Virtual Reality Virtual Reality is a synthetic technology combining three-dimensional video, audio, and other sensory components to achieve a sense of immersion in an interactive, computer-generated environment. Virtual Reality also appears under the title Virtual Environments or Virtual Worlds. Contemporary usage tends to prefer the term *virtuality* which avoids the paradoxes and overpromise that many see in the legacy of virtual reality proper. Popular culture now uses the terms *virtual* in a weak sense that refers loosely to any kind of computer-mediated experience or even to any kind of imaginative experience, but the stronger usage of the term implies the application of immersion techniques that remain specialized for certain applications and are not widely used. It is these immersion techniques that distinguish the aesthetic novelty introduced in the 1990s by Virtual Reality.

Whereas traditional sculpture and architecture involve the viewer in three-dimensional space, Virtual Reality insulates the human sensorium in a full-surround computerized sensory feedback loop. The technical configuration used to achieve immersion differs, ranging from head-mounted displays and datagloves to room-size projections for unencumbered full-body interaction with artificial entities and autonomous agents. High-speed computing allows Virtual Reality systems to track the user's sensory responses and to provide real-time feedback of appropriate images, sounds, and tactile pressure to create the feeling of immersion or being in a world. Some see in Virtual Reality the evolution of human—computer symbiosis, progressing from multimedia to cyberspace to virtual reality. A designer must take into account the specific immersion techniques and the kind of presence needed for the specific virtual world. The Virtual Reality artist can draw on a wide range of realism, from photographic realism to the softer realism of archetypal imagination. Virtual Reality has numerous applications in entertainment, scientific visualization, and industrial prototyping, as well as in telepresence and robotics, where it is used in surgery and in the exploration of outer space.

Definition in Historical Context

Virtual Reality can also function as an umbrella term for related research and commercial developments. The term *virtual reality* first appeared in the late 1980s with Jaron Lanier and his Virtual Programming Languages Incorporated (VPL), which introduced the first commercial system for controlling computer simulations through a dataglove and a stereoscopic head-mounted display (HMD). An artist himself, Lanier introduced Virtual Reality as a medium for shared self-expression. The fiber-optic glove or “dataglove” measures hand and finger movements and the helmet tracks the user's point of view so that the computer can adjust the stereo images to fit the user's position and hand gestures. The basic research behind the HMD and dataglove had been going on for twenty years before VPL, stretching back to Ivan Sutherland at Harvard and to several NASA research projects. In the following decades, two major streams of Virtual Reality emerged: the one stream based on the HMD and the other stream based on the room-size projection of graphics for unencumbered interaction sometimes called *artificial reality*.

The helmet-based stream of Virtual Reality emerged not from the art world but from military flight simulators. The “supercockpit” was begun in the 1970s by Thomas A. Furness at Wright-Patterson Air Force Base. Along similar lines was the groundbreaking work of Ivan Sutherland during the 1960s at Harvard and at the University of Utah. Sutherland's head-mounted displays could work with primitive graphic simulations, not just aircraft flight. Early computer art, stemming from Michael Noll's experiments at Bell Labs, provided the computer graphics. Sutherland influenced Frederick P. Brooks, who founded the virtual worlds laboratory

at the University of North Carolina. Brooks began designing virtual worlds for solving problems in medicine, physics, and engineering. The HMD pilot trainer became a universal simulator.

The other stream of Virtual Reality development came from the art world. Some of the kinetic and electronic art of the 1960s used cameras to create a feedback loop between the art objects and the participants. Interactive art, such as Myron Krueger's Videoplace, suggested an unencumbered way of participating in real-time, computer-generated, graphic worlds. Krueger's Videoplace put people in separate rooms who could then relate interactively by mutual body painting, free-fall gymnastics, and tickling. Krueger's Glowflow, a light-and-sound room, responds to people's movements by lighting phosphorescent tubes and issuing synthetic sounds. Another environment, Psychic Space, allows participants to explore an interactive maze where each footstep corresponds to a musical tone, all produced with live video images that can be moved, scaled, rotated, without regard to the usual laws of cause and effect.

Krueger's line of Virtual Reality inspired commercial products such as the Mandala System and scientific research such as the CAVE at the Electronic Visualization Lab (EVL) of the University of Illinois at Chicago. At EVL, the CAVE (CAVE Automatic Virtual Environment) uses surround-screen, projection-based techniques to create an entire room in which users can explore virtual worlds unencumbered by physical trackers. Applications in the CAVE included virtual environments for astronomy and physics. Krueger's influence was also manifest in the 1993 ALIVE (Artificial Life Interactive Video Environment) at the Massachusetts Institute of Technology Media Lab where semi-intelligent artificial agents with animated graphic bodies join human users who can relate to them with natural gestures.

Both streams of HMD and projection Virtual Reality share the common goal of providing an immersive experience. The user feels surrounded or immersed in a world of artificial, computer-generated entities with which he or she can interact. The “virtual” in *virtual reality* comes from the experience of being immersed in a world of entities that feel present when in fact they are not actually present, “virtual” meaning “in effect but not in fact.” It is this illusory quality of Virtual Reality that establishes its link with trompe l'oeil painting and the many variants of aesthetic realism.

Virtual Reality can shade into telepresence. Telepresent Virtual Reality is an interactive immersion in a simulation linked causally, usually through robotics, to real-world entities. Virtual Reality telepresence allows NASA operators in Houston to move a Moon Rover across the lunar landscape while feeling as if they were actually present in the vehicle on the Moon. The Mars Rovers Opportunity and Spirit are telepresence robots or six wheel machines that remotely execute instructions wirelessly received from Earth. When linked to robotic graphics, Virtual Reality becomes a technology for telepresence, which means presence at a remote location.

The complex notion of presence is tied to subtle shadings of human experience. Research in Virtual Reality continues to explore the issues of what constitutes presence and what gives humans the ontological confidence to declare something to be real.

A related meaning of virtual reality has arrived with the advances in computer graphics. As sound systems were once praised for their high fidelity, present-day imaging systems now deliver “virtual reality.” The images have a shaded texture and light radiosity that pull the eye into the flat plane with the power of a detailed etching. Landscapes produced on the GE Aerospace “Visionics” equipment, for instance, are

photorealistic real-time, texture-mapped worlds through which users can navigate. These graphic data-worlds spring from the context of mission rehearsal and training in military flight simulators. Researchers now seek to bring these techniques to medicine, entertainment, and education. The claim of Virtual Reality aestheticians often goes beyond the claims of photographic realism or representation as users may experience the virtual entities to have ontological properties indistinguishable from the ontological properties of actual entities. Aesthetics in the virtual realm then often involves questions of presence and of ontological identity.

Relation to Tradition

Early Western psychology distinguished five senses plus a sixth or common sense *(sensus communis)* that coordinates the five other senses. The sixth or common sense produces the feeling of being focused on a unified, substantial entity on the basis of which the perceptions of the other senses are synthesized. Later aestheticians conceived this common sense as "sensibility" (called "universal subjectivity" in Immanuel Kant's *Critique of Judgment*), which changes over time and differs according to cultural conditioning. Cultural historians trace the variations in this conventional sensibility as shifts in perceptions. A similar postulate underpins Virtual Reality research. The notion of presence is intimately connected with whatever the senses perceive as given. The right sensory input can activate the sixth sense or feeling of presence, and the user experiences being present (virtually) among real entities in a real world. In this way, Virtual Reality brings aesthetics closer to ontology. Much twentieth-century philosophy—especially existentialism—revolved around presence as the key to reality. Pragmatists like William James also stressed the power of the human senses to entrain belief: you see it, you believe it—unless you consciously choose not to believe it. Because Virtual Reality raises basic questions of ontology and epistemology, its vocabulary resonates with much of Western art and philosophy, from Plato to Maurice Merleau-Ponty and Martin Heidegger. The scholars who detail these connections will very likely cause the maps we have of past philosophies to be redrawn. Art, philosophy, and religion have from time immemorial discussed ways of transcending the immediate world. Knowledge, art, and thinking have achieved a considerable self-reflection on how to transcend bodily life. To this tradition Virtual Reality adds the factor of technology. Involvement with Virtual Reality may bring art, philosophy, and religion closer to the world of information.

Special Problems

The reference in Virtual Reality to "reality" or realism suggests a fundamental problem running throughout art history. If we want to create realistic experience, what indeed is reality? Is it largely a function of psychology or of empirical sense impressions? The introduction of technology does not answer this question but only heightens it—unless, that is, virtual reality shrinks to entertainment trivia and commercial applications. To achieve its potential as an art form, Virtual Reality will necessarily explore degrees of realism and of verisimilitude. What complicates the issue is the broad spread of disciplines from which Virtual Reality draws its sustenance: Virtual Reality combines art with technology, psychology with computer science, and electrical engineering with metaphysics. Another related problem is how to bridge the gap between the great expectations raised by the Virtual Reality concept and the actual achievements of research. The most widely available Virtual Reality systems today serve the limited goals of medical or therapeutic applications and arcade games.

As Virtual Reality becomes a metamedium—combining theater, film, sculpture, dance, and so forth—artists will break it loose from the constraints of entertainment and commercial applications. Only in this way will its

full potential unfold and truly appropriate applications appear. The learning curve will be high as Virtual Reality deviates from the experiential norms of previous art. One example of such experiments is the visual sculpture done at the Institute for Simulation and Training in Florida. An interactive painting and sculpture environment gives participants some fuzzy-ball primitives to work with in three-dimensional space. The balls float scattered either loosely or densely in space according to the speed at which the user's hand moves through the space. The tracker sensor determines *x, y*, and *z* coordinates of the ball placement, but the other three degrees of hand movement (pitch, yaw, and roll) give color mappings for the balls. Colors change with the pitch of the hand, yaw controls the color saturation, and the intensity is controlled by the roll of the hand. Such nonisomorphic mapping requires considerable practice before art can be created, but the experiment shows the rich potential of Virtual Reality as a metamedium.

Closely related to the question of realism is the notion of immersion or presence. Granted that immersion is part of Virtual Reality, the question remains: How are users best immersed in virtual environments? Should users feel totally immersed? That is, should they forget where they are (in a graphics environment) and see, hear, and touch the world much in the same way we experience the primary phenomenological world? (We cannot see our own heads in the phenomenological world.) Or should users be allowed to see themselves as a cyberbody? Should they be aware of their primary body as a separate entity outside the graphic environment? What makes full-body immersion? The two different answers to this question split the field into the two kinds of immersion: the one derived from Krueger's Videoplace and the other from the head-mounted displays of Virtual Programming Languages, NASA, and Brooks's lab at the University of North Carolina. The choice of different Virtual Reality platforms (HMD or projection) points to a deeper issue of Virtual Reality and concerns its relationship to primary reality. The aesthetic questions then impinge on ethical issues. Our bodies remain in primary reality, and our cyberbodies (whether first person headless, full graphic, or telepresent surrogate) add a secondary level of self-awareness. The unity of the human mind and its primary body becomes more tenuous than ever in virtual worlds. Pilots in the 1991 Persian Gulf War experienced an extraordinary detachment from their bombing raids after having trained themselves virtually on the same missions for weeks. The skills required to wield computer precision and power are producing what the Pentagon calls “Nintendo soldiers.” Avant-garde doctors also speak of the Nintendo surgeon who operates through telemedicine and whose patients evaporate into bodiless bits and bytes. Similar to jet lag and flight-simulator sickness, the Virtual Reality gap between mind and body leads to alternate world syndrome (AWS) or alternate world disorder (AWD) where fragments of the psyche get stuck in one world while working in another. Researchers find Virtual Reality users pointing their fingers in the real world and expecting to fly as they do in virtual environments. The positive side of such maladies is the possibility that Virtual Reality artworks in “augmented reality” will be able to connect virtual and real images in ways that enhance and transform the human connection to primary reality.

See also Artificial Intelligence and Aesthetics; Computer Art; Cyberspace; Digital Media; Hypertext; and Multimedia.

Bibliography

Aukstakalnis, Steve, and David Blatner. *Silicon Mirage: The Art and Science of Virtual Reality*. Berkeley, 1992.

Biocca, Frank. Will Simulation Sickness Slow Down the Diffusion of VE Technology? Presence: Teleoperators and Virtual Environments 1.3 (Summer 1992): 334-343.

Burdea, Grigore, and Philippe Coiffet. *Virtual Reality Technology*. New York, 1994.

Hayles, N. Katherine. How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics. 1st ed. University Of Chicago Press, 1999.

Heim, Michael. *The Metaphysics of Virtual Reality*. New York and Oxford, 1994.

Heim, Michael. *Virtual Realism: The Art of Emerging Technology*. New York and Oxford, 1998.

Krueger, Myron W. *Artificial Reality II*. Reading, Mass., 1991.

Pimental, Ken, and Kevin Teixeira. *Virtual Reality: Through the New Looking Glass*. 2d ed. New York, 1995.

Rheingold, Howard. *Virtual Reality*. New York, 1991.

Stanney, Kay M., and Kelly S. Hale. Handbook of Virtual Environments: Design, Implementation, and Applications. 1st ed. CRC Press, 2002.

Zudilova-Seinstra, Elena, Tony Adriaansen, and Robert van Liere. Trends in Interactive Visualization: State-of-the-Art Survey. 1st ed. Springer, 2008.

Michael Heim