Interactive Digital Signage

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Digital signage will soon appear in every aspect of daily life, offering a third foundational platform that, along with smartphones and tablets, will support communication in the 21st century.

Digital signs are rapidly becoming so commonplace, so natural, that we use them without even thinking. This issue of *Computer* focuses on recent developments in this technology, offering a look to the future when people will interact with digital signs in new and engaging ways.

TECHNOLOGY EVOLUTION

Signs are becoming ubiquitous, in part because LCD displays have decreased in cost more than tenfold over the past decade, making it feasible to build 100-screen video walls for airports and economical enough to add small screens to vending machines and gas pumps. The demand for flat-panel digital TVs has largely driven these cost reductions. Display sizes have also increased. Applied Material's latest TFT-LCD deposition machines can work with glass that's 11 feet on a side, or about as large as a garage door.

LCD-based digital signage is appearing across a wide range of market segments. For example, digital menu boards are replacing static backlit menus in fast-food restaurants. These dynamic wall and overhead displays can change throughout the day, promoting different items for breakfast, lunch, and dinner. In airports, train terminals, and bus stations, digital displays keep travelers informed about arrivals, departures, weather, and other travel-critical information. In movie theaters, sports stadiums, and entertainment venues, digital signs apprise viewers of show times, scores, statistics, and other related data. In retail outlets, point-of-sale digital signs have proven effective in driving sales, and malls and shopping centers now regularly use them for interactive directory services.

The images in Figure 1 show examples of current uses of interactive displays. If the trend continues, digital signs will appear in almost every aspect of daily life outside the home.

FORM FACTORS

The form factors for digital signs go well beyond traditional posters and billboards. Vending machines are incorporating ever-larger digital signs. Planar is promoting the use of its LookThru transparent LCD for the refrigerator section of convenience stores so customers can see the drink selection alongside dynamic product information (http://blog.planarsystems.com). John Lewis, Britain's largest department store chain, is teaming up with Cisco to develop a "magic mirror" that can superimpose new outfits over a customer's reflection. Home Shopping Network and Intel created a touch wall that invites passersby to play a pizza-making game with celebrity chef Wolfgang Puck.

At this point, it's difficult to say whether display walls, windows, magic mirrors, or something completely different will become a dominant form for digital signs, but it's likely that use of digital displays will continue to increase dramatically.

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Figure 1. Interactive display examples. (a) A kiosk offers shoppers the opportunity to select products of specific interest to them. (b) Viewers can participate in an interactive challenge to play games, win prizes, and design their own pizza. Images courtesy of Intel, Retail Division.

It's estimated that the current approximately US$5 billion digital signage market will triple by 2016 (http://imsresearch.com). This includes all aspects of the business: display hardware, networks, systems software, advertising services, and advertising content design. This kind of growth will likely provide a catalyst for innovation in the human-computer interaction aspects of signage. It's possible that we might see a standard look and feel evolve similar to the way the WIMP (windows, icons, menus, and pointers) interface evolved for the desktop computer. Interactive signage is, however, more challenging than the desktop because of the wide variety of form factors and use cases that have already found a niche in this area.

INTERACTION TECHNIQUES

One aspect of digital signs that will be fundamental is interactivity. Many digital signs are designed to only broadcast advertising content. However, interaction makes a digital sign far more useful. User interaction techniques include buttons, touchscreens, gesture interaction with cameras (2D) and depth cams (3D), and mobile phones.

The earliest form of interactive signage, introduced more than 50 years ago, employed a console of buttons, often labeled and dedicated to particular functions. This approach is commonly associated with vending machines, informational signs in a city center, or museum displays.

Some interactive displays allow users to navigate the content by pressing buttons located nearby, while others, which might be driven by a PC, expose a physically hardened keyboard to provide a full-featured and flexible interface. This type of interactivity is practical because most people are now familiar with keyboard interfaces as a result of the personal computer revolution.

Use of the touchscreen has experienced a resurgence in popularity in the past five years as a result of the success of mobile devices that use this interactive interface, namely, the iPhone and Android smartphones, as well as the increasingly popular tablet computers and e-book readers.

An interesting consequence of this popularity is that people who see noninteractive digital signage are touching the screens and expecting a reaction. Even for signs that have a traditional touch capability, users are likely to try using multitouch gestures to zoom in and out on the display.

Multitouch has become so popular for mobile phones that it's probably only a matter of time before it becomes the industry standard for all touch-based interaction. However, when employed for large signs, multitouch is a costly proposition because the capacitive touchscreen solution does not scale well, and light beam solutions require precise engineering. The industry is working hard to invent cost-effective multitouch solutions for use on large LCD display panels.

Designers of interactive signs have also used conventional digital cameras to enable automatic adaptation of digital content to the audience. For example, based on the audience's average height, a sign might infer age; based on the length of a person's hair and facial features, it might infer gender.

Clearly, there's a possibility of error with any of these techniques, but, in general, this approach can do a much better job of delivering appropriate content to the audience than would be possible with a passive sign. Potentially, this is a win for both an advertiser who wants to deliver a message to a target audience and for passersby who would prefer to see information they're interested in.

In the past 18 months, the Microsoft Xbox 360 gaming console using the Kinect peripheral has demonstrated the popularity of interactive gaming systems that don't require a participant to hold a special controller (http://en.wikipedia.org/wiki/Kinect). Instead, Kinect uses a camera in combination with structured light, a system that projects a pattern of infrared dots onto the active area. Although invisible to people, a digital camera can detect this arrangement of dots. The 3D objects that are present in the scene distort this pattern, which allows an image processing system to segment the scene into component objects and estimate their position and distance from the camera: near objects show up with a pattern of dots closer together than objects farther away. Because it's possible to do all of this in real time using a modern high-performance processor, gamers can make gestures that the system interprets at each instance of a game.

Another interaction technique for digital signage is the use of a smartphone to control the content. Using Bluetooth or other short-range wireless technologies, the smartphone can become a remote control for the display, presenting the control interface on its screen. Because short-range wireless minimizes delays between user and sign, it can be an effective method of low-latency interaction. Furthermore, as a user navigates information on the large display, the control menu on the phone can be adapted to match the content being shown.

The opportunities for experimentation with new styles of interactive digital signage are extensive, a fact that has not escaped the attention of the research community. For many years, researchers have been working in this field that they refer to as interactive public displays (the articles in this issue use both terms synonymously). Several universities in Europe and the US have developed experimental interactive digital display platforms, deploying them in public places so they can study them to determine how to create and deliver appropriate content, identify how they are used, and develop ways to make them more useful.

IN THIS ISSUE

The five cover features included in this special issue review the hard-won experience gained from years of research and experimentation, examine the core issues associated with advertising on public displays, and present a vision for how open networks of digital displays and signs could be used in the future.

In "Supporting Community Awareness with Interactive Displays," Nick Taylor from Newcastle University and Keith Cheverst from Lancaster University review the lessons learned from the deployment of an interactive display in public areas of Wray, a rural English village. The system was designed to support the local community by providing a wide range of information using photographs, text, and graphics. Typical content included village history, maps, local events, and advertising for local businesses. The authors describe the observed impact on community awareness, the use of mobile devices, interaction with the displays, and the more general social benefits of this resource.

"Reflections on Long-Term Experiments with Public Displays," by Adrian Friday, Nigel Davies, and Christos Efstratiou, offers a valuable retrospective from the team at Lancaster University, who have made a concerted effort over the course of 16 years to understand how to build an effective interactive public display infrastructure and capture the key lessons learned from their experience. The authors describe the architecture behind these systems and review the key results obtained from their associated deployments.

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In "Multipurpose Interactive Public Displays in the Wild: Three Years Later," Timo Ojala and his colleagues from the University of Oulu, Finland, summarize the experience gained from a digital signage deployment consisting of 13 UBI hotspots located in Oulu's city center. Their review of key results from one of the largest university experiments to date using a city-based digital-signage deployment includes a description of various aspects of the system design process; a discussion of the contrast between the public's perceived use and actual use based on the usage logs; and an examination of the factors that result in differences between a lab installation and actual deployment. The authors emphasize the importance of designing for an engaging user experience, while also combating user fatigue resulting from exposure to a digital sign positioned at one location over a prolonged period of time.

In "Advertising on Public Display Networks," Florian Alt, Albrecht Schmidt, and Jörg Müller present a more general discussion of the issues relating to the revolution occurring in the signage, billboard, and poster industry. With the cost reductions and improved size and quality of electronic displays, this dynamic new medium is rapidly

replacing the everyday use of paper. Acknowledging that online advertising is also driving this transition, this article investigates how to ensure that this new medium engages and motivates users. Affecting, measuring, and recording interaction is a key factor in accomplishing the objectives discussed in this article.

Finally, "Open Display Networks: A Communications Medium for the 21st Century" by Nigel Davies and colleagues describes a vision for future public displays that will inspire the public to engage them, rather than largely ignore them as they do today. The authors posit that public displays will form the basis of an important global communications network in the 21st century that provides value for users, site and equipment owners, and content providers. To illustrate these ideas further, the authors describe three compelling scenarios that relate to emergency services, persuasion, and self-expression.

To gain a perspective on interactive digital signage, consider the vision of ubiquitous computing that Mark Weiser proposed in 1991 ("The Computer for the 21st Century," *Scientific Am.*, Sept. 1991, pp. 94-104). His seminal article described the tab, pad, and board as foundational platforms that would be needed in the future to effectively support a modern digital life.

In this vision, Weiser used the analogy of traditional units of measurement (inch, foot, and yard) as a way to classify technology categories that are fundamentally useful to people, and thus the reason they evolve. The tab, an inch-scale device, is effectively implemented by the modern smartphone; the pad, a foot-scale device, is represented by tablets and e-books; and the board, a yard-scale device, is now emerging in the form of smart TVs and interactive digital signage.

The recent growth in the digital signage market is promising, but we're likely to see consolidation around form factors and user interfaces. The opportunity for interfacing with mobile devices is particularly exciting, as this may lead to the useful personalization of information presented on digital signs.

We're encouraged by the notion of open networks for digital signs. We believe there are similarities to the early World Wide Web and that openness might be a key, unlocking accelerated growth and increased utility for users of this technology.

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