Innovative Computing Powers Theme Park Adventures

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Entertainment technology has found application in a vast number of settings, from living-room console games to in-flight entertainment systems. Yet amusement parks provide the largest and possibly most impressive arena for showcasing these technologies.

Theme parks have emerged as a huge industry in their own right. More than 450 themed parks in the US attracted more than 350 million visitors in 1999 (http://www.iaapa.org/media/me-facts.htm). Theme parks have become the Walt Disney Company's most reliable and significant income source, accounting for 27 percent of its $25.4 billion revenue and 40 percent of its total operating profit. By contrast, Disney cut live-action film production by $500 million because films "weren't a major driver" for fiscal 2000 earnings (http://disney.go.com/investors/).

"Attractions"—the term the theme park industry applies to its rides and shows—have become a major force in the growth of central Florida. Last year, Orlando's Disney World drew more than 43 million visitors, Universal Studios attracted 14 million visitors, and Sea World netted 5 million visitors (Richard Verrier, "Attendance at Theme Parks May Cool Off," *Orlando Sentinel*, 23 December 2000).

MERGING TECHNOLOGY AND CULTURE

Today's theme parks create *entertainment spaces* in which people experience and remember the world in a different way—whether through short, vicarious thrills or by becoming immersed in a day-long fantasy.

Newer attractions at theme parks now take advantage of advances in computing that range from automated park management to biometrics that recognize guests. Disney, for example, uses fingerprints to validate season pass holders, while the design of attractions such as roller coasters leverages simulation technology for visualization and ride dynamics.

Park designers juggle many practical variables. Major parks must handle large volumes of people. Thus, to judge a ride's suitability, designers use the measure of theoretical hourly rider capacity. For rides at a large park, this value should range from 2,000 to 3,000—smaller values can cause huge queues and angry guests. Guarding against liability poses another major challenge, as does the desire to accommodate a wide variety of guests, from small children to elderly adults.

To comply with these constraints, theme parks have traditionally offered predominantly passive experiences. Continual advances in computing technology, however, provide the tools for implementing greater interactivity and creating more exciting adventures.

The tight integration of complex physical sets and 3D computer-generated imagery provides theme park customers with a wild ride.

The Harvard Graduate School of Design's Gregory Peck describes amusement parks as a form of "environmental storytelling" (http://www.etecnyc.net/ed/edthemed/edtheme.html). These environments combine the notion of place with technology and culture. For example, Disney's *California Adventure*, opening this year, shows how park designers attempt to evoke what virtual reality researchers call *presence*. By combining cultural icons—such as a Hollywood back lot or a simulated Redwood forest—with technology such as a virtual barnstorming plane ride, park designers strive to give guests a feeling of "being there."

UNIVERSAL'S MASTERPIECE

The centerpiece of Universal's Islands of Adventure theme park—*The Amazing Adventures of Spiderman*—showcases the strides computing technology has made in extending traditional theme park rides. Produced and directed by Scott Trowbridge, with computer graphics imagery by the Kleiser-Walczak firm, the $100 million *Spiderman* ride offers a technological and theatrical tour de force that exploits all the senses (Peter Lewis, "Terrifying Precision in High-Tech Amusement Parks," *New York Times on the Web*, http://www.nytimes.com/library/tech/99/05/circuits/articles/06pete.html).

The story behind the ride? Spidey surprises the ride's 12 riders by first jumping upon their futuristic trolley, called a Scoop. The Scoop then careens wildly while supervillains wreak havoc on New York City. Their antics subject passengers to fireballs, gale-force winds, downpours, and a simulated drop from a skyscraper. Only after they've weathered these trials does Spidey proceed to save the day.

The *Spiderman* ride uses the 1.5 acres it occupies to combine 13 IMAX-sized projection screens with large stage sets that depict New York landmarks such as the Statue of Liberty. Trowbridge and crew seamlessly combine stereo 70 mm imagery with the physical sets, even though the Scoop moves with six degrees of freedom along a fixed track. Maintaining synchronization between the moving car and the projection system requires millisecond accuracy—achieved using three on-board computers and Moog electromechanical actuators. To further the ride's immersiveness, the Scoop's 32 speakers with 10 channels provide realistic, surround-sound effects.

The ride's passengers wear polarized glasses that—combined with curved screens and computer graphics techniques that dynamically warp images, an effect Trowbridge calls "squinching"—produce a 3D experience so nearly perfect that computer-generated characters integrate seamlessly with physical props.

Which is just as well, considering that customers now expect such perfection. Noting how sophisticated today's audiences are, Trowbridge observes that "At the turn of the last century, electricity and magnets were the most advanced technologies at amusement parks. People would see tricks done with magnets and they would go away and talk about it for months. These days, we can't just float a paper clip over a magnet. Our audiences are much more sophisticated."

DISNEY'S IMAGINEERS

In contrast to the *Spiderman* ride, Disney has experimented with creating an entire *facility* that provides increasingly interactive experiences for its guests while exploiting advances in computing technologies. In 1998, Disney opened Disney Quest—its large, indoor location-based entertainment complex—at Walt Disney World's Downtown Disney shopping area. The facility accommodates around 1,000 visitors.

For $27, guests can experience the best virtual reality rides available, including *Aladdin's Magic Carpet Ride*, developed in the mid-1990s with Randy Pausch's help (http://hci.stanford.edu/pcd-archives/pcd-seminar/1998-/0000.html). Shown first at Epcot center, the *Aladdin* ride resulted from Disney's first major foray into interactive VR entertainment using helmet-mounted displays and haptics.

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For a twist on a traditional theme park ride, Disney Quest offers a simulator, *Cyberspace Mountain*, which resembles a large washing machine. As the ride tumbles occupants, it displays computer graphics that simulate the vistas seen from fantasy roller coasters. Guests can—with help from a computer program that features Bill Nye, the Science Guy—design their own coasters and add paths that contain loops, camelbacks, and turns.

Arguably the best of the original Disney Quest attractions, the *Virtual Jungle Cruise* simulates the effect of rafting on white-water rapids. The four-person crew sits in a rubber raft that bobs up and down on an air cushion while being sprayed with water. The crew strives to dodge dinosaurs and volcanoes as it paddles down a virtual prehistoric river (http://disney.go.com/Disneyquest/Guide/Explore/Jungle/Jungle.html).

Disney Imagineering's research and development group has also created an interactive adventure that provides a new take on an old theme. *Pirates of the Caribbean: Battle for Buccaneer Gold*, inspired by the original ride at Disneyland in Anaheim, California, offers an updated version of the classic that would make Walt Disney proud.

Essentially, the new *Pirates* ride provides a large, immersive 3D environment similar to a CAVE (Cave Automatic Virtual Environment; http://www.csun.edu/cod/93virt/CAVE~1.html), with a 270-degree high-resolution display and driven by an SGI Infinite Reality computer. The crew wears 3D shutter glasses made by IMAX, but otherwise the experience is seamless. The ride accommodates four people who stand on the virtual pirate ship while a motion platform simulates the roll of ocean swells. One person takes the wheel and captains the ship while the others serve as cannoneers who pull lanyards to fire virtual cannonballs at Spanish galleons. The simulation culminates in a final duel with the Jolly Roger and his Ghost ship in which participants must defend their pirated gold. The group must work as a team to win against imposing odds as they explore a world of fortress islands, erupting volcanoes, and buried treasure.

BEYOND AMUSEMENT

Many of the technologies pioneered in innovative theme park rides and attractions have found use in more serious applications. For example, the ABC Times Square Studios feature an undulating eight-story marquee that displays television shows such as *Good Morning America* to the crowds thronging the streets below. Very bright LEDs and fiber optics enable construction of displays that conform to the building's exterior design. Eddie Sotto, project leader and former senior vice president of Walt Disney Imagineering, describes the marquee as "media as architecture" (http://themedattraction.com/sotto2.htm).

In other work, researchers at the Navy Research Labs, Columbia University, Hughes Research Labs, and elsewhere explore using augmented reality displays to project synthetic scenes onto real ones (http://www.ait.nrl.mil/vrlab/projects/BARS/BARS.html). These efforts may be made feasible through the commercialization of retinal displays by companies such as Microvision (http://www.mvis.com). These displays scan images directly onto the retina, which allows computer-

generated graphics to remain constantly in focus while a person views a real scene.

Although current theme park rides provide experiences more vivid and intense than those available just a few years ago, even more impressive attractions will soon be possible. Wearable computing will likely exert the most exciting influence on future theme park design. Wearables can make the entertainment environment aware of a guest's presence and allow for continuous direct interaction.

Customers already deluge theme parks daily with cell phones, small two-way radios, and Palm-like devices. As these devices integrate with position-locating systems and become cheaper, park designers will be able to create attractions that can actually tell guests when a nearby ride has a short queue or provide a new mechanism for enhancing an attraction's story. Work on *interactive spaces* at the MIT Media Lab uses image-based tracking and wearable computing "to augment the traditional performance stage with images, video, music, and text, and ... to respond to movements and gestures" (*Media in Performance*, Flavia Sparacino, Glorianna Davenport, and Alex Pentland, http://www.research.ibm.com/journal/sj/393/part1/sparacino.html).

The Amazing Adventures of Spiderman and *Pirates of the Caribbean: Battle for Buccaneer Gold* rides represent cutting-edge uses of innovative computing technology to create novel experiences. They also demonstrate, however, the challenge of making a large entertainment environment interactive—a problem that the ubiquity of wireless communication and very large displays may soon neatly solve. ✷

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