THE EMERGING TECHNOLOGY OF CYBERSPACE
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Cyberspace is a new medium that gives its patrons a strong sense they have been embodied in a virtual reality (as opposed to film, say, which can effectively portray a virtual reality but without giving its viewers such a compelling sense that they are actually present within the reality). While cyberspace may be the most important new medium since television, there is nothing radically new in the technology that underlies it. The fundamental components are all readily available, off the shelf, from the various makers and suppliers of today's personal computer technology. In fact, the essential elements of cyberspace technology have been available since the sixties, and many cyberspaces have already been created by people who could afford sophisticated simulation systems. Today, three factors are stimulating broad interest in the potential of cyberspace: 1) rapid and continuing performance improvements in personal computers, 2) the availability of relatively low-cost, yet powerful, 3-D rendering engines, and 3) a reconception of the relationship between humans and computers (see main text).

Fundamentally, a cyberspace is a type of interactive simulation, called a cybernetic simulation, which includes human beings as necessary components. Of course, by definition, all interactive simulations can involve humans, but involvement is not the same as inclusion. You can poke and punch an interactive simulation, and get information back from it, without being a part of it. A cybernetic simulation is a dynamic model of a world filled with objects that exhibit lesser or greater degrees of intelligence. Certain objects, called puppets, are controlled by the actions of humans (patrons) whose movements are monitored by an array of sensors. Generally, a puppet in virtual space moves in direct correspondence with a patron in physical space. The basic job of cyberspace technology, besides simulation of a world, is to supply a tight feedback loop between patron and puppet, to give the patron the illusion that he or she is literally embodied by the puppet 6. e. the puppet gives the patron a virtual body, and the patron gives the puppet a personality).

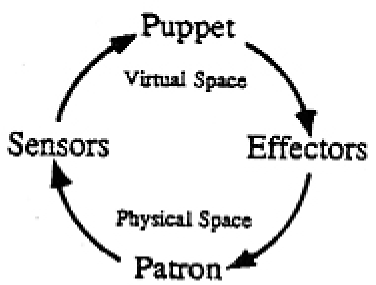

Figure 1: The cybernetic feedback loop

The relationship between patron and puppet is depicted in Figure 1. The puppet monitors the physical world through an assortment of sensors, and acts on the physical world through various effectors. The sensors include 6D trackers (devices that monitor a physical object's spatial position and orientation), keyboards, joysticks, steering wheels, speedometers, pressure gauges, mice, and voice recognizers, among many others. The effectors include various graphics and video displays, sound generators, resistance controllers, motion platforms, force feedback devices, and so on.

The paradigm shift that underlies the emergence of cyberspace (see main text), is implicit in the use of the terms "sensor" and "effector" in Figure 1. Under the old view, computer systems were designed extrinsically, from the point of view of human "users" who stand outside the system and who use "input devices" to put information in and "output devices" to get information out. A cyberspace system, on the other hand, is designed intrinsically, from the point of view of puppets who embody intellects (either human or artificial) within virtual space. Thus the term "sensor", in Figure 1, refers to a device through which a puppet acquires knowledge of events in physical space. That same device, a keyboard say, would be called an input device under the old view. Likewise, a puppet's effectors are output devices in the old way of speaking. Generally, a patron affects virtual space through a puppet's sensors and learns of events in virtual space through a puppet's effector. That is, a puppet's sensors are a patron's effectors, and a puppet's effectors are a patron's sensors. This can be confusing until you shift your thinking to the intrinsic viewpoint, and realize that discussion is always centered on a point of view from within virtual space (the term "patron", as another example, is meant to suggest an actual visit to a place, like a museum).

In William Gibson's stories starting with Neuromancer, people use an instrument called a "deck" to "jack" into cyberspace. The instrument that Gibson describes is small enough to fit in a drawer, and directly stimulates the human nervous system. While Gibson's vision is beyond the reach of today's technology, it is nonetheless possible, today, to achieve many of the effects to which Gibson alludes. A number of companies and organizations are actively developing the essential elements of a cyberspace deck (though not everyone has adopted the term "deck"). These groups include NASA, University of North Carolina, University of Washington, Artificial Reality Corp., VPL Research, and Autodesk, along with numerous others who are starting new R&D programs.

At Autodesk, a prototypical deck has been under development for about a year. The architecture of the deck is based on the feedback loop illustrated in Figure 1. The central component is an object-oriented simulation system consisting of a small, fast kernel (basically a library of C+ classes), together with a shell that allows programmers to interact directly with data structures and with virtual objects. A "cyberspace", in the implementation, is a cybernetic simulation system consisting of a collection of virtual objects that each gets a chance, each simulation cycle, to make whatever contribution they wish to the construction of the next simulation frame (where a "frame" is a state descriptive model of the space at one moment in virtual time). This gives great flexibility and power to cyberspace developers, as the system dictates nothing at all about the character of particular spaces. What happens in a space is determined entirely bythe behavior of the virtual objects, and that behavior is either programmed by developers or expressed spontaneously by puppets directed by patrons. The kernel contains certain fundamental object classes of mechanical bodies that can be linked into multibody systems, sensor handlers, and display drivers. Third party developers can override or specialize the fundamental classes in order to customize their own cyberspace decks.

Besides the simulation system, which runs on an ordinary personalcomputer (presently only on IBM PCs or compatibles, under DOS), the prototypical deck is made up of six other components: 1) sensor, 2) effectors, 3) a volume of physical space, called a control space, where the movements of patrons are tracked, 4) props, like bicycles, chairs, and railings, that provide physical analogs of virtual objects, 5) an interface to a local area network (presently Ethernet), and 6) an enclosure for all the components (presently an ordinary office space). A typical configuration is illustrated in Figure 2. This configuration, using a treadmill, would enable a patron to walk or run around in a virtual world, point, grasp objects, and issue spoken commands. A similar configuration, using a stationary bicycle (whose virtual analog can fly if it's pedaled fast enough), was implemented and demonstrated at SIGGRAPH '89.

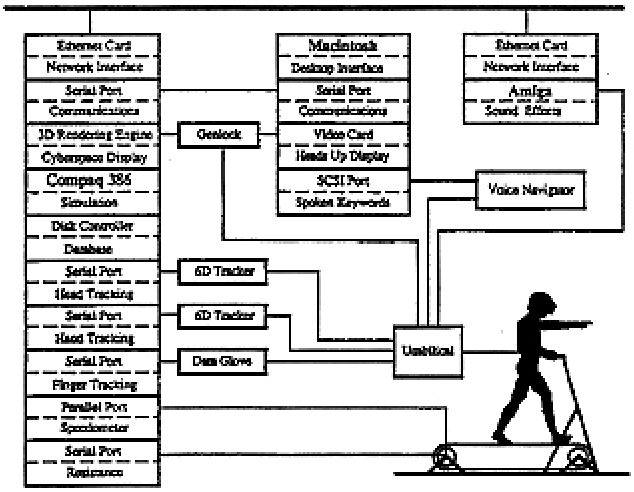

Figure 2: Typical configuration of a cyberspace deck based on personal computer technology. In general a deck is a collection of loosley couplet processor whose activities are synchronized on a single simulation clock. An umbilical is a bundle of cables through which patrons "jack" into cyberspace.

Notice that a deck, in Autodesk's approach, is composed of a collection of loosely coupled processors, including whole personal computers. That alternative, usually taken by makers of highend simulation systems, is to provide all that is necessary in a single box, with all programs running in a shared memory space. The advantage of the loosely coupled approach is that decks can be built up piecemeal, from lowcost decks, with limited performance, consisting of nothing more than an ordinary personal computer, on up to pricey but high performance decks consisting of several personal computers (or a single high performance machine) together with an exotic array of sophisticated sensors and effectors.

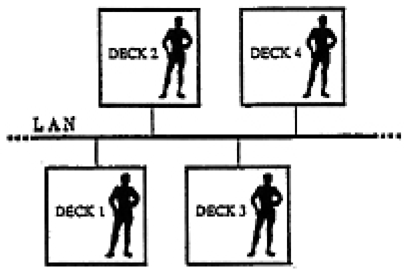

Figure 3: Cyberspace decks linked via a local area network.

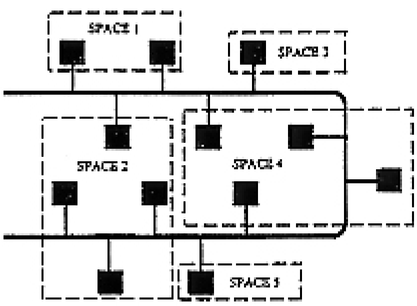

Figure 4: A network of 12 cyberspace decks participating simultaneously in five cyberspaces. Each deck maintains a complete copy of the space in which it participates. To minimize network traffic, only state changes are communicated among decks (except at times, during constructions tasks, when whole models are transmitted from one desk to another).

At the next level of organization, as shown in Figures 3 and 4, decks are linked into networks that enable more than one person to participate in a space at a time. To date, very little work has been done with multiperson spaces, though VPL Research demonstrated its "Reality Built for Two" system almost a year ago, and is continuing to make rapid improvements. Autodesk has only just begun to develop a multiperson capability, but will soon begin to emphasize that area of work.

Multiperson spaces are especially important, and intriguing, because they promise to be far more lively than spaces in which you interact only with a computer. In a multiperson space there will always be a possibility (at least under Autodesk's approach) that the virtual objects you encounter are directed by human intelligence, though they may be directed by computer programs, or they may be utterly undirected (inanimate). Sometimes you will know what is inhabited by whom (or what), but sometimes you will be surprised to find that objects, like trees or refrigerators, that your assumed were unintelligent, are in fact full of sophisticated abilities. This will bring cyberspace alive, giving it a magical and delightful (if spooky) quality.