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Where's My Holodeck? The New Frontier of Media Display

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Overtaking a minivan on a dark night, you might notice the occupants enjoying a DVD movie crisply displayed in quadruplicate on the back of each headrest. In many places, it's possible to watch television on your cellular phone. Perhaps you've seen a shopping cart with a flat-panel display, or been annoyed by video advertisements targeting customers queued at the check-out line or in the hospital waiting room.

This is the shock front of a coming explosion. The number and variety of media displays are set to take off dramatically. Many factors are at work. First, conventional displays (LCD, plasma, projectors) are getting geometrically cheaper and better, exactly as Moore's law predicts. Huge volumes, manufacturing innovations, and fierce competition are pushing flat-panel display costs down. Besides getting cheaper, they're getting bigger, and the display quality is continuously improving.

State-of-the-art LCD displays now use multihue light-emitting diode (LED) backlights and extra color channels for intense brightness and improved color gamut. Digital light processors, or DLP projectors, are also improving rapidly as micromechanical fabrication technology becomes mainstream and high volume. Today's compact video projectors are of a price and quality unobtainable at any cost just a few years ago.

On to the unconventional display

These are just the conventional displays—entirely new technologies could make nearly any surface a display. Organic LEDs (OLEDs) are light-emitting diodes that can be fabricated on a flexible substrate, potentially at low cost. Already used in some small phone displays, they promise huge active displays at a revolutionary price point. Recent developments indicate that transparent OLEDs are feasible, enabling even more far-out applications.

Other technologies—such as electrophoretic ink and Gyricon bichromal beads—promise high-contrast, bistable reflective displays and paper-like form factors. A roll-up electronic newspaper has been widely predicted, and myriad commercial applications are already being envisioned. For example, every supermarket shelf could have rewritable displays along the length of its edge. Automatically displaying item descriptions and prices benefits not only consumers, but the workers who must stock each shelf, and these displays can be updated in real time.

Futuristic projections

Handheld projectors are an exciting development, and are surprisingly close to market. Several companies promise tiny laser projectors not much larger than a matchbox—small enough to integrate inside a cellular phone. By scanning semiconductor lasers with vibrating mirrors or diffraction, this technology promises crisp, bright images from the palm of your hand. Although the first units to market will likely be monochrome, full-color versions using red, green, and blue primary lasers are entirely feasible and will no doubt appear as well. Because the lasers have a small divergence, they're in focus at any distance without bulky optics. This technology can also be used for tiny wearable retinal displays or heads-up displays in vehicles. Both of these superimpose the projected display onto the real world, enabling new applications.

Even for conventional projectors, researchers are investigating camera feedback to assist projection on nonideal surfaces, such as nonplanar areas or variable reflectivity. Prewarping the projected image can make it look right even if the projection surface isn't flat. Modifying colors and brightness can compensate for varying surface qualities.

Projecting brighter light in darker regions can

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make the reflected image much more consistent. In the near future, it might not be unusual to see someone working a spreadsheet on the wall of an airport departure lounge, or teenagers gathered around a video game projected on the floor of the local mall. Any wall or flat space can be a display.

That is, if there is any flat space left. Research groups at Stanford, Microsoft Research, and elsewhere are tiling multiple projectors for ultra-resolution wall-sized displays. As flat-panel prices inexorably decline from volume production, a video wall will be well within the reach of most businesses and consumers. Huge color LED display screens, already commonplace in Asia, are becoming the norm in Western sports venues and city centers, and no doubt will permeate more public and commercial spaces as their prices fall.

500 megapixels and nothing to watch

Taken together, all these trends promise a new era in media output. Displays can be available anywhere, anytime, for any purpose—from tiny wrist videos to immersive room displays. But this technology poses a challenge: How do you fill all those pixels? Conventional analog video looks ghastly on high-resolution screens. Streaming compressed video, like that from typical videoconferencing software, looks worse. The bigger and more immersive the display, the more glaring the problem. Even with high resolution, conventional videography is limited to one rectangular frame and one point of view. No matter how many displays have been installed in your high-end conference room, Microsoft PowerPoint will only comfortably run on one. How can tiny personal displays best complement giant shared projection screens? How do you create media for nontraditional displays and display clusters?

Work at Microsoft Research indicates that the familiar computer desktop metaphor has problems as screens become larger. Although users enjoy being able to open multiple windows without overlaps, there are corresponding drawbacks. As a basic example, on large screens it's easy to lose the cursor!

New methods and interfaces are crucially needed for the new display paradigm. Researchers at FX Palo Alto Laboratory are working on ways of automatically re-authoring conventional presentations for a more compelling multi-screen experience. Cheaper cameras and bandwidth enables other approaches. Researchers at several institutions are experimenting with multicamera panoramic imaging, which may be a good match with wide-angle or immersive displays.

New media creation and display technologies threaten a disruptive challenge to conventional formats and approaches. At the same time, they present some juicy research and business opportunities for those ahead of the curve. Science fiction may offer a glimpse of the future: witness the holodeck immersive display of *Star Trek* or the intrusively interactive advertising of *Minority Report*. Here's a challenge for the research community: given gorgeous high-resolution displays, surely we can create something more compelling and affirming than ultra-resolution commercials. **MM**

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