The Promise of Virtual Reality

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Virtual reality may be one of the most important technologies in our future, producing a great leap forward in many fields. While most people now focus on VR's use in entertainment areas, its real impacts will be in the arts, business, communication, design, education, engineering, medicine, and many other fields.

Due to the importance of this emerging technology, I would like to dispel some misinformation about it and suggest some important applications it will have in the future. But first, let's get clear about what virtuality is.

Defining Virtual Reality

Virtual reality can be defined as a three-dimensional, computer-generated simulation in which one can navigate around, interact with, and be immersed in another environment. In this sense, "virtual" is derived from the concept of "virtual memory" in a computer, which acts "as if" it is actual memory. Virtual reality provides a reality that mimics our everyday one.

Since human beings are primarily visual animals, we respond much better to spatial, three-dimensional images than we do to flat, two-dimensional text and sketches. With three-dimensional images like those produced in virtual reality, we are better able to see patterns, relationships and trends. Virtual reality goes beyond mere static images to ones that we can navigate through and interact with in real time. We can look at things from any perspective. Virtual reality is also immersive -it draws you into the visualization.

Virtual reality is not just a set of devices, but a medium for expression and communication. Virtual reality is a means to create, experience, and share a computer-generated world as realistic or as fanciful as you would like. Head-mounted displays, data gloves, and other devices are only tools to help us experience this parallel world.

Other names for the concept of virtual reality include "artificial reality", "augmented reality" and "tele-presence". However, the term "virtual reality", or "VR", seems to have won out in common parlance. The term hooks us with the excitement of creating and experiencing different realities.

There is also an ongoing debate over exactly what virtual reality is and what it is not. Most observers agree that one necessary characteristic is that you can navigate in a virtual world with-some degree of immersion, interactivity, and a speed close to real time.

Hype and Reality

Right now, there is a great deal of hype surrounding virtual reality. The technology's present state of advancement has been overstated. Coverage in numerous magazines and newspaper articles, on TV shows, and

even in TV ads suggests that virtual reality is now fully developed. Unfortunately, this is not true.

Present virtual-reality visualizations are often low-quality and cartoonish. The picture we see may be jerky and not respond quickly to our movements. Few systems allow for tactile feedback -a sense of touch. Some people even question the physiological and psychological safety of virtual reality, particularly in entertainment.

However, the future of virtual reality is important and real. We should not abandon the technology because it does not yet fit our expectations. Virtual reality is with us now in a very early and rudimentary form. Its state of development has been likened to the space program in the 1950s or microcomputers in the 1970s. We are just beginning to see the potential of virtual reality.

Faster computers, better software, and new devices to inform our senses are expected to come rapidly onto the scene, improving virtual reality and increasing its utility. Better content and new applications will rapidly emerge in the years ahead. Virtual reality will come to us over the Internet, reducing the need for complicated and expensive stand-alone equipment. Don't let the hype fool you. Virtual reality is not fully here yet, but it will become increasingly important for individuals, companies, and our society as a whole.

Let's now consider some present and future applications of virtual-reality technology. Our time frame is in the range of the next 10 years and our list is far from being all-inclusive. Virtual reality' s uses are still being explored and defined. The only thing we can be certain of is that we'll be surprised and that we must remain open to surprise.

Virtual Reality Applications, Today and Tomorrow

Architecture and construction. Virtual reality is already showing its potential in the architecture and construction industries. A building can be created as a navigable, interactive, and immersive experience while still being designed, so that both architect and client can experience the structure and make changes before construction begins. It has been said that every building built today is actually a physical prototype, leaving little room for input or changes until after construction. Virtual reality would allow for an electronic prototype to be created and modified, so that costly changes during or after construction are avoided.

In the future, clients will want to experience their house or building in virtual reality before final designs are completed and construction begins. Beyond today's capabilities, clients will not only be able to see the structure, but hear sounds from within it, feel its textures, and experience its fragrances. Home builders and real-estate developers are particularly excited about the potential of virtual reality to sell their designs. Why build expensive model homes or demonstration spaces when prospective buyers can see the range of options electronically ? City planners will use virtual reality to consider various changes in the community, greatly assisting the work of zoning and planning boards.

Art. At present, you can "virtually" visit a number of actual art galleries and museums via the Internet. Recently, the Guggenheim and other museums conducted special exhibits of virtual-reality art works.

Virtual reality will change our conception of what constitutes art. A work of art may become a physically navigable, interactive, and immersive experience. You may travel into a virtual painting, which will actually be a mini-world for you to explore. You may interact with its elements, perhaps even change them. You may enter a sculpture gallery and interact with the art pieces. You will actually become part of the art as you interact with it.

Business. Already, several companies have created three-dimensional visualizations of the stock market. The stocks appear as upright cylinders (like a stack of poker chips) on a three-dimensional grid representing different sectors of the market. The cylinders (each with a company logo) will rise and fall with stock prices and spin at different speeds as an indication of each stock's sales activity. With this arrangement, a stock broker or analyst can quickly see patterns for a market sector as a whole, as well as the activity of specific stocks. A click on a company's cylinder can bring in-depth information to the screen and give the broker an opportunity to rapidly buy or sell a stock.

The use of virtual reality in stock market trading will greatly increase in the future. Those companies trading on various stock markets globally will require this virtual-reality application to identify trends and make trades more rapidly. They will, in fact, be interacting with the stock market in real time. Their work will be much like playing a large and complex video game.

Some virtual-reality software developers have been working on a product called FlowSheet. It will be like a spreadsheet, but will show more than mere numbers displayed in two-dimensional columns and rows. Rather, it will give a three-dimensional depiction of numbers with varying sizes, shapes, colors, and spatial relationships. In the future, FlowSheets will allow for much clearer and quicker analysis of alternatives, relationships, and trends.

Still other software developers are considering the benefits of creating DataSpaces, a step beyond the database. Like the FlowSheet, DataSpaces represents information sources as objects that differ in size, color, shape, and spatial relationships. You will surf through information in a world of three-dimensional objects, selecting the information you need by clicking on the appropriate one. In the next few years, you will be able to conduct this kind of search on the Internet using a recently accepted standard called Virtual Reality Modeling Language (VRML).

Using a combination of the FlowSheet, DataSpaces, and other virtual-reality software, companies will be able to simulate their entire operation. Different aspects of operation, such as production, inventory, sales, and productivity, can be represented in three dimensions for analysis. Various "what-if" scenarios could be proposed. A company could also use this system to watch its actual operation in real time rather than in simulation.

Disabilities. Several organizations, such as Prairie Software and Hines Veterans' Hospital in Illinois, are experimenting with virtual reality to confirm the accessibility of buildings for people with disabilities. One university, Oregon Research Institute, has created a program that teaches children to operate wheelchairs. Another, the University of Dayton, is using virtual reality to train mentally retarded students how to ride a bus. Just beginning are many other applications aimed at allowing people with disabilities to experience worlds they cannot currently explore due to their physical limitations.

In the future, it will be standard procedure, if not mandatory, to use virtual reality in private homes and public places to test accessibility before plans are approved. People with disabilities will be able to visit new areas virtually before they visit them in the everyday world. They will also be able to experience skiing, hang gliding, and other sports in virtual worlds.

Education and training. VR is just beginning to be applied in education and training. Students can study anatomy or explore our galaxy. Some training applications relate to health and safety. One application from World Builder of Rochester, New York, allows trainees to walk through a virtual factory and learn about health hazards-a more engaging experience than reading a manual or attending a lecture.

In the future, students will be able to learn through studying in virtual worlds. Chemistry students will be able to

conduct experiments without risking an accidental explosion in the lab. Astronomy students will be able to visit a range of virtual galaxies to study their properties. History students will be able to visit different historical events and perhaps even participate in the action with historical figures. English students could be on stage at the Globe Theater as it was when Shakespeare's plays were first presented. They will also be able to enter into a book and interact with its characters.

Virtual reality will also be used in teaching adults. Trainees in a wide variety of environments will be able to safely try out new techniques. They will be able to learn by doing tasks virtually before applying them in the real world. They will use these practice tasks in hazardous environs and also practice dealing with emergencies on the job. However, much remains to be done to bring virtual reality fully into the classroom or the training facility.

Engineering. Engineers of all descriptions are already using virtualreality simulations to create and test prototypes. Each of the Big Three automakers is using some form of virtual reality to test new models. In the aerospace industry, the new Boeing 777 was the first aircraft to be designed and tested using virtual-reality technology.

Physical prototypes take a great deal of time to produce and are very costly. Changes to electronic or simulated prototypes can be done rapidly and inexpensively, shortening development time. Hoping to save money in prototyping and avoid cost overruns, the U.S. military has even coined the phrase, "Sim it before you build it !".

In the future, nearly every engineering pursuit will use virtual-reality prototypes so that designs can be shared, evaluated, and modified with input from both co-workers and customers. Even the manufacturing process and expected repairs will be simulated, saving money and aggravation. Given advances in electronic networks, virtual work benches will be created with engineers in distant locations around the globe working in teams to design products.

Entertainment. Virtual reality is already being applied in entertainment. Location-based entertainment centers are cropping up in major cities around the globe and traveling virtual-reality entertainment shows are on the road. Soon, nearly all video arcades will be VR centers; all games will be 3-D, interactive, and immersive.

While the number of such entertainment centers will increase in the future, home-based virtual reality will also grow dramatically. Current systems are primitive, due to a lack of computing power and the high cost of most virtual-reality equipment, but advanced virtual reality is set to invade the home entertainment scene in the years ahead. While stand-alone entertainment systems will be offered, perhaps the most important form of home VR will come over the Internet, and with it the potential for virtual reality to promote human interaction over wide distances.

Imagine an adventure game in which you are immersed in a three-dimensional world, interacting with other participants. It can become a real, role-playing event. Imagine a movie in which you are a participant interacting with the plot and other characters. While these kinds of entertainment have been seen as separating participants in the past, in the future they may be seen as a new kind of socializing, one which may lead to richer relationships in the "real" world.

Marketing. Virtual reality is just beginning to be used by companies who want customers to experience their products and to understand them better. They've found that a new technology, such as virtual reality, draws people to their exhibits and involves them with a product much more than standard displays. Cabletron, a cable network company in Rochester, New Hampshire, has customers travel through their network virtually. Sopporo, a beer company in Japan, allows customers to visit its production plant to experience the beer-making process in virtual reality.

In the future, virtual reality will be used to develop and test products with much greater customer involvement. A company will be able to create products, gain customer feedback, and then modify the products much more rapidly and inexpensively. The prototype will only be an electronic idea that they can directly test before creating the physical product. This electronic prototyping may also lead to individualized products that are portrayed in virtual reality, customized by the individual, and then transmitted electronically to a production facility.

Medicine. Virtual reality is just beginning to be used in medicine and medical research. The University of North Carolina (UNC) uses it in biochemical engineering. They test the docking of molecules using visual and auditory displays and a force-feedback device. Virtual reality is also being used at UNC and other locations to practice aiming X-rays before cancer treatments of that type are performed. Several companies, such as High Techsplanations of Rockville, Maryland, and Ciné-med of Woodbury, Connecticut, are creating virtual bodies, a kind of "body electronic", to enhance medical training.

In the future, medical students will study anatomy by dissecting virtual cadavers-a much more cost effective and efficient way of studying the human body. Medical students and surgeons will practice virtual surgery before attempting a new procedure. They may even practice an operation for a specific patient, whose unique body characteristics have been scanned into the computer. Different diseases and medical emergencies can also be simulated to test a medical student's or doctor' s knowledge regarding treatment.

On a different front, virtual reality could be used for treatments in guided visualization. Patients could use virtual reality to assist in visualizing a part of their body for healing. Likewise, virtual reality could help improve relaxation techniques, providing a pleasant world in which to relax.

Military. One of the first applications of virtual reality was in flight simulators. Today, these applications are used not only for aircraft simulation, but also for ships, tanks, and infantry maneuvers. With the advent of networked virtual reality, the U.S. military is able to stage SimNet tank battles between various military installations around the world over what it calls the "Defense Simulation Internet". First used extensively in the Gulf War, SimNet allowed nearly every flight and battle to be conducted in virtual reality before the real war began. Records of Gulf War events have themselves been turned into a large-scale simulation that can test the skill of military leaders and soldiers.

In the future, every aspect of warfare will be practiced in simulation before being conducted in a real-world situation. Simulations will become so real, it will become impossible to distinguish the real from the simulated. While there are dangers here in misunderstanding the real from the simulated, it may also be possible for combatants to see the folly of their aggression before a conflict begins. Perhaps we could substitute a virtual war for a real one.

Religion. At present, religion does not seem to be making much use of virtual reality. However, there is potential for VR in both religious education and experience. One Christian religious denomination reportedly has been having discussions with a virtual-reality developer about creating biblical scenes in virtual reality. One author, Richard V. Kelly of Digital Equipment Corporation, has proposed the creation of religious experiences from all of the world's various religions.

In the future, we can expect to see an array of religious experiences via virtual reality. A Christian student may be able to experience being at the Sermon on the Mount or even the Crucifixion, among other events in that faith's history. He or she could also explore events in Judaism or Buddhism. Even more profound mystical experiences, such as the prophecies of Ezekiel or a revelation from eastern religions, could be created in virtual worlds.

Sex. Virtual sex is a hot topic. It has been labeled teledildonics by several authors. At least one virtual-reality company, Thinking Software of Woodside, New York, is selling a "cybersex machine", and there are some multimedia sexual experiences that come close to virtual reality. These products are not very advanced, however, and many obstacles must be overcome to produce a satisfying tactile experience. But expect great strides to be made in creating advanced "sex machines" using virtual-reality technology. There is too much potential profit in these applications for them not to be pursued.

In the future, virtual sex will be either a stand-alone or networked experience. Expect virtual reality to be used in treating sexual dysfunction, communing with a loved one at a distance, and for sexual exploration or, unfortunately, exploitation. Today's 900 number hotlines and sex sites on the Internet will be tame by comparison. Expect major controversy over this topic from lawmakers, religious groups, and proponents of family values.

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These are just some present and future applications of virtual reality. As you can see, there are many potential applications for virtual reality. Perhaps, in the future, we will only be limited by our imagination regarding the uses of virtual reality. Virtual reality is neither good nor bad. It is a new tool that will have important implications in our future.

In working in the field of virtual reality, I have found a very important aspect of it that is often overlooked. In order to create virtual worlds, one must have an in-depth understanding of how our everyday world works. Perhaps one of virtual reality's greatest gifts will be helping us to understand better our own reality.

Examples

Students on Mars [2007]

The students stand on the surface of Mars, surveying the landscape with their all-terrain vehicle beside them. They have to identify the unusual rock formations before them, the ones with hues of orange and purple. A deep valley with a jagged rim is off to their left. They have to check their map of Mars to find its name and mark its coordinates. They leap into the vehicle and move toward the towering mountain ahead. Colors of the planet's surface and their perspectives change as they look around. Their leader challenges them to identify their surroundings.

All of a sudden, a voice comes over their headphones -"Time to return to Earth". Removing their virtual-reality glasses, the students are back in the classroom lab. The voice is that of their teacher. "Remember to be ready for your Mars terrain test tomorrow", he says. "You will be quizzed on the details of what you have just seen".

These sixth-grade students are studying science using virtual reality in their classroom. They have traveled virtually to study Mars on PlaNet, a communication and educational network. While no human has actually gone to Mars yet, several orbiting probes have mapped the terrain and a robotic roving vehicle on the surface has provided live pictures. These visualizations are turned into a virtual-reality visualization of the red planet for

scientific and educational purposes. It is an experience that they will never forget.

The students are particularly excited because, in the next year, a new rover will land on Mars and offer live tours of additional regions of the planet's surface through virtual reality's "telepresence". They will actually be able to maneuver the vehicle across the planet to explore its secrets. Stereo cameras will transmit the rover's travels back to Earth while they control its path. They will move in any direction, zoom in on interesting finds, and map the terrain more carefully. In a sense, they will be exploring Mars just as they expect live humans will in the next 20 years. Today's lesson will help prepare them for that event.

Vira's New Home [2006]

Vira carefully inspects her new house with her architect and contractor. The spaces that her architect had designed seem fine, except that the kitchen counters are in the wrong place. With her architect's help, she rearranges the counters until they meet her needs. They walk through the rest of the house, inspecting its various spaces and the flow between spaces. Vira turns on the entertainment system and considers how various sounds will travel throughout the house.

Vira rearranges the furniture in her living room to see how it could take advantage of natural light and the lamps that she has chosen. She views and feels the textures of her couch. She even goes into her bedroom and considers how the light would strike it at various times of the day during different seasons. She is particularly pleased when she looks out the windows into the garden that she will have below. Turning to her architect and her contractor, Vira says, "I like the house. You can make the changes I noted and build it now. Thank you for showing me exactly what the house will be like. I could never have understood it from your floor plans".

They step out of the VR Cave into her architect's office and flip a switch. Vira's "house" disappears behind them. Four blank walls, a floor, and a ceiling are all that remain. Vira has participated in the design of her house using virtual reality and has inspected the house before it is even built. The changes she makes are automatically transferred into construction documents, which in turn are translated into a set of building materials with a new cost estimate for her approval. It is "as if" she has already lived in the house.

My Company, Live and Virtual [2010]

Bob eases into his seat on the plane and pulls out his computer, connects his headset, and switches it on. A figure in the form of his assistant, George, pops onto the headset's screen, appearing just as he had seen him 20 minutes ago. "Where would you like to go ?" asks George. Bob replies, "take me to the Dallas plant".

In an instant, the factory is before him, just as it would appear if he were overlooking it from a platform. Display boxes appear to the side of the visualization, showing him the plant's activity. "George, please focus on inventory and show me today's flow of parts. Then, overlay the plan on our actual flow". The visualization shows him that they are right on target. "Thanks, George", he says. "No need to run a simulation to improve our flow. We have just enough parts to complete the next cycle". Bob had worried that they had understocked parts at the distant assembly plant, but a plea to his associates in recent communications had corrected the potentially damaging situation.

"Now George, would you take me to that relaxation program you've been raving about ?" Bob lays his head back on the seat cushion as a scene on a beach in Tahiti surrounds his consciousness. The sun is shining, the sand is warm, and the wind blows softly. Bob hears the sound of waves lapping on the beach. He feels far away from the cold winds of the Chicago winter he has just left.

Bob has traveled to one of his distant manufacturing plants using virtual reality. He has connected through the

VR SatNet and used his computer agent George, appearing in the form of an avatar (a virtual representation of a being) on the screen to guide his journey. Everything is displayed in three dimensions and Bob is able to interact with the environment in an immersed state. Having finished his work, George provides Bob with a recently created virtual relaxation experience that would relieve Bob's stress and speed his journey to Hong Kong.