A Survey on virtual world

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Abstract- Virtual reality is simulated reality. Computers introduced us to the virtual world. In the virtual world one can assume any identity and no one will be the wiser. Such identities are called 'avatars'. This is part of its attraction. But it also has its dangers. Many youngsters today live more in the virtual world than in the real world. This has made sociopaths out of some of them. They are so used to interacting with people in the virtual world that they no longer know how to interact with real people. Virtual worlds like Second Life are becoming important tools for, among other activities, socialization, social networking, entertainment, collaboration, and business development. These environments offer information systems researchers a unique opportunity to study how these environments are built and managed by operators, how they are used and misused by users, and the impact that they have on users, communities, organizations, and societies at large. The paper provides an introduction to this topic and offers a survey on virtual worlds based on insights offered by several academics and practitioners who are actively involved in building, managing, and using virtual worlds.

Index Terms- virtual worlds, synthetic worlds, multi-user virtual environments, online games, virtual reality, human computer interaction, Second Life, research frameworks,v-CRM" (Virtual Customer Relationship Management).

I. INTRODUCTION

Three-dimensional virtual worlds, also called synthetic worlds, are multimedia, simulated environments, often managed over the Web, which users can "inhabit" and interact via their graphical self-representations known as "avatars." In a virtual world, the users, represented as avatars, experience others as being present in the same environment, or "being there together" even though they are geographically distributed. Users converse in real time through gestures, audio, text-based chat and instant messaging communication (e.g. Meadows, 2008). These virtual worlds support communication and collaboration more effectively than two-dimensional web-based environments by extending the user's ability to employ traditional communication cues of face-to-face interactions such as gestures, voice, having visual presence and mutual awareness in real time, and sounds, in a way that two-dimensional (web-based) environments do not (Bronack, et al., 2008; Eschenbrenner, et al., 2008). Today virtual worlds are being used in many applications: education and training, social networking, entertainment, gaming, marketing, and commerce.

Nowadays computer graphics is used in many domains of our life. At the end of the 20th century it is difficult to imagine an architect, engineer, or interior designer working without a graphics workstation. In the last years the stormy development of microprocessor technology brings faster and faster computers to the market. These machines are equipped with better and faster graphics boards and their prices fall down rapidly. It becomes possible even for an average user, to move into the world of computer graphics. This fascination with a new (ir) reality often starts with computer games and lasts forever. It allows to see the surrounding world in other dimension and to experience things that are not accessible in real life or even not yet created. Moreover, the world of three-dimensional graphics has neither borders nor constraints and can be created and manipulated by ourselves as we wish – we can enhance it by a fourth dimension: the dimension of our imagination.

But not enough: people always want more. They want to step into this world and interact with it – instead of just watching a picture on the monitor. This technology which becomes overwhelmingly popular and fashionable in current decade is called Virtual Reality (VR). The very first idea of it was presented by Ivan Sutherland in 1965: "make that (virtual) world in the window look real, sound real, feel real, and respond realistically to the viewer's actions" [Suth65]. It has been a long time since then, a lot of research has been done and status quo: "the Sutherland's challenge of the Promised Land has not been reached yet but we are at least in sight of it" [Broo95].

Let us have a short glimpse at the last three decades of research in virtual reality and its highlights [Bala93a, Cruz93a, Giga93a, Holl95]:

• Sensorama – in years 1960-1962 Morton Heilig created a multi-sensory simulator. A prerecorded film in color and stereo, was augmented by binaural sound, scent, wind and vibration experiences. This was the first approach to create a virtual reality system and it had all the features of such an environment, but it was not interactive.

• The Ultimate Display – in 1965 Ivan Sutherland proposed the ultimate solution of virtual reality: an artificial world construction concept that included interactive graphics, force-feedback, sound, smell and taste.

• "The Sword of Damocles" – the first virtual reality system realized in hardware, not in concept. Ivan Sutherland constructs a device considered as the first Head Mounted Display (HMD), with appropriate head tracking. It supported a stereo view that was updated correctly according to the user's head position and orientation.

• GROPE – the first prototype of a force-feedback system realized at the University of North Carolina (UNC) in 1971.

• VIDEOPLACE – Artificial Reality created in 1975 by Myron Krueger – "a conceptual environment, with no existence". In this system the silhouettes of the users grabbed by the cameras

were projected on a large screen. The participants were able to interact one with the other thanks to the image processing techniques that determined their positions in 2D screen's space.

• VCASS – Thomas Furness at the US Air Force's Armstrong Medical Research Laboratories developed in 1982 the Visually Coupled Airborne Systems Simulator – an advanced flight simulator. The fighter pilot wore a HMD that augmented the out-the window view by the graphics describing targeting or optimal flight path information.

• VIVED – Virtual Visual Environment Display – constructed at the NASA Ames in 1984 with off-the-shelf technology a stereoscopic monochrome HMD.

• VPL – the VPL company manufactures the popular Data Glove (1985) and the Eye phone HMD (1988) – the first commercially available VR devices.

• BOOM – commercialized in 1989 by the Fake Space Labs. BOOM is a small box containing two CRT monitors that can be viewed through the eye holes. The user can grab the box, keep it by the eyes and move through the virtual world, as the mechanical arm measures the position and orientation of the box.

• UNC Walkthrough project – in the second half of 1980s at the University of North Carolina an architectural walkthrough application was developed. Several VR devices were constructed to improve the quality of this system like: HMDs, optical trackers and the Pixel-Plane graphics engine.

• Virtual Wind Tunnel – developed in early 1990s at the NASA Ames application that allowed the observation and investigation of flow-fields with the help of BOOM and Data Glove.

• CAVE – presented in 1992 CAVE (CAVE Automatic Virtual Environment) is a virtual reality and scientific visualization system. Instead of using a HMD it projects stereoscopic images on the walls of room (user must wear LCD shutter glasses). This approach assures superior quality and resolution of viewed images, and wider field of view in comparison to HMD based systems.

• Augmented Reality (AR) – a technology that "presents a virtual world that enriches, rather than replaces the real world" [Brys92c]. This is achieved by means of see-through HMD that superimposes virtual three-dimensional objects on real ones. This technology was previously used to enrich fighter pilot's view with additional flight information (VCASS). Thanks to its great potential – the enhancement of human vision – augmented reality became a focus of many research projects in early 1990s.

II. BACKGROUND

Virtual worlds are increasing in popularity and have garnered significant attention from the public at large, from businesses and other organizations, and from scholars in disciplines as diverse as law, sociology, psychology, math, and, more recently, information systems. Virtual worlds are growing not only in popularity but also in numbers. While no reliable statistics are yet compiled on the industry, hundreds of publicly accessible virtual worlds exist (e.g., visit www.virtualworldreview.com for a list of only a few such environments) and firms like Forterra Systems (www.forterrainc.com/) build and manage countless numbers of private virtual worlds used for corporate or military applications. These environments have been designed for a variety of functions as well as a diverse set of target markets. Environments such as Second Life, There, and Active Worlds are general purpose and targeted to adults, while other environments such as Disney's Virtual Magic Kingdom (VMK.com), General Mill's Millsberry, and Sulake Labs' Habbo Hotel are focused on specific ages, demographics, and functional applications.

Virtual reality (VR) is not a new concept. The origins of VR can be traced as far back at least as "The Ultimate Display" [85], a seminal paper by Ivan Sutherland that introduced the key concepts of immersion in a simulated world, and of complete sensory input and output, which are the basis of current virtual reality research. The following challenge was set:

The screen is a window through which one sees a virtual world. The challenge is to make that world look real, act real, sound real, and feel real [85].

Sutherland's challenge, which can be summarized as offering presence simulation to users as an interface metaphor to a synthesized world, has become the research agenda for a growing community of researchers and industries. The motivation for such a research direction is twofold. From an evolutionary perspective, virtual reality is seen as a way to overcome limitations of standard human-computer interfaces; from a revolutionary perspective, virtual reality technology opens the door to new types of applications that exploit the possibilities offered by presence simulation.

2. What is Virtual Reality (VR)? What is Not Virtual Reality?

Virtual Reality (VR), also known as 'artificial reality', 'artificial worlds', 'virtual worlds', 'virtualities', is a fully-immersive, absorbing, interactive experience of an alternate reality through the use of a computer structure in which a person perceives a synthetic (i.e., simulated) environment by means of special human-computer interface equipment and interacts with simulated objects in that environment as if they were real. Several persons can see one another and interact in a shared synthetic environment.

Many people, mainly the researchers use the term Virtual Environments instead of Virtual Reality "because of the hype and the associated unrealistic expectations" [Giga93a]. Moreover, there are two important terms that must be mentioned when talking about VR: Telepresence and Cyberspace. They are both tightly coupled with VR, but have a slightly different context:

• Telepresence – is a specific kind of virtual reality that simulates a real but remote (in terms of distance or scale) environment. Another more precise definition says that telepresence occurs when "at the work site, the manipulators have the dexterity to allow the operator to perform normal human functions; at the control station, the operator receives sufficient quantity and quality of sensory feedback to provide a feeling of actual presence at the worksite" [Held92].

• Cyberspace – was invented and defined by William Gibson as "a consensual hallucination experienced daily by billions of legitimate operators (...) a graphics representation of data abstracted from the banks of every computer in human system" [Gibs83]. Today the term Cyberspace is rather associated with entertainment systems and World Wide Web (Internet).

III. THE PERSPECTIVES

The following includes remarks summarizing the presentations made by the panelists. The majority of the panelists included comments about their individual presentations as well as about questions that were addressed to them by the audience.

David Bray and Benn Konsynski: Structure and Organization of Virtual Worlds

Who's running the Show? Governance of Virtual Worlds:

More than 15 million people now inhabit virtual worlds. In this section, we consider the question of who really is "in control" in virtual worlds: real-world organizations or virtual citizens?

Since most virtual worlds are operated by a single real-world firm, to date the answer to who is in control has been the private, real-world firm hosting the virtual world. Dotsoul.com and other open-source efforts provide intriguing virtual worlds attempting to empower the virtual participants themselves to help define property rights and rules. Other virtual worlds clearly are focused on corporate ownership and profit. Free and unregulated virtual worlds can be problematic, as the chief virtue of Second Life is also its most glaring flaw: Everyone is free to create anything they like, which can result in ugly sprawl and ugly developments. A potential parallel "Tragedy of the Commons" could arise in virtual worlds [Dawes et al. 1986; Ostrom 1991; Hof 2006a].

Yet recent activities have shown a maturing in virtual worlds, as virtual designers like Anshe Chung and Aimee Weber begin to realize that their virtual customers want some order and regulation. Real-world corporations are asking Second Life to consider more regulation to ensure the stability of the Linden dollar before they invest further in a virtual world. It could be that a combination of virtual citizens and businesses in virtual worlds may endogenously produce additional laws and hybrid, inter-world social institutions designed to stabilize virtual worlds [Kharif 2006].

We posit that virtual worlds represent an interesting intersection of three parties wrestling for power, influence, and authority in these relatively new spaces (Figure 1). Specifically, these parties are: (1) corporations, representing virtual businesses (V-BIZ) to include economic and business interests; (2) governments, representing virtual governments (V-GOV) to include political and legal interests; and (3) voxpopuli , representing a heterogeneous third party, distinct in its dissociation from either corporate or government interests, and instead attempting to speak on behalf of "digital citizens" in virtual worlds.

We also posit that these three parties—as they wrestle for power, influence, and authority in virtual worlds— embody similar (though less pronounced) struggles for power, influence, and authority as in the real world. Virtual worlds, due to their newness and digitally liberating features, including anonymity and dissociation with physical form, present relatively less pronounced consequences for actors (versus the real world). Yet the power-based outcomes obtained in virtual worlds represent salient economic and legal influences; to wit, Second Life sees an average of $70 million real U.S. dollars spent monthly.

Given fewer adverse consequences for losers (i.e., reduced risk to both individuals and institutions), combined with salient rewards for obtaining power, virtual worlds provide more attractive areas for power and influence struggles.

Edward M. Roche and John Lester: An Overview of the Summer Meeting's Research Roadmap

Virtual worlds offer a broad range of research opportunity. On one hand, there are many issues that are IT related. These concern the underlying technology infrastructure and how it is designed and managed. But the research does not stop here. There also are legal, psychological, sociological, media and business strategy issues on the horizon. Even national security might be involved (Roche, 2008). Recent press reports have warned about possible international criminal and terrorism issues that may arise from virtual worlds. So there is a broad range of concern and thus an ample field from which to pick a research topic. The following is a synopsis of the research issues discussed at ICIS.

Technology Performance of Virtual Worlds:

The evidence thus far indicates that virtual worlds do not scale very well. When too many avatars attempt to participate at once, responsiveness lags, and rendering of the environment becomes more problematical. In our meeting at Columbia University, even with an Internet bandwidth of 100Mbps+, we were experiencing up to a 20-second delay in audio between our live audience and the avatars who were joining the meeting. This may indicate that a variety of technical issues have not been solved in the design of the application. What are the methods of optimizing performance? How can required network capacity be defined as a function of virtual world loading of avatars? What is the optimum partitioning of server space? How is response time determined, and what is its psychological optimum? What are variations in design that yield different performance levels? How much is cached on the local end-user device? What is the most efficient graphics rendering system? What algorithms can be discovered to help a virtual world adjust to rapid and dramatic changes in the number of participants at any one time? Finally, there is an important research discussion around technical standards for virtual worlds. Will Open Source gain ground? How will standards emerge and what should they be? There is, of course, a theory that explains emergence of standards, but no one yet has applied it to virtual worlds.

Defining the Entry Strategy:

If a firm (or any organization) decides to take the plunge into virtual worlds, what paradigm do they use to make the decision (Roche 2007)? Expending whatever resources will be required must be justified to management, but how? Several paradigms fit. First Mover Advantage theory might be used. A firm may wish to move into virtual worlds to preclude any advantage that its competitor might obtain by getting there first. But does the first mover advantage really exist for virtual worlds? Professor Clemmons' Competitive Necessity Theory [Clemons 1991] also may be applicable. If a firm's competitors move into a space, and gain an advantage, then this forces the firm to follow, or lose the advantage. This is even more compelling if the competitor is picking up new customers. But have we seen real competitive advantage yet in virtual worlds? If not, why? If not yet, then when? Another perspective is simply R&D experimentation.

Most firms have an experimental arm, and several are experimenting with virtual worlds. The majority of firms have an entry strategy that is exploratory in nature. They can test new products and ideas. An important research question would be to examine and address the entry strategy problem.

Defining the Corporate Purpose:

Closely related to strategy is the question of purpose, or application. Already researchers have identified a range of possibilities. Some firms are using virtual worlds simply as a "showcase." They build a presence to show off, even if it is for the time being merely a cost write-off. Others are focusing on advertising. Panasonic constantly runs video commercials inside Second Life. But where are the advertising metrics? What type of consumer lurks behind the avatars? Are they middle-aged, living in suburbs with two kids, driving an SUV, watching a DVD player, and earning an income of $65,000 to $150,000 per year? No one really knows, and until researchers find ways to understand this, it is difficult to predict how well advertising will work, at least advertising as we know it now.

Another application is "v-commerce" or "v-customer service", including "v-CRM" (Virtual Customer Relationship Management). The idea is to service your customers in a virtual world, or enable them to establish "customer communities." But there are a host of problems researchers need to solve. One issue is how to verify if the avatar really is your customer, and thus entitled to see private or sensitive information on their account. There is also the accompanying slew of issues around cost and efficiency; that is, can a virtual world be as efficient as a call center?

Globalization of operations is a fact of life. Some firms view virtual worlds as a new way to improve their global operations by serving as a new collaboration platform to help coordination. Here, the theory is simply the old story of using a new technology to improve operations. But does anyone yet have evidence on this?

Who Is in Charge?

For those interested in the organizational theory of the firm, virtual worlds raise many issues. How does one manage a virtual world? Is it done with a corporate committee? If so, who is on it? Does the Internet portal team already in place take the lead? Is it a sales and marketing issue? Does the corporate strategy group get involved? Perhaps different groups are involved at different stages of the process; first strategy, then an IT or customer service operations group after the virtual world is set up and running? Who will manage and underwrite the budget? What does Legal need to review and approve? Perhaps by using a series of case studies, researchers could get a sense of how this is done, and how it best can be done. For the time being, however, most firms are flying blind and need research to point the way.

Selecting the Right Virtual World:

One team of IBM employees has been quoted as saying that they were researching “more than 1,000” virtual worlds. Others are reporting a smaller number of environments. We may not know the exact number, but there is agreement that virtual worlds are highly differentiable. Some like Second Life and World of Warcraft have broad appeal, at least for now. Others are being developed for the military. Some appeal to children from the ages of 8-13. Some are being rolled out for the elderly or for veterans with serious injuries. At the ICIS meeting, John Lester from Linden Lab demonstrated how severely handicapped people are using Second Life to "live a life they really want."

The research question centers around how to make the choice. Does one use a psycho-graphic approach and attempt to match your customer profile against a particular virtual world? Is a portfolio approach best; i.e., where bets are made on several virtual worlds, perhaps for different customer segments? Is it better to choose a virtual world that is completely private, operating as a closed community under your control, or one open to the public? What are the pros and cons of each alternative?

Certainly research needs to apply what we know about decision theory to these questions. Essentially, there is a need to match two sets of factors: those describing the adopter, and those describing the virtual world. But what factors? Here is where the inherent "social encoding" of virtual worlds comes into play. Virtual worlds are 100-percent engineered environments, and nothing is random. The researcher must understand how the virtual world is programmed to work, e.g., what avatars can do and not do and why. A general model is needed that maps virtual world characteristics against adopter needs.

3. The future of VR

The future of every new technology, including virtual reality, must be considered in two different aspects: technological and social. Technological aspects include new research directions and potential use of them for scientific aims. Social aspects include the influence of new inventions on people: individuals and society as a whole.

3.1. Research directions in VR

The idea of the ultimate virtual environment as stated by Sutherland [Suth65] means that VR should be indistinguishable from “real” reality (RR). Most of today’s VR applications do not conform to reality and have poor quality, but are still very useful and persuasive. Without doubt VR has a big potential, but must be improved a lot to allow more comfortable and intuitive interaction with virtual worlds. It does not have to simulate reality in every inch of existence: for training, the simulation should closely match real operating conditions, while e.g., in the UNC’s nanomanipulator application we do not even have any reference to reality (since humans cannot experience the interaction with molecules in real life).

Independently from the application and its purpose, human factors must be considered or the system will fail to be sufficiently comfortable and intuitive. There is need for mechanisms allowing people to easily adapt themselves and their behavior from VR to reality and vice versa. To address these requirements better than current systems do, a lot of research must be carried out and new technologies must be developed [Fuch92, Broo94]. Therefore Andries van Dam called VR a “forcing function” [VanD93].

3.1.1. Ergonomics of visual displays

Up to now, the major interest was paid to visual feedback and visual display technologies. Nevertheless the quality of nowadays shipped HMDs is far from ideal: resolution is significantly below eye’s resolving capability, luminance and color ranges do not cover the whole eye’s perception range (brightness range and gamut respectively), and finally the field of

view is relatively narrow. All these disadvantages make virtual worlds appear “artificial” and unreal, which severely contributes to the simulator sickness.

Despite continuous improvement of operational parameters, LCD- and CRT-based HMDs (currently at 1280x1024 resolution on 1.2”x1” area [Burd94]) will not offer the ultimate quality. To overcome these miniaturization problems a competitive solution was presented recently by HITLab – a virtual retinal display [Koll93, Tidw95]. It uses a laser beam that projects images directly on the user’s retina. Nowadays this technology offers approximately the quality of an average LCD screen. Yet, it is very promising: theoretical limits of such displays are essentially equal to the limits of the human eye.

An alternative approach for presenting images to VR user(s) are large projection screens. Images can be seen with bare eyes, have better brightness and resolution than typical HMDs. Stereo viewing is possible with light and comfortable LCD shutter- or polarization-glasses. For the full immersion (360˚ look around) CAVE-type displays or recently introduced domed projection screens can be used [Lant95]. Toshiba Corporation has lately developed a “volume scanning” display consisting of many slices of semi-transparent LCD screens. This new technology allows three-dimensional viewing of stereoscopic images without any additional equipment [Kame92, Kame93].

IV. 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 foryou 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.

Busines:. 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 Flow Sheet. 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, Flow Sheets 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 Flow Sheet, 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 Flow Sheet, 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.

4.1 The Promise of Virtual Reality

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.

V. Concluding Comments

While virtual worlds have been on the developmental radar for some time, it is only recently that the critical convergence of technical capacity and developer interest have enabled the creation of virtual worlds capable of attracting participants from the broader population. The current models of virtual worlds, in both the social networking and gaming domains, offer relatively attractive and easy to use platforms that have created demonstrable public interest in the virtual world phenomenon. As participation continues to increase, and as technologies make these worlds ever more accessible, the scale and scope of research opportunity and market exploitation grow exponentially. The research questions articulated here, hopefully, anticipate the emerging importance of the phenomenon and provide a rough schematic for its exploration.

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