Applications of Large Displays

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The emergence of large displays holds the promise of basking us in rich and dynamic visual landscapes of information, art, and entertainment. How will our viewing and interaction experiences change when large displays are introduced in our workplace, home, and commercial settings? What technology is needed to implement this vision? This special issue on large displays attempts to provide a sample of the research being conducted in this domain.

Five years ago, *IEEE Computer Graphics and Applications* published a special issue on large-format displays edited by Thomas Funkhouser and Kai Li (vol. 20, no. 4). They showcased a number of research efforts focused on overcoming the challenges of constructing large-display systems. Today, some of the same challenges still exist but technology advances have consumed a significant portion of the challenges.

In terms of constructing large, high-resolution displays, the affordable solution still remains to tile an array of projectors together to simulate one uniform display space. While this has become more affordable as projectors have become less expensive, the overall cost of constructing and maintaining these arrayed projectors is still high. Each of these projectors often needs to be driven by a dedicated PC and must be adjusted and positioned to simulate one contiguous display space. Maintaining the collection of networked PCs also incurs a cost. In addition, specialized software must be designed to orchestrate a unified image across multiple PCs and projectors. See the article by Wallace et al. in this issue for a description of the state of the art in building large-display systems.

However, as previously stated, technology continues to reduce these challenges. High-resolution multiheaded graphics cards—which are now more mass market and affordable—have become an alternative approach for mid-sized display walls. For example, building a large-display system composed of one PC with two graphics cards and four tiled projector displays is a viable and robust approach. Here you have the benefit of running traditional applications on one PC in one large, addressable display space.

Research is also addressing the user interface issues. A large-display space changes how users relate to and interact with digital information. Many of the traditional desktop user interfaces and interaction techniques become awkward or next to impossible to use on a large display. For example, try pulling down a menu on the top of a 10-foot-high screen or imagine dragging an icon for 20 feet. Researchers are focusing not only on fixing these types of user interface glitches but also are exploring radically new interface techniques to take advantage of the large-display format. See the articles in this issue by Bezerianos and Balakrishnan, and Robertson et al. for an example of research on large-display user interfaces.

User interfaces for large displays need some sort of input system so the user can interact with the display. In this domain, input technologies continue to lag behind display output. Few solutions have been designed and even fewer commercial solutions are available. Input systems that allow "pen-on-whiteboard" styles of interaction remain elusive. Some input devices can handle a large-display space of, say, 6×8 feet but lack pressure sensitivity. Rich, multihanded, and multiuser input remains in the research realm. In this issue, Morrison describes a state-of-the-art commercial system for large-display input.

Research on large horizontal displays is also quite active. This configuration is well suited for collaborative activities and has the additional challenge of dealing with the viewing orientation of the information. For example, two people sitting across from one another often must view data by other users that is upside down or at a strange viewing angle (see the article by Scott, Carpendale, and Habelski).

While many challenges remain for large-display systems, such as high cost, setup, and maintenance, we believe the future remains promising as other industry forces push the large-display evolution. For example, the high-definition TV format becoming more readily adopted by industry is promising. The $1{,}920 \times 1{,}080$ HD resolution will put pressure on individual displays and projectors to increase in resolution while, ultimately,

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becoming more affordable. Apple's 30-inch Cinema display boasts a 2,560 × 1,600 resolution. It does indeed feel like a large display when you are sitting in front of it. More recently, Sony introduced the SXRD 4K digital projector with a native resolution of 4,096 × 2,160 (see http://www.sony.com/sxrd). This allows you to project a high-resolution image up to a maximum of 70 feet wide. More important than affordability, this type of HD projector might be an industry-shifting disruptive technology in that it offers an order of magnitude change compared to an array of projectors. For example, in a 4 × 3 array of 1,024 × 768 projectors, you need 12 projectors. However, you only need one 4K projector for the same array, plus you get uniform color and illumination across the frame.

Independent of any specific technology, it is these types of advancements in conjunction with new applications that will continue to fuel the emergence of large displays as ubiquitous technology. Ah, the future is indeed large and bright. ■

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