typical places for installing public displays.

In the study, they asked 72 participants about the relevance of the applications for public displays and particular locations. Situated applications or those that provide general information were seen as the most relevant applications, while the most relevant places for those applications were on public transportation and in bars. Taivan noted that expectations for available applications depend on the particular place. Furthermore, different places can appropriate different amounts of application diversities—for example, the content should be more focused for shop windows than for displays appearing in bars.

A potential limitation of this questionnaire method was discussed during the follow-up questions after the presentation. This was contrasted by the success of many entertainment applications (such as games) in public display deployments, which didn't come out in the questionnaire study. The consensus was that the questionnaire study needs to incorporate real-world application usage data to further understand the potential of different application categories. This is a typical problem in gaining insights from users when such infrastructures and applications aren't yet commonplace and potential uses remain unclear.

## TOOLKITS AND FRAMEWORKS

An encouraging trend at this year's PerDis was the large number of toolkits and frameworks presented. Stefan Schneegass presented SenScreen, a toolkit for simplifying the development



Figure 3. Nora Broy talking about stereoscopic head-up displays (HUD) for cars.

of interactive applications. It supports pluggable adapters for different sensing devices, and a service that collects the sensor inputs and processes them. Different Web clients can request the preprocessed sensor data via a high-level JavaScript API by registering themselves to the server as "listeners." Schneegass also reported a study with two groups of four developers, who developed two Microsoft Kinect controlled games with the help of the toolkit. The results show that the toolkit simplifies the implementation of interactive applications.

Nicholas Gillian also presented a framework related to sensors focused more on sensor fusion and analysis. The "Gestures Everywhere" framework was developed specifically with performance and scalability requirements in mind for writing pervasive systems for an entire building. Fusing is based on radial basis function particle filters, which is then analyzed in real time to detect spatiotemporal properties—for example, presence and location estimation in addition to higher-level information, including social clustering

and gesture recognition. The Gestures Everywhere framework provides a client API implemented in the Open Sound Control network protocol and HTTP/JSON. Gillian reported a deployment of the framework to their pervasive display network called the Glass Infrastructure consisting of over 30 displays. He also demonstrated the system in use. For more information about Gestures Everywhere, see <http://ge.media.mit.edu>.

## DISPLAY DESIGN

In designing large public-display installations, small details, such as the presence and width of interior bezels, could be an important factor to consider. James R. Wallace investigated how these two factors might influence the performance of a simple task of visual search on large, tiled displays. Such displays usually enable researchers to create wall-sized display installations that are highly flexible in terms of size and shape. However, these displays introduce interior bezels.

In a lab study, Wallace and his colleagues discovered that the bezel width





**Figure 4.** The poster and demo session, held at a University coffee shop. (Photo courtesy of Mateusz Mikusz; used with permission.)

doesn't have any significant influence on visual search performance. He suggested that the extra costs associated with thinner bezels might not be necessary for visual search tasks and pointed out the opportunity to use bezels as visual anchors and places for interface elements. As the development and deployment of display systems increases, the study of fine-grain interaction details, such as bezels, remains important to help guide cost-efficient system design.

### CONTENT AND EMOTIONS

Content on public displays was discussed from different perspectives. Christopher Ackad asked a provoking question: "Who cares about the content?" Ackad presented the results of a field study with a public interactive display application that allowed passersby to explore display content using simple gestures. Ackad and his colleagues observed that a large number of passersby were more engaged in playing with the display installation than interacting with the content. They concluded that carefully designed playful interactions might help attract

and engage passersby in front of public displays.

Although content might not be of a high importance for playful interactions, it can help create emotional attachments to public displays. Kobo Lee and her colleagues from Lancaster University experimented with display content and whether photographs that might invoke memories can influence viewers' emotional ties to public displays. In a pre-study questionnaire, Lee found that 96 percent of people had noticed public displays around the campus, but only 19 percent ever actively looked for particular content. However, with an increased number of photographs of memorable events and places displayed on the screens, the researchers were able to evoke viewer memories that in turn resulted in an increased interest in the campus displays. The results showed an increased number of viewers who actively looked at the displays as well as an increased number of emotions evoked, both positive and negative.

### FUTURE DIRECTIONS

The session on future directions closed the conference and was followed by

a brief town hall meeting discussion. Simo Hosio presented a thought-provoking talk about the value proposition of real-world studies and the challenges involved. Hosio argued that public-display researchers should aim to provide benefits to those who own the property or building where the display is located, rather than simply focusing on user benefits. He explained these points using practical experiences, noting that the location owners need to see the benefit of having the displays occupy their space.

Hosio also questioned the overly optimistic vision of always decreasing hardware costs of public displays. Again, he used practical experiences to explain that the initial investment cost is just one piece of the overall cost distribution of the public display deployments and that the public displays still continue to be expensive.

The town hall meeting was initially planned for the pre-conference day but was moved to the end of the conference to attract more attendees. This turned out to be a good choice; most participants stayed for the entire conference. The discussions were led by Sebastian Boring. One topic discussed was whether next year's PerDis should allow demos to be submitted without a paper. This would lower the barrier for submitting demos, which could lead to more submissions, but then the demos wouldn't be included in the conference proceedings. (For this year's proceedings, see <http://dl.acm.org/citation.cfm?id=2611009&picked=prox&cfdid=566936340&cftoken=35326425>.)

### POSTER AND DEMO SESSION


In addition to great presentations and high-quality papers, the conference also had a small poster and demo session, which concluded the first conference day in a cozy corner of a University coffee shop (see Figure 4). It provided a hands-on experience with display software and allowed researchers to discuss interesting topics presented on posters.

During the demo session, Sarah Clinch and Mateusz Mikusz were busy presenting their suite of software components for open pervasive display networks. Clinch and Mikusz demonstrated the possibility of opening currently closed and isolated public displays to present content that can be obtained from a wide range of sources. According to them, one of the key challenges is to provide an appropriate infrastructure that can support multiple management domains and address often conflicting requirements of different stakeholders. They presented a mobile app for fast and easy content creation, which can be easily deployed in the display network; a Web-based application store for content distribution and display management; and a multiplatform media playback software component.

In addition to supporting content management and playback, underlying display software can play an important role in encouraging and supporting interaction between strangers at social places such as coffee shops. Roberto Calderon presented a multidisplay application that supports collaborative interactions using a table-top community garden metaphor. Because the demo venue was a coffee shop, it was a perfect place for Calderon to demonstrate his system and let attendees collaboratively nurture a table-top garden using a smart watch, mobile phones, touch-enabled projections, and interactive furniture.

Stereoscopic 3D interfaces received additional attention during the poster session. After Broy introduced the topic of stereoscopic displays for cars during the main track, and Florian Daiber presented novel interaction techniques for large stereoscopic displays, Ashley Colley presented his poster on exploring gesture-based interaction with stereoscopic displays. Colley used a 3D puzzle game to investigate and compare one- and two-handed interaction with objects in the game. Although you might

expect two-handed interaction to be more fun and easy to use, Colley concluded during a lab study that users prefer one-handed gestures with stereoscopic displays.

**P**erDis 15 will be held June 2015 in Saarbrücken, Germany, at DFKI (the German Research Institute for Artificial Intelligence). Nigel Davies, a steering committee member, had an opportunity to announce Sven Gehring and Antonio Krüger as PerDis 15 conference chairs and Florian Alt and Nick Taylor as program chairs. Gehring assured the audience that Saarbrücken is an inspiring historical place to visit and promised another great conference. 

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