



## PerDis 2017

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The 6th ACM International Symposium on Pervasive Displays (PerDis 2017) took place from 7–9 June in Lugano, Switzerland. PerDis 2017 featured two tutorials, an opening keynote, 21 papers, two posters, five demos, and four videos. The general chair, Marc Langheinrich from the Università della Svizzera Italiana (USI), and the program chair, Sarah Clinch from the University of Manchester, opened the conference by reporting the statistics of PerDis 2017. This year, the conference attracted 34 attendees from 12 different countries.

### TUTORIALS

The two in-depth tutorials were offered on the first day of PerDis 2017.

The first tutorial, “Public Display Analytics,” by Julie Williamson (University of Glasgow), Mateusz Mikusz (Lancaster University, UK), and Ivan Elhart (USI), introduced attendees to the field of digital signage analytics. It included a session about data collection via logs and visual analytics, followed by a hands-on session during which attendees analyzed public display usage data using Jupyter.

The second tutorial, “Urban Information Visualization,” by Florian Alt (LMU Munich) and Jorgos Coenen (KU Leuven) taught attendees about encountering, interpreting, and discussing urban data in the city. The tutorial introduced information visualization before diving into visualizing and interacting with data in public and

urban spaces. Participants were given two datasets and asked to come up with appropriate visualizations for two settings near the conference location.

### KEYNOTE

The opening keynote talk was given by Michael Bronstein, an associate professor of informatics at USI and of applied mathematics at Tel Aviv University, and a principal engineer in the Intel Perceptual Computing group. He started his talk with a brief history of computer vision research, arguing that vision provides the highest bandwidth compared to other modalities. The remainder of Bronstein’s keynote centered on some of the most widely discussed challenges in computer vision, such as face detection. For example, faces appear very differently due to different illumination. He argued that a problem is that we treat 3D objects as 2D illustrations (see Figure 1a). This motivates the need for 3D sensors, and Bronstein showed how 3D sensors can perform better in face recognition and in detecting mid-air gestures.

Bronstein’s own research and startup, Invision, was acquired by Intel in 2011 and contributed to the development of Intel RealSense, a sensor that uses laser projectors and infrared cameras to estimate the geometry of objects in front of it. Bronstein showcased several applications enabled by RealSense that illustrated his vision of an ecosystem that senses 3D objects, stores them in 3D repositories, and then prints them

out using 3D printers. Bronstein also pointed to potential future work that could also be relevant to the PerDis community. For example, multiple RealSense sensors, which are faster, smaller, and cheaper than Kinect, can augment public displays to detect users and enable interaction.

### CONFERENCE SESSIONS

The papers presented at PerDis were split into six sessions. Topics ranged from introducing public display applications, platforms, and frameworks to proposing interaction modalities and understanding the audience behavior, engagement, cognition, and performance.

#### Public Display Applications

The first session was chaired by Florian Alt (LMU Munich) and featured five papers addressing the wide-ranging applications of public displays.

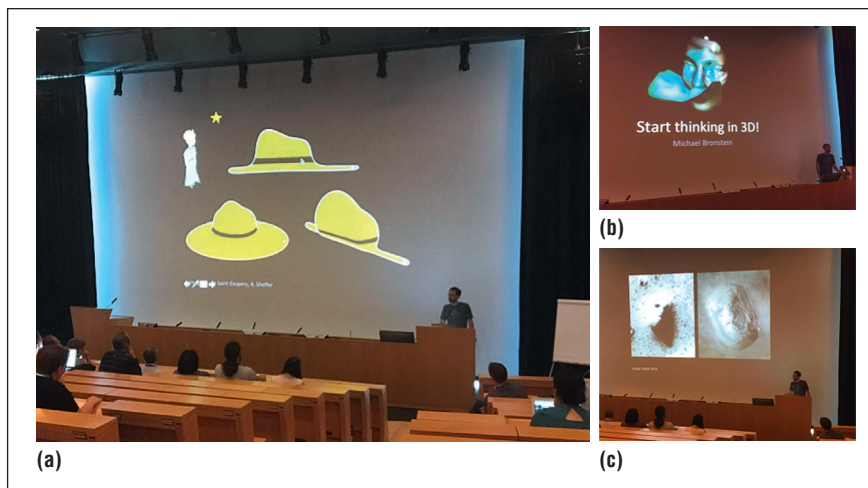
Brygg Ullmer (Louisiana State University) opened the session with an art museum installation, where tangible interfaces with keywords such as “human rights,” “terror,” or “interrogate” could be used to retrieve related news articles. Ullmer reported experiences and insights from multiple deployments. During subsequent audience discussion, Albrecht Schmidt (University of Stuttgart) raised the question of how to avoid the funneling news problem, where users are fed a certain side of the news. Ullmers argued that we should provide users

with an alternative that is compelling enough for them to choose it over the funneled news to which they're currently exposed.

Thomas Marrinan (Argonne National Laboratory) introduced StickySchedule, an interactive multiuser application for conference and event program scheduling on large-scale shared displays. StickySchedule borrows concepts from both online scheduling tools (remote collaborative scheduling) and traditional methods in which the organizers gather in a large physical space. He discussed how StickySchedule's features enabled both collaborative and competitive actions. However, large-scale conference scheduling is often challenging, and some constraints might not be immediately resolved. Christian Kray (University of Münster) asked about the potential for StickySchedule to support invalid states that are intended to be resolved later. For example, assigning a talk to two sessions can be done by putting a sticky note between them. This behavior is not currently supported, and Marrinan argued that it might indeed be unwanted.

Maria Husmann and Daniel Huguenin (ETH Zurich) jointly presented OmniPresent, a system for orchestrating presentations on multiple devices. They argued that the present-day classroom is filled with technologies that can be used to help with content presentation rather than simply being sources of distraction. Addressing concerns raised by Schmidt, Huguenin noted that while OmniPresent increased the burden on presenters, students learn more with more than one screen present at a time.

Afterward, Hiroaki Tobita (Advanced Institute of Industrial Technology, Japan) presented his Ghost-Hack AR telepresence application. His system combines the benefits of static telepresence and mobile telepresence by allowing a transfer from a static to a mobile state. For example, a remote user on a Skype conference call could move from a large display to a mobile telepresence robot to follow the local user as he or she goes out for coffee. In the discussion session, Ullmer wondered if



**Figure 1.** Michael Bronstein gave the keynote talk at PerDis 2017 where he spoke about how 3D sensors can revolutionize the way we address some of the most widely discussed challenges in computer vision research: (a) 2D images are often insufficient. For example, it is hard to tell that the picture denotes a hat from only the topmost image. (b) Bronstein argues that computer vision research should shift attention from 2D images to 3D ones. (c) A photo from Mars led many to believe it shows a face, only because the illumination made the 2D image seem like a human face. (Source: Anton Fedosov and Mateusz Mikusz; photos used with permission.)

Tobita had considered wearable telepresence concepts in which actors would wear a display showing a remote user's video feed. Tobita confirmed that this would be an interesting direction for future investigation.

Jani Väyrynen (University of Lapland, Finland) presented work on exploring the design of stereoscopic 3D for multilevel maps. The work was motivated by the difficulty of navigating multiple floors with the traditional top-down view. Stereoscopic 3D displays were found to result in users performing wayfinding tasks quicker than when using traditional approaches. Audience discussion shed light on directions for future work, such as the exploration of gesture interaction to navigate 3D models, and investigating whether users would perform differently when presented with easier navigation tasks rather than maze-like interfaces.

### Interaction Modalities

The second paper session was chaired by Ivan Elhart (USI) and featured four papers.

Will Walker from the Mobile Experience Lab of MIT opened the session with "Exploring Spatial Meaning with a Tangible Map," which he suggested

should have been titled "The Blood, Sweat, and Tears of Making a Tangible Map." Walker and his colleagues designed and 3D printed a tangible user interface of the MIT campus buildings, which they then installed in the ATLAS Welcome Center. The presentation outlined the triumphs and struggles associated with developing a publicly installed interactive tangible map, including addressing usability issues, securing building structures, and ensuring installation flexibility for an ever-changing campus.

Next, Andrea Nutsi and Michael Koch (Universität der Bundeswehr München) debated the use of sound in multiuser large displays. Their studies included tasks being assigned to multiple users concurrently using a large display, while varying whether or not audio icons were present. When several users were working on different tasks in parallel, sound was found to be a distraction that reduced information perception. However, these disadvantages were found to be smaller in public, multiuser scenarios, with users working together in an exploratory or playful context.

Public displays, such as automated teller machines, function to display



**Figure 2.** Jorgos Coenen (shown here standing between Sarah Clinch and Marc Langheinrich), Sandy Claes, and Andrew Vande Moere received the Best Paper Award for their paper, “The Concurrent Use of Touch and Mid-Air Gestures or Floor Mat Interaction on a Public Display.” (Source: Anton Fedosov and Mateusz Mikusz; photo used with permission.)

and provide personalized content to those who use them. It is evident that these can be vulnerable to different attacks, such as shoulder surfing, thermal attacks, or smudge attacks. One of us (Mohamed Khamis, LMU Munich), along with colleagues, addressed these with the system, GTmoPass, which uses gaze and touch inputs for password entry while requiring possession of a particular mobile device to even be able to attempt entering the password. The researchers conducted a laboratory-based usability and security study, suggesting GTmoPass is a valid method of two-factor authentication.

Assessing public displays is challenging in these laboratory studies. This brings light to “The Concurrent Use of Touch and Mid-Air Gestures or Floor Mat Interaction on a Public Display,” by Jorgos Coenen, Sandy Claes, and Andrew Vande Moere (KU Leuven), which earned the Best Paper Award (see Figure 2). As Coenen explained, they conducted an iteratively designed “in-the-wild” evaluation study at a busy train station in Leuven, Belgium, observing the concurrent use of multiple interaction techniques on a dual-screen display. Notably, the researchers

coined the term *affordance blindness*, which occurs when an interactive display fails to accurately or understandably indicate its supported modalities and intended operation.

### Audience and Performance

Closing the first day of the symposium, Matthias Baldauf (Vienna University of Technology) chaired the third session on audience and performance.

The session opened with Mateusz Mikusz (Lancaster University) presenting a set of design considerations for multistakeholder display analytics based on a comprehensive overview of analytics data captured by different stakeholders in a display network. Langheinrich was interested in the volume of data needed to analyze stakeholder requirements. Mikusz commented that both time scale and volume were important considerations. Rui José (University of Minho, Portugal) also noted the importance of privacy in multistakeholder analytics, particularly given the prevalence of mobile devices and network analysis.

Vito Gentile (University of Palermo) and one of us (Khamis) presented an investigation of how a passive audience can influence users who intend to interact. The investigation found there was an influence in terms of where interacting users position themselves relative to the display and passive audience. Perhaps owing to the privacy concerns raised following the previous talk, attendees asked how users were informed about the recordings taking place during the study. Gentile confirmed that signs were used to communicate study information but admitted that users likely still forgot that they were being recorded.

Finally, Julie Williamson presented her group’s research, “Sunken Ripples,” exploring performative interactions with nonplanar displays. Her group proposed an interactive experience that paired a spherical display with an IMAX screen, where small interactions ripple into huge proportions. The experience from an exhibition highlighted

the success of the audio/visual design and the pleasure of interacting with Sunken Ripples and “making” something through interaction. Coenen was interested in the content they showed on the display—current content was described as “quite abstract,” but future development will provide support for 3D videos content.

### Platforms and Frameworks

Friday’s Platforms and Frameworks session, which exhibited three papers, was chaired by Rui José.

The session was opened with Amir E. Sarabadani Tafreshi (ETH Zurich), who, with colleague Moira C. Norrie, proposed a rapid prototyping tool “ScreenPress” for display owners to customize content on their pervasive display systems. After conducting an analysis of the requirements of a pervasive display system, the researchers developed their platform on top of the WordPress content management system. Tafreshi also noted that the system supports connections with other pieces of content, such as depth cameras, that will allow for interaction.

In contrast to the flat surfaces that are our everyday companion, Patrick Reuter (University Bordeaux) introduced an interactive spherical display to simulate a physical globe. The work Reuter and his colleagues completed required tackling hardware with projections, a 2D-to-3D mapping, and input processing. Their system provides an advantage, because developers can create applications for spherical displays as a classical web application.

Marius Hoggenmueller (LMU Munich) presented a nontraditional display titled P+, which he built for his master thesis at the University of Sydney in Australia. He created an open-sourced test fit generative platform for the design of 3D media facades. The presentation addressed challenges faced during development, including integration into surroundings, aligning stakeholders, developing content to suit the medium, and supporting robustness and stability.

The presented proof-of-concept was a large visual display for the Vivid Sydney exhibition.

### Informing Research

The fifth session was chaired by Nigel Davies (Lancaster University, UK) and featured three papers.

Rui José opened the session with his talk about multipurpose place-based display systems. He presented an analysis of 27 places where non-digital displays were deployed. One important finding was the significant role of external content in place-based communication, implying that supporting low barrier access to external media sources is essential for place-based digital display systems. Schmidt raised the issue of transferability of findings for digital and paper displays—that is, if digital displays are still used in the same way as paper-based displays. José's experiences suggest that the low barrier to entry still gives paper-based displays some superiority over their digital counterparts—deploying and maintaining digital displays can be challenging.

The second talk of this session, by one of us (Guiying Du, University of Münster), presented a survey on the use of public displays for public participation in urban settings. The survey reviewed 36 papers published between 2012 and 2016 that addressed the topic of public participation in urban settings. The majority of the studies were done in developed regions and were inclined to make contributions based on empirical research. Furthermore, most of the displays used in this context were single-purpose displays, and evaluation was usually a challenge. In response to a question from Salvatore Sorace (University of Palermo), Du noted that the majority of the reviewed deployments employed touch interaction.

The session concluded with a talk from Ivan Elhart (USI) about the Audience Monitor, an open source tool for tracking audience mobility in front of pervasive displays. Elhart reported experiences derived in the

design, implementation, and evaluation of Audience Monitor (the authors evaluated their tool over a 52-day deployment). Vito Gentile and Amir Sarabadani Tafreshi raised discussions about handling occlusions. Elhart suggested putting the Kinect device on the ceiling to overcome them.

### Users: Engagement and Cognition

The sixth and final session was chaired by Julie Williamson (University of Glasgow) and included three presentations.

Davies started the session by asking: “When should pervasive displays be powered down?” Although his research team didn't believe the research community was prepared to answer the question, their work provided a lot of insights. Challenging existing practice by considering arguments from the perspectives of multiple stakeholders, Davies and his colleagues have identified multiple facets for consideration, including levels of attention, cognitive load, impact on social interactions, energy, financial costs, and so on. In the subsequent audience discussion, Dieter Michel (*Media Technology and Systems Integration* magazine) wondered if educating children to use public displays properly might help address some of the identified challenges.

One of us (J. Henderson, University of Waterloo) then presented work exploring mechanisms to foster interaction with public displays. Henderson and her colleagues designed a study to explore responses to a user skeleton versus a simple game, comparing their relative efficacy at capturing the attention of those passing by and keeping them engaged. Julie Williamson was curious about whether it was necessary to have the game on public displays. Henderson thought making something playful was effective in fostering interaction with public displays. Both Henderson and Williamson discussed whether there are other methods to foster interaction with public displays.

The final presentation was by Vito Gentile, whose work focused

on investigating how user avatars in touchless interfaces that replay a user's movements affect the perceived cognitive workload. The study results showed that an avatar helped lower the perceived cognitive workload during display interactions. During audience discussion, attendees considered the impact of avatar complexity on performance.

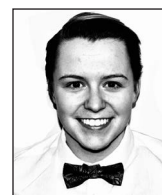
The steering committee members (Schmidt, Davies, and Langheinrich) concluded with an open discussion about PerDis 2017 to gather feedback and ideas. The participants proposed ideas such as trying to involve industry partners and encouraging more tutorials. The participants expressed high satisfaction with the review process.

Next year's general chair, Schmidt, announced that he will be hosting PerDis in June 2018, with Williamson as the program chair. The conference will be hosted at LMU Munich in Germany. ■

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