Haptics: Gaming's New Sensation

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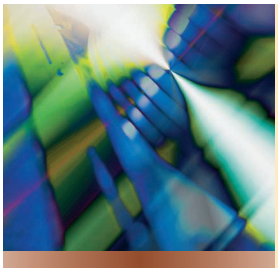

Computer gaming, long the domain of audio and video, will soon be shaken, rattled, and rolled by a new technology.

In 1972, Atari founder Nolan Bushnell debuted *Pong* at a Sunnyvale, California bar. People responded by forming long lines and, quarters in hand, waited to play the curious contraption that forever transformed computers into entertainment devices. That transformation has since spawned a video game industry that grossed $10 billion last year in the US alone, according to market research firm NPD Group.

A quarter century later, as 3D graphics and microprocessor advances nudged in-game visuals ever closer to photorealistic standards, long lines of people again formed to play another dull-looking game that, like *Pong*, displayed only two plain lines representing paddles, and a circle representing a ball.

This unusual scene played out repeatedly in 1996 and 1997 at cutting-edge graphics and entertainment conferences and expos. What was it about this simplistic game, displayed on a monochrome monitor, that captivated everyone's imagination?

Haptics. The simple *Pong*-like game engaged players so effectively because, as they batted its virtual ball across the screen, they could magically *feel* the impact of each volley fed back to them through the game's controllers. Stunning graphics can fool the eyes into believing a few lines of code and a few electrons really are an intricate world, but only with haptics can players reach in, touch, and manipulate that world as if it were real.

THAT MAGIC TOUCH

Haptics is the science of touch. In the real world, we use our sense of touch thousands of times daily, consciously and subconsciously. Everyday tasks that we take for granted, like dialing a touch-tone phone, finding first gear in a manual-transmission car, or playing a musical instrument like a guitar or a piano all rely heavily on tactile and kinesthetic cues. Tactile cues are sensations like textures, vibrations, and bumps, while kinesthetic cues are sensations like a stone's weight, the resistance encountered when stirring molasses, or the impact felt when hitting a tennis racquet's sweet spot.

In the computing world, however, we usually must interact with purely visual cues. Ever try using Microsoft Windows' Calculator with a mouse? It's incredibly frustrating. Yet this task does not differ much from dialing a touch-tone phone, which most people can do effortlessly, eyes closed.

The software Calculator is clumsy because it does not provide the rich flow of information we get from the sense of touch when moving from button to button on a phone's dial pad. Haptics technology can simulate these tactile and kinesthetic sensations so that computer interfaces not only look but also *feel*—in the literal sense of the word—like the interfaces we're accustomed to using in the real world.

NUTS AND BOLTS

How does haptics work? With a dash of electronics, a smidgeon of mechanical design, and a pinch of software. Whether embodied in a $25 million flight simulator from CAE, the iDrive knob in the $70,000 2002 BMW 7-series sedan, or a $59 force feedback joystick from Logitech, all haptic devices derive from a convergence of mechanical, electrical, and software engineering. All have

- some sort of motor or actuator and transmission mechanism that together impart some kind of motion or physical stimulation to the operator, generally upon the fingers or arm;
- some sort of electronics for precisely controlling the motors and reading the sensors; and
- sophisticated software algorithms to simulate real-world physics and interactions.

As a sign of the technology's maturation, What You See Is What You Feel software authoring tools can help haptics engineers rapidly and intuitively design and customize the simulated sensations.

All three components—mechanical, electronics, and software—are interdependent, and imprecision in any one will result in a poor haptic device overall. Figure 1 shows a typical haptic system using Immersion's TouchSense architecture.

HAPTICS GOES MAINSTREAM

For many years, advanced flight simulators have used haptics technology. Companies such as Toronto-based CAE make extremely accurate and realistic flight simulators with cockpits that look, sound, feel, and respond just as a real Boeing 777 or C-5 Galaxy would. Motors and actuators push, pull, and shake the flight yoke, throttle, rudder pedals, and cockpit shell, replicating all the tactile and kinesthetic cues of real flight.

Some examples of the simulator's haptic capabilities include resistance in the yoke from pulling out of a hard dive, the shaking caused by stalls, and the bumps felt when rolling down a concrete runway. These flight simulators look and feel so real that a pilot who successfully completes training on a top-of-the-line Level 5 simulator can immediately start flying a real commercial airliner.

Barrel rolls

In 1996, Immersion Corporation standardized a consumer version of this haptic technology and made *force feedback*—gaming industry's term for haptics—available to the general public. Immersion-licensed joystick products like Logitech's Wingman Force and Microsoft's Sidewinder Force Feedback Pro let fans of flying games like *Microsoft Flight Simulator* experience on their PCs many of the same haptic effects that CAE simulators generate. These gamers could also now enjoy feeling machine-gun recoil, weapon-fire damage, and explosions. Dogfights with friends became much more competitive and fun when the participants knew the smoking plane they had just blasted would transmit the palpable jolts, coughs, and heaves of its death throes directly to their opponents. Soon, PC flying games offered industry-wide support for haptic technology.

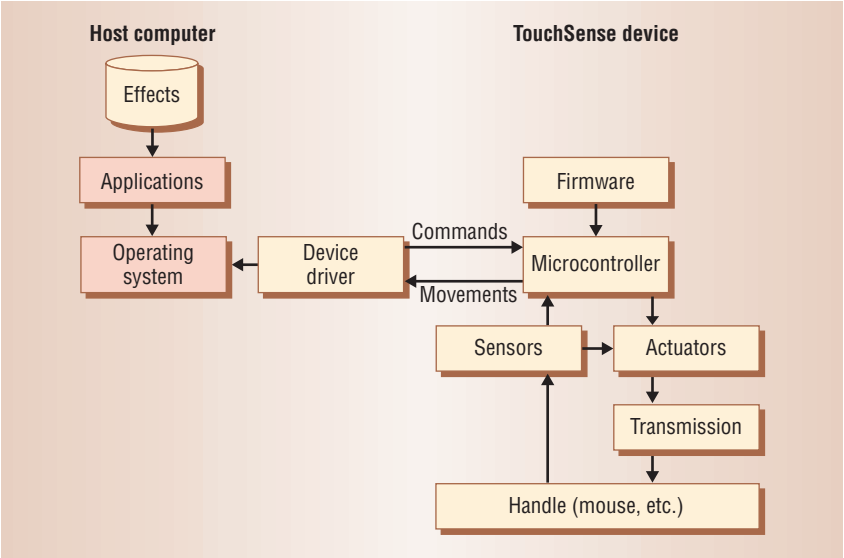

Figure 1. Typical TouchSense haptic system architecture.

Hairpin turns

The driving simulation genre, headlined by games like Electronic Arts' *Need for Speed*, also heartily embraced the new force feedback standard used in a slew of steering-wheel products from Logitech, Microsoft, Thrustmaster, Saitek, Interact, and others.

Without force feedback, game steering wheels felt the same at 5 mph as they did at 200 mph. However, with a force feedback wheel, gamers could feel the centripetal forces in the wheel dynamically changing as they accelerated through turns. They could also feel the jostling force of collisions or driving over cobblestones. If a jump sent them airborne, they could feel the wheel go loose when the tires left the ground, followed by the jarring jolt of crashing back to earth.

Light sabers

The tactile feedback mouse has now opened the door to haptics for all the other PC game genres: first-person shooters like *Half-Life*, adventure games like *Myst*, strategy games like *The Sims* or *Black & White*, and role-playing games like *Everquest*. For example, in LucasArts Entertainment's recent *Jedi Knight 2: Jedi Outcast*, the player can actually feel the weapon's power when wielding a light saber. The unmistakable sounds of the light saber powering up, swinging around, and clashing with an opponent's weapon are accompanied by visceral, high-fidelity tactile sensations communicated to the gamer's fingertips through a haptic mouse.

REJUVENATING THE PLAYSTATION

Although haptics made its debut in gaming on the PC in 1996, it also played a critical role in shaping today's console gaming industry. In 1998, with PlayStation starting to show its age against new contenders like Nintendo's N64, Sony Computer Entertainment breathed new life into its console by launching the Dual Shock controller, which contains a form of tactile feedback. This midlife kicker captured gamers' attention when titles such as *Gran Turismo* claimed, according to a Sony press release, to offer the most realistic driving experience ever by "allowing the player to feel every bump, nudge, and wheel spin, every pot hole and every camber—in fact every single inch of the track."

Such haptics-focused marketing by Sony proved critical to maintaining PlayStation's position as market leader. Although most considered the N64's graphics far superior to the PlayStation's, Sony successfully showed that simultaneously stirring the senses of sight, sound, and touch was the best way to deliver the ultimate gaming experience.

Today, all major video consoles have built-in tactile feedback capability. Various sports games, for example, let you feel bone-crushing tackles or the different vibrations caused by skateboarding over plywood, asphalt, and concrete.

THE MEDIUM IS THE MASSAGE

Konami took haptics a step further by employing a vibration effect artist for its *Metal Gear Solid* series, which critics frequently applaud for its remarkable range of tactile effects. In addition to the standard weapon recoils and explosions, *Metal Gear Solid* adds tactile effects that help create a certain mood or environment. When a low-flying helicopter passes overhead, for example, the gamer can feel the ground-shaking rumble gradually intensify and then fade, like a musical crescendo and decrescendo.

Likewise, gamers can feel their in-game pulse slow after taking a drug to help steady their hands when using a long-range sniper rifle. And, in a truly humorous meeting of the virtual and physical worlds, after a prolonged and hectic action sequence of rapid button-gnashing on their controller, they can get a real forearm massage. This occurs when the in-game, onscreen doctor instructs the in-living-room, on-sofa gamers to place the vibrotactile controller against their lactic-acid-filled forearms for a magic-fingers-style treatment.

Although haptics in PC gaming began by focusing on kinesthetics, while haptics in console gaming began by focusing on vibrotactile effects, gamers' appetites and market pressures are driving the wide adoption of both forms by both sectors. Altogether, more than 500 games use force feedback, and more than 20 peripheral manufacturers now market in excess of 100 haptics hardware products for gaming.

When considering what gaming haptics' future holds, it's fun to think of the haptic peripherals designed for other industries that could be applied to entertainment with fabulous results. For example, the CyberGlove could make possible a virtual archery game in which the gamer can actually feel the pull of the bowstring. However, substantial advancements will come when game developers simply catch up with existing haptic controllers' capabilities.

In *Metal Gear Solid*, Konami showed what adding a dedicated and talented haptic effect artist to the development team can do, but game developers must take this approach even further and create entirely new games and genres predicated on haptics. Sports games like golf and baseball could then evolve from simple exercises requiring timed mouse clicks to fluid swing choreographies that replicate the distinctive and satisfying feeling of making solid contact with a three iron or Louisville slugger. If haptic *Pong* could draw a crowd at the Game Developers Conference, imagine what a haptic Tiger Woods game could do. ■

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