From Space to Stage: How Interactive Screens Will Change Urban Life

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Framed digital displays will soon give way to walls and facades that creatively motivate individual and group interaction. A stage serves as an apt metaphor to explore the ways in which these ubiquitous screens can transform passive viewing into an involved performance.

In many ways, cities have become utilitarian networks that people traverse on their way to somewhere more interesting. Individuals pass one another with rarely a second look, and billboards or other public displays are usually predictable, rectangular frames that garner only cursory attention.

City venues were not always so uninteresting. Before the digital age, the city was a highly interactive stage on which society played out a variety of creative experiences. European traders invested in elaborate facades to ensure that their houses stood out in an already impressive town square. Great town halls created displays of public life. Each person had a social role, and public venues were the place for all to act their parts, typically by being seen in clothing and accessories that reflected how they wanted others to view them.

With the digital age, much of this stage has become virtual, with the Internet serving as a powerful platform for creative and interactive play. Facebook, YouTube, Twitter, and Flickr have replaced the bustle of a city square. Like their ancestors, modern actors and actresses invest huge amounts of time to enhance their images and foster their community roles. The stage has moved from the town square to the living room and office, and public places have become shadows of their former color—spaces with very little opportunity for self-expression.

Screen technology is promising to return the interactive experience to urban spaces. Economies of scale are enabling any surface to become a display, offering a window to the Internet. No longer are displays limited to the conventional frame shape but can accommodate arbitrary shapes and sizes, walls, and even entire squares and streets.

As a result, surfaces and environments need no longer be passive. With the aid of large-scale automation and ubiquity, pervasive computing can transform urban areas into the most impressive stages the world has yet seen. Through this metamorphosis, city spaces become more lively, and inhabitants become more aware of their community.

THE STAGE IN EVERYDAY LIFE

Creating and shaping these impressive arenas requires first understanding what constitutes a stage. A play usu-

ally takes place inside some kind of magic circle, where performers enact roles using props and interactions to elicit a fictional space. The performance relies on a socially interpretative act, "translating real bodies, words, and movements into the objects of another, hypothetical world."[1]

In a sense, everyday social life is also a play in which people can take one of many roles.[2] In this interpretation, social space can be front stage (what the audience sees) and backstage (what the actors see), and an individual can be both audience and actor. For a salesperson, for example, the salesroom is the front stage, where he performs the specific role of showing customers the products. However, when he enters the storage room—the backstage—he plays a different role. In this play, the salesperson can switch roles and change behavior instantly, and even take on new roles, becoming a husband, father, or another persona once he leaves the job.

This role changing implies that the main power of stages and props stems from their ability to frame situations. If the salesperson changes into shorts, grabs a racket, and moves to a tennis court, his role changes from salesperson to tennis player. Similarly, if a man wearing a police uniform is shouting at another man in rags, the impression is that the other man might have committed some crime. If both men are wearing business attire, the impression might be quite different. Location can also influence impressions, as can spotlight and shadow. Thus, control over the stage implies the ability to control a situation's framing.

Framing is equally important in imaginative play. People readily use local props and media to experience fictional situations, such as those in pervasive games.[3] Performance behavior and playfulness are emerging in various strands of everyday life such as entertainment, advertising, and general social interaction. All these efforts aim to tell a story, evoke emotions, and sometimes even move the audience to some action.

TOWARD UBIQUITOUS SCREENS

Digital signage—the use of digital displays to replace analog signs—is a promising way to augment the everyday stage and make it more flexible and engaging. According to several industry reports, digital signage is already a billion-dollar business, and the markets are expected to grow more than 20 percent annually through 2013. Most of this growth is for signage in public or semipublic spaces.[4]

At present, most digital screens show videos or graphics according to some predetermined schedule, and users cannot manipulate them. However, such passive screens will soon give way to interactive displays such as touch screens, fueling the growth of the interactive public display market at a pace that is expected to exceed that of the market for public noninteractive screens.[4]

Most digital signage installations operate remotely: the screens connect through the Internet to a digital content management system, which operates scheduling and updates videos and graphics. Theoretically, the same system could deliver updates in real time, allowing installations to adapt to their environments.

Currently, LCD and LED technology drive the digital screen market. Alternative technologies, such as electronic ink, are on the horizon. Such novel technologies are expected to provide new design economies as displays become paper-thin, transparent, and flexible. In a decade or so, some researchers expect more advanced technologies such as displays based on carbon nanotubes to replace conventional technologies, pushing the market even more aggressively toward increasingly less expensive and larger installations.

If these projections and expectations even approach reality, a significant part of the wall space in popular public and semipublic spaces will be covered with digital screens. This proliferation will undoubtedly redefine how the space will look as well as how people will use it.

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INTERACTING WITH DISPLAYS

So far, human-computer interaction research has involved primarily scenarios in which a single user interacts with the system through a personal display. Design paradigms and usability factors differ considerably when multiple users access the display simultaneously[5,6] or when people interact with a screen only in passing.[7] Relative to the single-user scenario, these design and usability shifts require the study of many more design aspects and considerations, such as those in Table 1.

Basically, public display interaction paradigms require either *touch interaction*, which can also be a tangible interface, or *distance interaction*, through, for example, a mobile device or camera installed with the display. Public displays most commonly provide information or advertising, but other use cases are certainly possible. For example, people can use the display interface to post photos or just as a way to have fun. Euclide's virtual puppets[8] and Magical Mirrors are evidence of how a display can offer entertainment value.

Table 1. Current and future design challenges for interactive public displays.

Design issue	Considerations
Multiple users	Can social interaction occur through the display or around the display? Does the interaction design and visualization allow simultaneous use?
Implicit interaction	Does the display support implicit interaction based on behavioral cues from video and acoustic features? These are generally difficult because of noise and lighting conditions.
Adaptive screen	Does the display adapt to general conditions (such as weather, time, and events), social dynamics around the display, and person or role identification?
Interaction sessions and life cycle	Does the display support different interaction phases: passing by, viewing and reacting, subtle interaction, direct interaction, repeat interaction, follow-up, and memorabilia?
Screen form and shape	Does the screen's form suit its purpose? Many shapes and form factors are possible, from cylindrical to wall and facade displays, including multiple display orchestration.
Environmental factors	Have developers taken architecture and urban design, lighting, sound, safety, and connectivity into account?
Privacy	Does the system protect the data created in interaction, to avoid exposing identity by managing private and public interfaces?

Interaction perspectives

Researchers view human-display interaction from both the user and system perspectives. From the user perspective, interaction occurs in phases: passing by, viewing and reacting, subtle interaction, direct interaction, multiple interactions, and follow-up actions.[9] From the system perspective, the display has different behavior and thus requires varied interaction techniques, depending on the user-interaction phase.

In the first three phases—passing by, viewing and reacting, and subtle interaction—camera-based techniques can facilitate interaction. With camera-based detection, designers can exploit many natural interfacing techniques, such as pointing, gazing, facial expression, and posture. Most important, such detection enables the screen to recognize that a person is in front of it. Speech and sound recognition can also provide presence information, although the interfacing techniques are more limited.

Camera-based detection might include identification techniques such as face recognition. Mobile phone mechanisms, such as Bluetooth identification, radio frequency identification, and optical markers can also identify

EUCLIDE'S VIRTUAL PUPPETS

Visitors to the Cittá della Scienza science museum in Naples can interact with virtual puppets that entertain while explaining various exhibits, adapting dialog to a particular visitor, such as a child. The Euclide system uses a data glove, standard and MIDI keyboards, and a mouse to operate puppets at five museum stations. The puppeteer at a control system sees what the puppet sees through a camera and microphone at each station and can rapidly switch between stations and choose to interact with passersby.

Pupils interact with the virtual puppet display while a puppeteer controls the puppet using multimodal interfaces at the hidden station.

MAGICAL MIRRORS

In 2006, SAP and the Berlin University of Arts installed Magical Mirrors as a temporary art project in the street-level windows of a Berlin office building. The mirrors were four large public displays that showed a mirror image of the environment in front of them and used optical effects, such as aura, flexibility, and luminescence, to react to audience movement. Users could observe the gesture-based interaction of others or be an audience to their own gesturing image. The degree of interaction depended on age and role. For example, children were highly interactive, playing freely, while policemen tended to avoid interaction.

From left to right: hand motion creates an aura; a flexible band (next two photos); and luminescent numbers (last two photos).

an individual. Identification personalizes the interface, making it a powerful medium for optimizing usability, tailoring a marketing message, and enabling more complex social interaction and communication through a display. For example, a screen might recognize a first-time user and provide feedback that a frequent user wouldn't need. This usability optimization ensures that the screen adapts to each user's background. The first-timer isn't lost and frustrated, and the experienced user doesn't have to wade through unnecessary components and endure redundancy.

There is a delicate balance between personalization and privacy threats, however. Adaptive and sentient displays that can constantly store interaction data pose privacy issues. Anonymizing methods attempt to address these issues. Another approach is to use interaction data only locally and then delete it. Regardless of the method, the displays must put people in control of their screen interaction and any revelation of personal data and provide a way to transparently convey this control.

Environmental variables

An alternative to user identification is to base adaptivity on environmental variables, such as weather, time, traffic, people flow, news, or Web activity. This begs an interesting research question: How do you know when a flow of people is an environmental variable versus a crowd of interacting individuals? Similar to implicit interaction and adaptivity, cameras, sounds, or mobile devices can aid in implementing crowd or large-group interaction. For example, during breaks in Finnish hockey games, simple audio- or camera-based crowd interaction games on large stadium displays engage the spectators and enhance their shared experience (www.uplause.com/what_is_it). In crowd interaction, the public screen cannot provide individual feedback for single users, which significantly limits the possible screen designs. On the other hand, multiple users create a significant amount of social content, so even a simple design can quickly become lively and complex when many people are interacting.[10]

Shape and size

Many people assume that public displays must be framed, which is not surprising since current manufacturing technology limits production to flat, rectangular displays with a physical frame. Like a painting, these displays hang on the wall, except that the viewer has a window to the virtual world. And, similar to a painting, a framed display clearly differentiates the virtual world inside the frame from the real world outside and defines an optimal viewing position some distance from the frame's center.

New display technologies will change all this. Any surface, regardless of its shape, will be a candidate for serving as a frameless display. Freed from its restrictions, screen content will become part of the real world instead of being always virtual.

Between these two extremes are semiframed displays of various shapes. Cylindrical displays, for example, have a frame at the top and bottom, but not at the left and right, which gives them extreme flexibility in the horizontal view and removes the need for a single dominant viewing po-

DIGITAL ADVERTISING COLUMN

The digital advertising column is a cylindrical display that can detect user movements and react accordingly: for example, by drawing flowers in relation to the user's movements. The round shape invites users to stay in motion more than a flat screen.

Furthermore, a flat screen has a single preferred standing position in the center front. Possession of this position identifies a single main user or performer. In contrast, all the positions around a cylindrical display are equal, making it easier for others to join the performance.

A passerby discovers the column and explores it from several positions. Unlike a flat display, all vantage points are equally important. Because it isn't necessary to occupy the center-front position to get the display's full value, more people can join in the viewing.

sition. The digital advertising column is an example of a semiframed display.

WHAT DOES A MEDIA STAGE OFFER?

Clearly, public-display interaction has multiple design dimensions. Interaction modalities and social dynamics, adaptation and personalization, screen layout, and multiple-screen orchestration all influence design. General space variables, such as lighting and sound, safety, and indoor-outdoor considerations are also critical design factors. In a sense, the design of a public digital display is akin to staging a theater play or an art installation, requiring careful attention to visual details. Also, gaining the community's trust and engagement is a delicate matter that often involves public relations work. And deploying a physical public-display installation requires special attention to practicalities from avoiding vandalism to moderating user creativity.

The tradeoff for all this extra work is the amazing potential of a media stage: it can create a social place, increase an event's visibility, foster a collective awareness that can change behavior, and even serve as an outlet for spontaneous creative performances.

Social place

Ubiquitous displays offer a way to transform an urban space into a sociable place. A place is a space with meaning: spaces are merely constructed areas, while places include the practices and cultural understanding of the people in the space.[11] Positioning interactive screens that encourage participation in an urban landscape can make places into spaces that serve as a stage for social interaction.

Configurability is an environment's capacity to become adaptable to different uses and provide varied experiences.[12] Developers can use ubiquitous media technologies to facilitate configurability, creating places that open people's eyes to the unique features of their living space.

Event visibility

Cities are filled with special events, but many go unnoticed. In addition to promoting transformative events such as the Olympic Games, public displays can make even small events more visible, giving the impression of a more lively and social urban life. As people discover that old familiar places have something new to offer and explore, the city can regain its capacity to surprise.

Public displays offer an alternative to receiving event news through a broadcast e-mail or webpage. Instead, users learn about the event through a location familiar to them. Traditional posters serve a similar purpose, but with an interactive digital screen, advertisers can change the message more rapidly and target it more accurately to the intended audience. Ultimately, a digital screen can extend the actual event—for example, with live streaming—or event organizers can design specific remote interfaces for those outside the event to participate in the event and interact as a spectator crowd. An event might even be distributed, using public displays to connect remote locations.

Indeed, the extended event stage is already in practice. All large concerts feature a screen that increases the artist's visibility, and some of the larger events stream a live broad-

CITYWALL, A MEDIA EXPLORATION

CityWall, an experiment we conducted in one of Helsinki's central pedestrian areas, turns a store window into an interactive display. The area is between bus and railway stations and major shopping centers, thus connecting two key locations. It consists of several small shops and cafes and often hosts temporary attractions that attract random groups.

Repurposing an existing architectural element—the store window to an interactive display—is very different from introducing an architectural element into the space as a new construct. CityWall effectively transforms an architectural object into an interaction of space and events. In the window, it is, of course, highly visible, yet it also changes how people use that space. For example, passersby initially grouped around CityWall's shop window to seek shelter from the rain, but then started using the space in front of the display to engage in playful and social media explorations.

Clockwise from left: passersby play with images on the CityWall timeline; the display from a street view; and two users share comments on pictures of Helsinki.

cast to another location. During the 2010 World Cup finals in Netherlands and Spain, massive crowds gathered to participate in an event that took place on the other side of the world. They could have watched the same stream in their homes, but chose instead to join the crowd experience.

At present, such event visibility enhancements involve only massive events and temporary infrastructures, but as permanent public-display infrastructure proliferates, similar arrangements will become feasible for lesser events. The technical setup is not complicated, making it suitable for short events as well. Connecting remote locations to a place of central importance is one basic use case: the action hotspot is the main stage, but public displays can partially reproduce that stage's physical and social presence for people at another location.

Collective awareness and group behavior

People constantly adapt their behavior according to what they see others do and what feedback they receive for their actions. A major goal in this social process is to maintain role consistency—to ensure that actions don't contradict the desired roles, but strengthen them. In the context of this goal, a media stage can support behavioral change in three significant ways. The first is by letting users be the audience, observing how others (their role models) behave so they can change their behavior accordingly.

A media stage can also support behavioral change by providing immediate and continuous feedback about the users' actions. Nuage Vert, or Green Cloud (http://hehe. org2.free.fr/?language=en), is a city-scale display that illuminates the vapor emissions of Helsinki's Salmisaari power plant to show local residents their current electricity consumption level. A laser ray traces the cloud during the night, turning it into a citywide neon sign.

Such persistent feedback on collective behavior can be an efficient way to help communities achieve some common goals, such as cutting energy consumption or riding bicycles instead of driving cars. Feedback is essential to learning how to change behavior, and it is relevant to a range of applications, from safety and security to antisocial behavior prevention. Using public displays as a feedback channel in a city space can transform the way its inhabitants approach responsible living and use the city's resources.

Finally, the media stage can encourage participatory civic discourse and critique,[13] particularly in light of the

increasing reliance on social media platforms to express opinions. For example, by providing a forum for posting pictures about Helsinki, our CityWall experiment effectively uses a media stage as content for public debate. The stage can also serve its conventional purpose, which is to allow creative expression. Spontaneous playful interaction can nurture self-esteem and embolden individuals to be more proactive in other walks of life.

Almost any surface might soon become a digital display, which will transform the appearance of cities, bring the Internet out of homes and offices, and return the center of social life to the public places where it originated. Turning billboards into media stages can benefit both organizations, which have a new influence channel, and individuals, who can present themselves in desired roles.

A challenging open issue is how cities, individuals, and organizations will share influence on the media stage. Many cities have forced organizations to adopt a shared brand appearance, where the organization must adapt its logo to the city's style. It is likely that cities will grant the right to deploy display technology only if they can influence how deployment affects public appearance. Traditionally, cities prescribe only the number of billboards and their location. Digital displays allow much more fine-grained negotiation on what appears on the screen, when, and how. Public and private organizations are likely to negotiate influence, such as screen time and mixed content, but individuals must also have a say.

Regardless of the perplexities surrounding any sharing arrangement, public-display installations will fuel the next wave of social change. Broadcasting media made people more globally aware. Social media has made them more socially aware. Public display-based ubiquitous media will make them more community aware. **C**

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