7 things you should know about...

Haptics

Scenario

When Arthur showed up for the first day of his industrial design course, he was surprised to see so much computer hardware in the lab. He had used CAD programs and modeling tools in other design courses, but this lab was full of haptic devices that the students would use in designing anything from electric toothbrushes and gardening tools to office furniture and exercise equipment. Arthur decided to design a chair suitable for cafés or coffee shops. He wanted his chair to be comfortable but also easy to move and store on occasions when, for example, a coffee shop hosted a poetry reading or live music.

Arthur used a haptic device that simulated textures to test different choices for the seat and backrest materials. He could "build" a virtual version of his chair with a deep cushion and suede fabric, or a thin layer of foam covered with slightly stretchy nylon, or simply a molded piece of plastic. Sliding his hand into a small haptic sleeve connected to a computer interface, Arthur could run his fingers along the surface of his virtual chair and press against it as he watched an animation of the chair on a monitor. The haptic device simulated the textures and firmness of the different material choices, transmitting those sensations to Arthur's hand.

Arthur wanted his chairs to stack easily and be light enough to comfortably slide across a floor. With the haptic design tools, Arthur could choose from various materials to construct his chair, and, using a two-handed controller, he could "pick up" his virtual chair and feel for himself how heavy it was. The choice of materials and the design of the mating surfaces affected how easily the chairs could be stacked and unstacked, and Arthur could feel these differences through the haptic controller. He could choose different flooring materials and simulate pushing a stack of chairs, feeling the varying resistance through the controller.

1

What is it?

Haptics technologies provide force feedback to users about the physical properties and movements of virtual objects represented by a computer. A haptic joystick, for example, offers dynamic resistance to the user based on the actions of a video game. Historically, human-computer interaction has been visual—words, data, or images on a screen. Input devices such as the keyboard or the mouse translate human movements into actions on the screen but provide no feedback to the user about those actions. Haptics incorporates both touch (tactile) and motion (kinesthetic) elements. For applications that simulate real physical properties—such as weight, momentum, friction, texture, or resistance—haptics communicates those properties through interfaces that let users "feel" what is happening on the screen.

2

Who's doing it?

Haptics tools are used in a variety of educational settings, both to teach concepts and to train students in specific techniques. Some faculty employ haptic devices to teach physics, for example, giving students a virtual environment in which they can manipulate and experience the physical properties of objects and the forces that act on them. Such devices allow students to interact with experiments that demonstrate gravity, friction, momentum, and other forces. In subjects such as biology and chemistry, haptic devices create virtual models of molecules and other microscopic structures that students can manipulate. In this way, students can "feel" the surfaces of B cells and antigens, for example, testing how they fit together and developing a deeper understanding of how a healthy immune system functions.

Many disciplines depend on the execution of physical techniques with a high degree of precision and dexterity, and instruction in these fields can take advantage of haptic technology to help students hone those skills. Medical students can use haptic devices to develop a sense of what it feels like to give an epidural injection, perform laparoscopic surgical procedures, use dental or orthopedic drills, or any number of other highly tactile techniques. Such simulators give users the opportunity to develop a tactile sense of the structures, organs, and tissues of the body. Flight simulators combine visual and auditory elements with haptic technology, including resistance and vibrations in the controls, allowing student pilots to experience the kinds of sensations they will feel when flying real planes.

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Haptics

3 How does it work?

Haptics applications use specialized hardware to provide sensory feedback that simulates physical properties and forces. Haptic interfaces can take many forms; a common configuration uses separate mechanical linkages to connect a person's fingers to a computer interface. When the user moves his fingers, sensors translate those motions into actions on a screen, and motors transmit feedback through the linkages to the user's fingers. The screen might show a ball, for example, and by manipulating a virtual hand through the device, the user can "feel" the ball, discerning how much it weighs or the texture of its surface. Because the ball and its environment are purely virtual, the properties can be changed—adding more air to an underinflated ball to make it less squishy, or altering the amount of gravity to let users feel how much the ball would weigh on the moon.

4 Why is it significant?

The interface between humans and computers has been described as an information bottleneck. Computers can store and process vast amounts of data, and humans experience—and learn—through five senses. But computers typically only take advantage of one or two sensory channels (sight and sound) to transmit information to people. Haptics promises to open this bottleneck by adding a new channel of communication using the sense of touch. Haptics expands the notion of bidirectional communication between humans and computers to include sensory feedback.

Active learning strategies result in stronger comprehension of subjects, and haptics provides a mechanism through which students can actively engage in learning a range of ideas and skills, putting control of learning literally into their hands. Haptics also has a growing role in assistive technologies. The haptic mouse, for instance, provides sensory feedback that allows users with visual impairments to "read" a computer screen by feeling buttons and other elements. Such devices can also benefit users without disabilities but who are tactile or kinesthetic learners.

5 What are the downsides?

Haptics applications can be extremely complex, requiring highly specialized hardware and considerable processing power. Insofar as the objects being manipulated in haptics are virtual, a compelling interaction with the device requires that all of the physical properties and forces involved be programmed into the application. As a result, costs for haptics projects can be considerable. Those costs become manageable, however, if they are split among several institutions developing a haptics project or when haptics technologies are freely shared, allowing other institutions to pursue new applications based on existing frameworks.

The complexity also means that many haptics projects rely on fixed installations of equipment and are not easily portable. Because the field of haptics is relatively young and many of the devices that allow haptic interaction are at an early stage of development, some haptics projects still offer somewhat crude experiences to users.

6 Where is it going?

Development and refining of various kinds of haptic interfaces will continue, providing more and increasingly lifelike interactions with virtual objects and environments. Researchers will continue to investigate possible avenues for haptics to complement real experiences. Advances in hardware will provide opportunities to produce haptic devices in smaller packages, and haptic technology will find its way into increasingly commonplace tools. Additionally, consumer-grade haptic devices are starting to appear on the market. As access to haptics increases, usage patterns and preferences will inform best practices and applications—ultimately, users will decide which activities are appropriately represented through haptics and which are perhaps better left in the real world.

7 What are the implications for teaching and learning?

Research indicates that a considerable portion of people are kinesthetic or tactile learners—they understand better and remember more when education involves movement and touch. Because formal education has traditionally focused on visual (reading) and auditory (hearing) learning, these learners have been at a disadvantage. Haptics opens the door to an entirely different learning method and style, one that for many students provides the best opportunity to learn. Moreover, even for visual and auditory learners, haptics can improve learning. For a broad range of subject matter, incorporating sensory data and feedback allows for a richer understanding of the concepts at hand. Haptics technology has found its way into a range of commercial video game controllers, including joysticks and steering wheels. Whether such devices are used for educational games or as external devices for other types of simulations, new opportunities are arising to incorporate haptic technology into teaching efforts.

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