TRAINING IN VIRTUAL REALITY

William Bricken
August 1990

Virtual reality (VR) refers to a new computational paradigm that fundamentally redefines the interface between humans and computers. The essence is *inclusion*, the participant is included in a computational environment. The central issue for use of VR for training is whether or not experience in VR generalizes to similar experience in physical reality.

VIRTUAL REALITY

Virtual reality is a direct experience computational environment. The participant wears hardware which senses his natural behavior, and displays from his personal perspective. The best way to think about the experience of VR is to look around the physical reality each of us inhabit. When we turn our head, the world holds still while we redirect our perception in the new direction. VR has the same inclusive quality. In physical reality, there are objects, localities of contiguous mass. Most objects, and most of what people see, are manufactured. In VR, everything is manufactured. VR has objects, but they do not necessarily have mass. VR objects are programmable, their properties can be arbitrarily changed. VR includes software for the construction of, maintenance of, and interaction with arbitrary databases with visual semantics.

Here is a list of the changes that define the paradigm shift accompanying VR technology:

symbol processing	-->	reality generation
viewing a monitor	-->	wearing a computer
symbolic	-->	experiential
observer	-->	participant
interface	-->	inclusion
physical	-->	programmable
visual	-->	multimodal
metaphor	-->	virtuality

Generating applications for VR in education, training, or most any other human activity is easy and fun. Just substitute the virtual for the actual, then get rid of the constraints of the actual. What follows are some deeper educational issues posed by VR. (For a detailed discussion of the application of VR to education, see Meredith Bricken, Virtual Reality Learning Environments: Potentials and Challenges, to appear in the Proceedings of SIGGRAPH'91.)

PROGRAMMABLE PARTICIPATION

The characteristics of VR are the same as those of good teaching. The teacher wants to create an environment which is programmable (the curriculum) and which the students participate. "The most important principle of classroom activity design is that the student's actions determine what will be learned." (Walker, Fundamentals of Curriculum). That is, attention comes first, learning comes after attention is focused. And learning is primarily action (Dewey, Bruner).

The idea is simple, everything we do to educate with words and with pictures can be provided as virtual experience. We can vary location, scale, density of information, interactivity and responsiveness, time, degree of participation. VR provides programmable environments and personalized worlds.

Individualized Instruction: Programmable environments are personalized worlds. They are at the call of the participant, they can accommodate to prior actions or to specified preferences. The art of user-modeling has been weak because context has been omitted. VR provides a fully controllable, empirical context. Imagine that each VR object stores its history, activities and interactions with the student. Imagine that each object has access to statistical and classification algorithms. A teacher could ask for a synopsis of each students work in LogicLand; could toss tasks into a student's environment, each task calibrated to an appropriate skill level; could observe by inhabiting the task, by being the challenge.

Intelligent Training: Imagine assembling a carburetor composed of 15 intelligent virtual parts. As you try to put one piece into another, the piece could refuse, gently guiding your hand to the correct position. A part could squeak out if mishandled, could record the attempts to place it in a wrong position and offer diagnosis and immediate negative reinforcement.

Not all jobs become easy in VR, but programmable participation may well provide an idealized training environment . Specifying and knowledge engineering a task will still require massive effort, but once specified, the tasks themselves will be easy to teach. What-if scenarios, positive and negative reinforcement regimes, records of behavior and of common errors, weaknesses in the training sequence, lessons learned, in fact all aspects of training evaluation can be automated.

NATURAL SEMANTICS

VR input is coupled to natural behavior. The rule of thumb is that a child should be able to command the system. No command lines or mouse clicks, rather, simple walking and pointing and speaking and grasping.

VR makes sense when what a participant sees and hears has a meaning that does not require explanation. Consider a house. A textual description requires reading skills, a procedural database (lists of coordinates) requires decoding, a picture can be recognized immediately but is not interactive. A house in VR is most like a physical house, you can look at it while walking around it, you can walk in the front door and explore each room. A physical house has natural semantics, no one needs to explain it. Natural semantics is what a child learns before symbolic schooling.

Most sciences have natural semantics, most symbolic studies (the three Rs) do not. But, except for graduate school, almost all symbolic studies are an attempt to refer to natural (visceral) semantics. We read in order to build a picture of the world, we write in order to describe our world to others. Mathematics is a tool for solving measurement problems in the world. In the study of naive physics, folks are shown to have unrealistic (simplistic) models of behavior. Most of these studies actually measure a person's understanding of symbolic representations of physics. We should expect confusion. Put a kid on a baseball field and see if he ignores the concept of momentum.

Text does not fair well in VR, it is not constructed for interaction. The VR analog for text is natural speech. Mathematics can be transcribed into VR easily, either by the embodiment of problems in an experiential context, or by the representation of abstractions by concrete images.

The challenge to the design of training materials is to place learning in a natural (although virtual) context, to make learning as-if-real. Rather than teaching a structure of symbols (such as algebra) and then teaching the meaning of that structure, in VR we will first teach meaning through experience, then (if necessary) teach the symbolic abstraction of our experiences. Manuals and written descriptions can be integrated into the simulated display of objects. More fundamentally, written materials may be unnecessary, replaced by direct experience with virtual objects.

CONSTRUCTIVISM

Virtual environments are not constrained to only viewing. The student can interact with objects and spaces in VR. The student can use tools to create new environments, to modify old ones, to take simulation exams, to fix errors, to play.

Rather than teaching a structure of symbols (such as algebra) and then teaching the meaning of that structure, in VR we will first teach meaning through experience, then (if necessary) teach the symbolic abstraction of our experiences. But the computer is an ideal tool for manipulating symbolic abstractions. Rather than teaching the abstraction, we may just teach how to use the VR tool, a natural interface with abstractions. VR is not a simulation of reality, it is a superset of reality, it is more than reality. this is easy to see from the programming perspective. To introduce gravity into VR, we introduce a property (mass) and then constrain (limit) the objects to a particular relationship between their masses. To introduce solidity, we constrain boundaries so that the insides of two objects do not occupy the same space. Simulation of physical reality in VR is always an act of decreasing its flexibility. One of the joys of VR is that it permits us the freedom to escape the bounds of the physical.

VR teaches active construction of the environment. Data is not an abstract list of numerals, data is what we perceive in our environment. Learning is not an abstract list of textbook words, it is what we do in our environment. The hidden curriculum of VR is: make your world and take care of it. Try experiments, safely. Experience consequences, then choose from knowledge.

THE RESEARCH AGENDA

To demonstrate the value of training in VR, we must establish two types of validity. First, does experience in VR transfer to similar experience in physical reality? Second, does experience in VR transfer to later experience in other VR tasks?

The question of transfer of learning to physical environments requires assessment of the adequacy of modeling the physical task, of the training procedure itself, and of the learning of the trainee. In helicopter maintenance training, for example, the match between the virtual model and the physical equipment, the sequence of maintenance training steps, and the performance of the maintenance trainee will each have to be factored and evaluated.

There may be information tasks for which VR is a naturally more comfortable environment. For example, recording and tracking the flow of supplies through-out a fleet might be better presented and understood as a virtual simulation rather than as a large pile of physical documents. When dealing with information, the question of training may best be posed as transfer between separate tasks in VR, without regard to a physical circumstance. Here the modeling question is not focused on learning, it is focused on understanding of existing information (visualization). Within a particular visualization approach, the training issue is one of generalizing the visualization to better perform information tasks when new data are presented by the same visualization technique.