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April 2, 1996
Date
Virtual Reality: The Force Behind the New Paradigm
Shift in Health Care Delivery

A Thesis
submitted to the Faculty of
the School for Summer and Continuing Education
in partial fulfillment of the requirements for the
degree of
Bachelor of Arts in Liberal Studies

By

Nancy Jo Kloberdanz

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Virtual Reality: The Force Behind the New Paradigm Shift in Health Care Delivery

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ABSTRACT

Welcome to the virtual reality health care frontier. This environment is filled with the potential to unlock the unique mysteries of science that hold the secrets of humanity. The potential applications of virtual reality in the medical arena will only be limited by one’s imagination. Perhaps, it will be the technology of virtual reality that fulfills societies quest for youth and immortality.

Soon, not only will people be linked throughout the U.S., but the virtual medical communities will be globally linked in cyberworld. In this computer-linked culture, health care professionals in the U.S. medical community will be able to bring health care to rural areas of our country that do not have easy access and also state of the art health care to other countries. Many will applaud this undertaking. However, there are those individuals who are concerned by the over population of the planet and they will not support this endeavor.

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Through the collected efforts of many, the vision of virtual reality has been realized. Chapter I explores this creative endeavor.

The technology of virtual reality will forever change the U.S. health care environment. No longer will man depend solely on human health care providers for their medical treatments. Now, U.S. society will begin to experience a growing dependance on the compatible alliance of man and machine to meet their health care needs. Chapter II discusses the development of virtual reality and the tools that are being used to facilitate the use of virtual reality in the medical community.

Virtual reality has the potential to greatly enhance health care delivery. The virtual reality health care frontier offers individuals the opportunity to more actively participate in their health care by easily learning about their disease process. Health care professionals have also found a new arena in which to participate in a current intellectual exchange of knowledge. Chapter III explores how virtual reality can facilitate in the diagnosis, medical treatment, surgical intervention and rehabilitation of a human.

New applications of science in the medical arena are never without ethical controversy. Due to the very nature
of the new virtual reality health care frontier, controversy over its uses are sure to raise ethical questions. I have addressed the issues of equal access and distributive justice, informed consent, accountability man or machine, and privacy in chapter IV.

Chapters V and VI address the cost benefits-to-risk ratio and the governments role in the development of this technology. To further foster this new alliance between man and computer in the health care arena, government must continue to support its citizens by providing funding for research, development and enacting laws that serve to protect it's citizens.

Chapter VII offers conclusions and opinions regarding the new virtual reality health care frontier. Judgement is based on my professional medical experience, the facts presented in this paper and the notion of benefit-to-risk ratio.
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I. INTRODUCTION

Technology is the driving force behind society in that it has the power to unlock the secrets of our universe and globally link all societies. It is health care technology that holds the secrets of an individual's longevity of life and humanities quest for the possibilities of youth and immortality.

It will be the technology of virtual reality that will cause the greatest paradigm shift in health care delivery that society has ever experienced. Through the centuries the sick have always been cared for by someone whom they knew and trusted; and more importantly by someone who was physically present. No longer will humans rely solely on the presence and the mysteries of human health care providers. Virtual reality will force humanity to face the question of whether it is ready and able to place its trust in computer technology for preventative health care and health care intervention of what might be a potential or a real life and death situation?

While the scientific application of virtual reality is still in its infancy, we are now witnessing the birth of a new form of medical intervention. As society turns
more to health care technology rather than health care humanity, society will become increasingly challenged by the enormous ethical dilemmas that this technology will pose. It is health care technology that creates the tension for some of the most difficult ethical decisions that must be made. Issues such as privacy, informed consent, equal access, distributive justice, and accountability will be regenerated by the application of virtual reality. The values that are in conflict are equally important, yet one often must be denied if the other prevails. Frequently, the discussions of the ethical uses of technology are raised only after the application is firmly in place. At this point, the discussion is often too late because the members of society deem that the technology is a right rather than a treatment and demands its uses.

The use of the virtual reality technology has the potential to greatly enhance a patient’s medical treatment. Cost containment can be achieved through the enhanced education of medical staff, accuracy of diagnosis, increased precision of surgical procedures and decreased patient recovery times. However, cost containment can only come from an ethical, realistic approach to the conditions under which virtual reality is applied. This debate has
not yet begun in any meaningful, productive way. Due to the explosive nature of the real health care issue of quantity vs. quality of life; this issue has not yet been placed on the political agenda or brought to the forefront of public debate.

The technology of virtual reality has the potential to offer society the hope for a healthier tomorrow. However this vision will not be realized unless an alliance is formed between the medical community and the technology community to develop research and delivery strategies that work toward the improvement of the quality as well as the quantity of health care. This alliance must be nurtured through the support of government both fiscally and in establishing regulations to protect it's citizens.

The impact of the medical virtual reality frontier on society cannot be underestimated. Trust develops through knowledge and knowledge is gained through thoughtful open dialogue. It is time for the public to learn about how this new alliance between health care professionals and the technology of virtual reality will affect the health care that they seek. Only then will society be able to embrace this paradigm shift in health care delivery.
II. Computer Technology: From Where Have We Come and Where Are We Going?

The Birth of the NET

The visions of many individuals came together to lay the foundation for the computer revolution that has become an integral part of our society today. However, as is often the case, the engine of technological change was fueled by what one individual perceived necessity. In 1950, Douglas Engelbart’s desire to manage the complex new world of technology lead him to the idea that computers could automate symbol-handling tasks, and therefore be used as a tool to help people think faster and increase their ability to solve complex problems. (Reingold p. 65)

Engelbart’s dream caught on and by the mid-1960’s and he received the funding needed to create his futuristic vision of computers. People were convinced that computers were useful tools. However, the use of computers was limited to high-tech scientific research and payroll devices for business. (Reingold p. 66)

Others soon shared Engelbart’s vision. The existence of computer-linked communities was predicted twenty-five years ago by J. C. R. Licklider and Robert Taylor, research
directors for the Department of Defense's Advance Research Projects Agency (ARPA). They set in motion the research that resulted in the creation of the first such community, the ARPANET. Licklider had written a paper in 1960, "Man-Computer Symbiosis," predicting that "in not too many years, human brains and computing machines would be coupled together very tightly, and that the resulting partnership would think as no human being has ever thought and process data in a way not approached by the information-handling machines we know today." (Reingold pp. 24, 7)

The essential elements of what became the NET were created by people who believed in, wanted, and therefore invented ways of using computers to amplify human thinking and communication. It was Licklider that suggested that new ways of using computers not only were valuable to weapons and air defense technologies but also could improve the quality of research across the board by giving scientists and office workers better tools. At the AEPAs Information Processing Techniques Office in the Pentagon, Licklider brought together a whole subculture of unorthodox programming geniuses like Ivan Sutherland who created the field of computer graphics and Robert Taylor. Licklider was also responsible for funding Engelbart, whose Augmentation Research Center at Stanford Research Institute
lasted for more than a decade and created the first word processors, conferencing systems, hypertext systems, mouse pointing devices, mixed video and computer communications. (Reingold p. 67-70)

Before ARPANET went online in 1969, the people who had sponsored its initial development J. C. R. Licklider and Robert Taylor, wrote an article with E. Herbert, "The Computer as a Communication Device," in which they set forth their vision for the future of computer-linked communities:

Although more interactive multiaccess computer systems are being delivered now; and although more groups plan to be using these systems within the next year, there are now perhaps only as few as half a dozen interactive multiaccess computer communities. For the society, the impact will be good or bad, depending mainly on the question: Will "to be on-line" be a privilege or a right? If only a favored segment of the population gets a chance to enjoy the advantage of "Intelligence amplification," the network may exaggerate the discontinuity in the spectrum of intellectual opportunity.

On the other hand, if the network idea should prove to do for education what a few have envisioned in hope, if not in concrete detailed plan, and if all minds should prove to be responsive, surely the boon to human kind would be beyond measure. (Reingold p.76)

The global ASCEND was created by a couple of students in North Carolina who decided it was possible for computer communities to communicate with each other without the benefit of an expensive INTERNET connection.

The computer frontier spread like wild fire. It took
only two decades of research and development for interactive personal computers and CMC to mature, proliferate, and converge into the increasingly citizen-accessible NET of the 1990's. By the 1990's, PCs were linked to telephone lines. The prices of PCs and modems became more affordable so the average citizens can now afford to join the electronic frontier. ARPANET, the BBSs and the conferencing systems that had separate origins ten and twenty years ago are growing together now into one system with many parts - the INTERNET. The total number of connected networks grew from a couple hundred in the early 1980's to over seventy-five hundred by the early 1990's, reaching people in more than seventy-five countries. (Reingold p.70-79)

The hosts on the INTERNET are the individual computer communities. Some hosts, like the WELL, have thousands of users. Cyberspace has become the virtual community in which an individual can gather specific information or receive an expert opinion. The WELL is where one goes to meet and socialize with people and it is also where some come in search of information. One should think of the WELL as a building, it is the conferencing system. You can walk down the halls and look at the signs on the doors to different rooms of various sizes. The sign on the door
tells you about the general subject of the conversations that take place inside. The rooms are blackboards covered with writing. Approach one of the blackboards, and you will see a sign at the top that indicates which subtopic of the conference room’s specified domain is under discussion. For instance, in the health conference, you might have topics about recent drug approval by the FDA, topics about different diseases, topics about medical discoveries, topics about the latest medical research, or topics about the politics and economics of health care. Each of those topics has its own blackboard, known in the WELL as the topic level. That is where Experts on the WELL exists, as a topic in the News conference. (Reingold p. 62)

The Technology of Virtual Reality

The 1990’s is an exciting time for the electronic frontier. Society has successfully accomplished a new sophisticated emotional outlet. This is being done through interactive communication in cyberspace. Now society is witnessing the birth of human physical interaction with the machine. This interaction is called virtual reality.

What is virtual reality? Virtual reality has been defined by William Nugent as:
a computer-synthesized, three-dimensional environment in which a plurality of human participants, appropriately interfaced, may engage and manipulate simulated physical elements in the environment and, in some forms, may engage and interact with representations of other humans, past, present or fictional, or with invented creatures.

and by Norman Goldfarb as:

an interactive computer system so fast and intuitive that the computer disappears from the mind of the user, leaving the computer-generated environment as the reality. (Larijani p. 4)

Creating the artificial three-dimensional environments that make up the virtual world has only recently been possible. 3-D Wraps pictures and sounds around us and immerses our senses in such a way that the line between the real and illusionary worlds disappears. This is made possible by the dynamic convergence of many different technologies. Computer speed and power have had to be combined with advances in image processing, tracking mechanisms and intuitive human-to-computer communication to converge into this experiential medium call virtual reality.

As early as 1965, Ivan Sutherland spoke of tantalizing virtual worlds and, in 1966, conducted preliminary three-dimensional (3-D) display experiments at Massachusetts Institute of Technology. Today, virtual reality exploits all current imaging techniques and extends them by ushering
them into environments in which users can examine the displayed objects, interact with them and manipulate them. The technologies which are necessary to make virtual reality possible have grown rapidly, but have only been in existence for about the past ten years. (Larijani pp. 12, 13)

Since the sixties, the virtual reality technology had been used mostly for military purposes such as flight simulation. However, the technological advances during the last ten years has afforded great improvements in three areas that are particularly critical to independent virtual-reality research:

- Liquid Crystal Display (LCD) and Cathode Ray Tube (CRT) display devices (tiny television-like screens to show images);

- Image-generation systems (high-resolution, high-speed graphics workstations to produce the images); and

- tracking systems (for converting position and orientation information into computer-readable signals that can be reflected in images). (Larijani p.13)

Because of these technological advances, researchers could now successfully apply this technology to other areas
such as entertainment, education, engineering, science and health care.

Many different levels and degrees of sensory immersion are included under the heading of virtual reality. By viewing a three-dimensional space, a person is subjected to an elementary level of virtual immersion. If, within that space, objects are defined for user perception and manipulation of the images, the user is subjected to another level of immersion. Total immersion requires that all reference to the real world be effectively blocked, substitute stimuli be provided, and a user be convinced it is real. (Larijani p.28)

The total immersion into the virtual environment will provide the greatest potential for the application and benefits in the medical setting. Humans get information through enhanced visualization, images received through his or her eyes. However, to achieve total immersion into the virtual environment, the environment must appeal to our other senses of touch, auditory and smell.

The virtual environment image can appear to the user in either of two ways: opaque, in which the view of the virtual environment blocks out and supplants the view of the real world; or as a see-through display, in which the virtual images seem superimposed on the real world, which
remains visible through the visor. The speed of the machine used to produce virtual images is important. Generating the images fast enough so that they seem to reflect real-time actions is the biggest problem facing creators of virtual reality environments. To date only the Super Cockpit and a few other military applications, such as the fighter plane environments used to train pilots for the Gulf War, approach a level realistic enough to completely fool users. Work is being funded for image grabbing systems to allow developers to capture, store and modify real scenes for use in virtual environments.

(Larijani pp. 17-20)

There are several problems with virtual reality display units that must be overcome before total immersion can be completely successful:

- low image quality of small LCDs (i.e. low resolution);
- expense and availability of tiny CRT systems;
- elimination of the lag between user motion and system response;
- wide field of view in stereo that is superimposed on the view of the real world;
- superimposition of virtual objects on the real world in a way that makes sense to the human visual system;
- comfort vs. encumbrance of virtual reality-users head and body gear;
- performance of non-real-time operating systems;
- ability to model complex virtual worlds;
- image generation for complex scenes. (Larijani p. 24)

We already have the capability to close our eyes and
listen to our surround sound systems which have the capability to touch our senses in a way that takes us to other environments. Aroma therapy has also become a popular treatment to relax, stimulate or remind us of pleasurable places. There are now touch screens which rely on a human body’s ability to conduct electricity. Touch screens are now being used as interfaces to a computer system that generally rely on pressure, sound waves or infrared beams. Hepatic displays are used to enhance the feeling of pushing, pulling and movement in different directions with varying degrees of strength. (Larijani p.13)

Gloves and bodysuits are gradually being lined with areas that relay haptic and tactile effects to their wearers. Participants in particular virtual world become accustomed to certain cues and use them to estimate real depth or force or distance. Practice improves both performance and the level of perceived realism. (Larijani pp. 22, 23)

Because our heads are the most important sensory channel, the head-mounted display units have become the most important piece of equipment necessary to enter the virtual reality frontier. Cathode-ray-tube devices and liquid-crystal-display devices are currently being used to
display virtual realizations. Some display units resemble a helmet, some resemble goggles and some are shuttered glasses hanging from a head brace. It is sound which bring the visual effects alive. Two different audio feeds are incorporated in the headgear earphones, providing the wearer with simultaneous sounds from as many as four sources. (Larijani pp. 29-39)

For tracking purposes, a physical device is attached to the object or user so that head or hand movements can be detected. This is usually done by electromagnetic or optical means. The movements are translated into position and orientation coordinates, which are deciphered by the computer. Then, images corresponding to that viewpoint are displayed. As the user moves, calculations are being done, and the images are constantly regenerated and updated. These images reflect changes in the virtual scene corresponding to what the user would expect to see if similar movements were made in a real environment. (Larijani pp. 29-39)

Two types of values are used to determine where something is and how it "sits" in the virtual environment. If its position and orientation are measured from a single point of origin, for example, one "corner" of the virtual space, the values are absolute. Coordinates for tracking
are constants within that virtual space. If an object is moved, previous measurements do not count; its new position and orientation are remeasured each time from the "corner".

(Larijani pp. 29-39)

Control devices are becoming unobtrusive extensions for the person using them. One of the most useful devices used for control and input to a virtual system is a glove. The glove looks like a wired ski glove, without fingers. The glove connections are designed to measure flexion and extension of the major joints of the hand. A glove allows the user to work with virtual objects in the same manner he or she would work with real objects - reaching for them, touching them and grabbing or otherwise manipulating them via the animated hand. Applications suitable for glove input include:

- CAD/CAM design environments, so that the user can grab objects on the screen;

- biomedical training and collaboration when, for example, surgeons need to assess hand function and performance;

- robotics, so that gestures can be used to command a robot;

- tele-manipulation, in which robot arm and grip actions can be practiced in real time;

- animation, for which a glove or other device’s sensors can be "mapped" to computer-generated characters and control their actions;

- sign language and printed letter recognition
research and training;
- simulation, in which the glove's signals can be incorporated to control data. (Larjani pp. 43, 44)

The bodysuit incorporates the same idea as the data glove. The suit has the same type of fiber-optic cable running through it. The digitized signals are translated by the computer into a realization. A virtual body is displayed on a screen or in a virtual scenario. The generated image becomes enslaved to signals dictated by the movements of the user and is continually regenerated. A user identifies with the realization. (Larjani pp. 45-52)

Applications suitable for input and feedback via the bodysuit include:

- movement assessment and testing, including ambulatory monitoring of movement and gait measurements, and physical assessment for occupational purposes;

- kinesiology and sports-medicine training and applications, especially for function and performance measurements;

- rehabilitation therapy for stroke or injury victims and preventive aids for repetitive strain injuries;

- biomechanics;

- sex therapy and erotica. (Larjani pp. 45-52)

Some models of gloves and bodysuits are lined with areas of micropins and little inflatable bladders that deliver haptic and tactile effects. Users lifting or maneuvering a virtual object can be made to sense its
heaviness or lightness by the amount of pressure and movements of the pins in the glove or body suit. Thermodes can also be utilized to simulate hot and cold. (Larijani pp. 45-52)

There are a number of remote manipulator devices on the market:

- GROPE which is a handgun-like grip attached to a mechanical arm becomes the means by which simulated forces and torques are fed back to the user;

- billiard balls which contain a directional sensor device are placed at the end of a rod or mechanical arm;

- force balls are devices which are rigged so that directional forces applied to them by a user’s hand are measured as input;

- joystick and joybox allow a user full freedom of movement;

- wands have a sensor at its tip and a six-degree-of-freedom sensor at its base, this device is considered to be the simplest control device used within virtual environments;

- finger devices have also been developed;

- voice controllers which provide instant hand-free control of a procedure.

A person can also navigate within the virtual environment on a treadmill or bicycle. (Larijani pp. 45-52)

As the virtual reality tools become more refined and sophisticated, so to will the applications for their use. If society can overcome its machine paranoia, then it will certainly benefit from the application of virtual reality
in the health care setting.
III. Applications of Virtual Reality
in the Health Care Frontier

The paradigm shift in health care has begun. I am speaking of the shift from a human to human interface to a culture in which medical intervention will be dominated by a computer to human interface. The application of virtual reality in the health care setting will cause the greatest change in medicine and challenge to society that humanity has ever witnessed. Virtual reality has the potential to change the very fundamental aspects of health care delivery which society is familiar with today. Through the applications of complex information databases and the information highway, the video monitor at the physicians work station is quickly becoming the central focal information point of medical care. Soon this arena will give way to even more sophisticated display technologies such as head mounted displays, video glasses, holograms, and palmtop computers.

Uses in Education

The mystery of medicine has long been controlled by human health care providers who closely held the power of
knowledge. However, interactive technology is beginning to take this long revered power from the few and placing it in the hands of many. Today, not only does the medical community have easy access to medical information, but advances in the interactive technology has made this information readily available to all persons with the curiosity and desire to learn. Now, anyone has the capability of logging onto the INTERNET and having access to a medical data base to obtain information or exchange ideas.

Virtual reality gets its power from the fact that people can comprehend images more quickly than they can understand columns of numbers or lines of text. It has been reported that a person can absorb the equivalent of about a billion bits of information per second while his or her ability to read is limited to only about 100 bits, or characters, per second. (Thierauf p.1)

The educational application of virtual reality will allow a surgeon to pre-plan an operation so that errors in surgical judgement can happen in the virtual surgical environment instead of on the actual patient. Medical students, interns, residents as well as attending physicians now have the opportunity to practice and refine their hands on surgical techniques prior to performing the
actual surgery on a patient.

With the improved accuracy of programs, virtual reality will become an even more valuable resource tool in medical education. Many Universities are now recognizing the importance of virtual reality as a learning tool. The University of California at the San Diego, School of Medicine is undertaking a multi-year project to create an educational computing environment which integrates the elements of virtual reality, multimedia and communications technologies. The goal of this endeavor, the Virtual Reality-Multimedia synthesis project, is to create next-generation educational tools which extend the flexibility and effectiveness of medical teaching, promote the development of lifelong learning, and gain acceptance within the mainstream academic community. (Satava et al. p. 130)

The goal of the virtual reality environment will be to add depth and clarity to the learning process. It will give medical students a means of understanding basic anatomy as well as repetitive practice of surgical techniques. Repetitive practice is a very important application of the virtual environment because now much of the training and practice that a medical student, intern or medical resident receives is done on the actual patient.
Through the use of sophisticated software packages such as off-the-shelf virtual body parts, Adam and the Virtual Human, medical students will have access to a means of problem solving, diagnosing disease and repetitive simulations of surgical techniques. Through the use of virtual reality technology, medical students and faculty will actually have the capacity to experience and explore the human virtual environment.

This basic virtual human is a multidimensional, computer-generated image comprised of picture slices taken from different angles of a real person's body. The data used to create this image may be combined with data from other sources to enhance the model so that it may convey not only clinical information, but also expert analysis and interpretation of the data. Soon the technology will become so detailed that it will also be able to provide genetic structures and immune systems for laboratory research. (Larajani p. 79)

Through the use of this interactive technology during consultation, patients will be able to learn and therefore take a more active and responsible role in their health care. By learning more about their disease and treatment options, the average citizen will be given the window of opportunity to unlock the mysteries of medicine in the
virtual environment with the simple touch of a key. The importance of this simple fact cannot be underestimated. Virtual environment scenarios will be capable of providing a first hand view to the patient about his/her potential course of illness, necessary surgical intervention and final outcome such as how the incision or reconstruction will look. The virtual reality environment has the potential to inform as well as alleviate unnecessary fears.

**Diagnosis and Consultation**

Through the use of the virtual reality environment distance will not have to be an obstacle to receiving quality health care. Teams of surgeons, diagnosticians and practitioners have the capability to share virtual examination rooms for diagnostic and consultative purposes. There they can explore and interact with the models and with each other to determine the most effective means for treating a patient. Many rural areas of the country are experiencing a shortage of physicians and access to health care. Telemedicine is a means of providing health care to remote rural areas and in areas such as prisons where physicians find it less desirable to practice.

In 1991, East Carolina University began performing telemedicine consultations to the largest prison in North
Carolina and two rural hospitals. Fifty-nine sites will soon be connected, including two medical schools, nine community hospitals and a host of clinics. Physicians see and talk to the patients that are hundreds of miles away via the telemedicine link. Digital stethoscopes, a graphic camera and a miniature, handheld dermatology camera aid in patient examination, diagnosis and treatment. (Satava et al. p. 15)

Dr. Jack W. Moncrief in Texas has begun to monitor his rural renal transplant patients via the use of telemedicine. Dr. Moncrief interviews his patients as they are sitting in front of a camera and television monitor. A panning shot with the camera assists Dr. Moncrief with his examination of the patient. Dr. Moncrief can then determine whether the patient is experiencing any shortness of breath or if the patient is retaining fluid by looking at his ankles. (New p. 115)

Last year, the U.S. Army operated a field hospital in Mogadishu. Video links have field doctors access to the specialist at Walter Reed Hospital in Washington, DC. (New p. 115)

Physicians at the Mayo Clinic are routinely examining their patient in a specially designed studio examine rooms. A physician in the room with the patient shares lab results
or performs an on-camera examination for the benefit of the other physician who is viewing from thousands of miles away. (New p. 116)

According to the American Hospital Association, soon every medical center and physicians's office in the country could be just a mouse click away. Since 1990, the number of U.S. networks has jumped from three to at least 30, and every state is now developing one. (Cowley et al. p. 65)

Doctor's house calls are being replaced by cable link. Researchers from the U.S. Army and the Medical College of Georgia are planning a study which will involve installation if computer-linked cable TVs in 25 Augusta homes. The computers will have ports for several diagnostic instruments. By holding the instruments, the user will be able to send readings to the doctors while talking to them on the TV monitor. Virtual checkups will become pay-per-view. (Cowley et al. pp. 65-66)

The telecommunications deployed in the creation of these virtual environments is a hybrid network utilizing fiber optics, conditioned copper phone lines cable TV I-nets, and microwave links to provide two-way audio, video and data capabilities. The system provides far-end camera controls for pan, tilt, and zoom, and memory for four preset camera positions. Track lighting and acoustical
treatments have been provided in the telemedicine consultation room. Echo cancelers and audio-video routers are integrated in the video conference system. (Satava et al. pp. 15-20)

A patient's physical examination can also be aided by the interactive technology of ultrasound, magnetic resonance imaging or computerized images. However, these diagnostic tools are not three-dimensional. Now, a "see-through" virtual map can also be superimposed on the actual area being looked at by the doctor to help him visualize what lies beneath. Arm the physician with a synthetic sense to see things that are normally invisible (like ultrasound readings), the virtual reality system transforms image data from the ultrasound equipment to the visor. The images displayed are generated from datasets from the real patient. A visualization system interprets and transforms the data collected into computer-enhanced images that show the anatomical structure and reveal details of the surrounding tissue. This transparent, ultrasound-generated image, placed between the physician's eyes and the real body, equips the doctor with a type of ultravision. A 3-D image of the actual bone is visible as tissue around it are manipulated. This ultravision is especially helpful, to physicians planning facial or hip reconstruction
surgery. (Larijani pp. 79-81)

Uses In Psychology

The heightened sense of control and safety that a person can feel in a virtual environment makes it a suitable arena for psychological intervention. There a person is actually engaged in the interactions that determine the course of events. The therapist from a local or remote site can accompany a patient through visual scenarios, encouraging dialogue and behavior modification techniques along the way. The virtual environments facilitate creative structuring and the pace of treatment sessions. Immersion in a virtual environment or the use of transparent displays help a person visualize what is happening and can positively reinforce mental and behavioral techniques that work best for him or her. Techniques for meditation and stress reduction can be reinforced when enhanced through positive visual stimuli in a virtual environment. Physicians are finding that the use of guided mental image paths often speed up the healing process and are beginning to include what is termed as biopsychosocial image paths into their practice. (Larijani pp.89-91)
Uses In the Treatment of Cancer Patients

The virtual reality environment is becoming a very important tool for the treatment of those individuals who require radiation treatment for cancer. In some cases, the application of virtual reality will make the difference between life and death.

The application of the virtual reality technology will make it possible to deliver lethal doses of radiation treatment to the precise location of a tumor. The precise replication of the three-dimensional structure of the tumor or organ being targeted will help the physician decide on the most effective angles and means of destroying the tumor. (Larijani p. 82)

The placement of the radiation beams is very important because the radiation beams also destroy healthy tissue. For instance, if someone has emphysema and develops a lung tumor, the radiation therapy may kill the tumor, but if the beams are not exact, they will also kill what is left of the healthy tissue. Therefore, the cancer cells may be destroyed, but the patient will be left with little or no healthy lung tissue, the patients lung capacity will decrease and he/she will die.

The treatment process begins with a traditional CAT-
scan or MRI image of the patient. This is turned into a 3-D model of the patient’s body. This virtual-reality rendering of the patient’s actual anatomy, including the tumor, becomes the virtual patient. A head-mounted device becomes the means by which the physician is able to enter visually and interact spatially with the virtual world of the tumor. Armed with virtual arrows or beams of radions, the physician can examine the patient’s tumor and its surrounding tissues from all angles. The physician can then place the virtual beams in positions deemed the least likely to damage healthy tissue. Areas depicting healthy tissue can be computer-sensitized so that, if healthy tissue is invaded by the virtual beams, the physician is alerted so that the procedure can be stopped. (Larijani pp. 82, 83)

It has been proven that cancer patients who are receiving chemotherapy can also benefit from the use of virtual reality during their treatments. Virtual reality can be used to diminish the psycho-oncological symptoms of insomnia, unrest and vomiting. Through the use of virtual reality technology, the patient can experience the feeling of being present in the nature outside of the hospital and see a picture of the scenery in nature produced in the virtual reality space. Relaxation sound also can be chosen
to enhance this experience. (Satava et al. pp. 443-437)

**Surgical Application**

Imagine a surgeon rehearsing the removal of a patient's brain tumor by moving surgical instruments into the air while he or she manipulates a three dimensional view of the tumor using a head-mounted display. Imagine the use of micro-machines that use lasers to vaporize cholesterol plaques in the blood vessels of the heart. Finally, imagine being able to walk through a 3-dimensional model of your body to see how a particular medication is acting to prevent an asthmatic attack or watch a particular organ at work. (Merril p. 1) This will all be made possible through the use of virtual reality technology.

The medical community did not venture into the virtual reality frontier until 1989 when the first laparoscopic gallbladder operation was performed. The acceptance of this procedure was driven by the patient, who benefited from having an operation to remove internal organs that resulted in no scars, essentially no pain, immediate return home (many of these operations are done as outpatient surgeries) and return to work in a week or less (instead of 6 weeks).
In order to perform the laproscopic surgery, a miniature camera on a tiny "scope" is inserted through the umbilicus into the abdomen; this requires the surgeon to look at a video monitor rather than the actual organs where the image of the internal organs are displayed, and manipulate long instruments through tiny holes in the abdominal wall. Through the use of this procedure, the surgeon is actually removing internal organs without ever seeing or touching them. What makes this possible is the electronic, video image of the internal organs. It is this digital image which represents the fundamental change in medicine. (Satava et al. pp. 334, 335)

Currently interfaces between the surgeon and the surgical instruments he or she controls via the system need improved accuracy of the feedback and calibration. However, surgical cut planes that are optimally effective and minimally intrusive can be superimposed upon the images to guide physicians as they cut through the soft tissue to the bone. (Larijani p. 81)

Surgeries on body sites previously inaccessible or inhibiting to surgical or mechanical interventions is now possible. Minimally invasive surgery such as laparoscopic abdominal surgery, endoscopy, angioplasty, vascular surgeries and gene interventions are being performed by the
combined use of virtual reality, micromachine (miniature motors, levers, gears, switches and pulleys) and remote control. The virtual reality environments transmitted through stereo three-dimensional pictures to a physician's eyes through a head-mounted display unit allows a surgeon to accentuate his or her sense of feel or position. By facilitating a high degree of control over the actual surgical device and site, enlarged virtual scenarios allow surgeons that are less dexterous the ability to perform the surgical procedures. (Larjani pp. 84-87)

Through safe, shared virtual environments, surgical procedures can be conducted and refined by teams of experts located far away. To facilitate this virtual environment, remote operative and surgical workstations are devised. There is a 3-D vision, dexterous precision surgical instrument manipulation, and input of force feedback sensory information. Although this is actually telepresence rather than virtual reality, the surgeon is operating on a virtual image in front of him/her. (Satava et al. p.335)

The medical community has seen rapid development and growth in the application of virtual reality in the surgical setting. However, the best is still to come. The medical community still looks forward to the day when
it will have a system that has the capability to detect when one object is in contact with another. This tool is sometimes referred to as the collision detector. The collision detector is integral to simulating the precise interaction between surgical instruments and tissues as well as the interactions between the tissues themselves. Significant operative risk reduction could be made possible by the development of a surgical simulator that allows transference of skills from the surgical application simulation the actual patient. (Merril p. 5)

In terms of patient morbidity and mortality, the use of virtual reality in the surgical setting will greatly enhance positive patient outcomes. Patients will benefit from less time under anesthesia, greater precision of surgical intervention, less unnecessary manipulation of tissue and other organs, decreased pain and quicker recovery times.

Virtual Environments at the Cellular Level

Medical exploration and intervention at the cell and gene levels are facilitated in a virtual environment because of the micro- and macro-scaling features of virtual reality allow surgeons to work as if the areas were
expanded. (Larijani p.78)

Patient Rehabilitation

The virtual environment can offer the physically disabled person a sense of control over the environment and can greatly facilitate the relearning and training process. The virtual world can offer the physically challenged individual an environment where he or she can be viewed as an individual and not judged solely on his or her handicap.

The standard set of input devices such as gloves, body suit or steering bars will be augmented with eye-controlled or muscle-controlled signallers - whatever limited controls or movement a user has. Measurements are made of a person's possible range of motion, and motions within that range are converted into computer-readable signals to start the software and keep it running. (Larijani p. 95)

The biocontrollers or biosensors, can detect and process most bioelectrical signals, such as eye movement or the electrical activity of muscles or the brain. Collections of biocontroller signals can be programmed meaningfully as a complex commands to the system, thus giving the person an enabling sense of control to manipulate his or her virtual environment. (Larijani p. 95)
Three types of biocontrollers are being targeted for medical application:

- eyecontrollers, which enlist horizontal and vertical eye movements as control signals;

- muscle controllers, which capture as signals and map various traces of electrical activity in muscles;

- brainwave controllers, which do not yet exits but which hold the potential for detecting and transmitting brainwave signals representing subvocal/subverbal commands to systems. (Larijani p. 95)

These applications can route signals produced from these biocontrollers to robots or other mechanical devices.

For blind persons, getting familiar with new environments can be hazardous. With the use of virtual reality environmental reproductions of new territories, a blind person can get use to his/her environment without harming themselves. (Larijani p. 95)

A deaf person can use virtual reality in shared virtual environments as a cross-sensory substitution. For participants unable to speak but able to provide some sort of communicative input such as a sound or gesture, the signals are translated into synthesized speech and displayed simultaneously over the head of the speaker as a bubble caption. (Larijani pp. 96, 97)

The gesture-recognition systems provide an enabling input technology for the physically impaired, and one
called the GloveTalker is being tested as an alternative communications device. It can be programmed to interface with a system so that hundreds of phrases can be evoked merely by gesturing. (Larijani pp. 96,97)

As shown, the science of virtual reality used in the health care setting is causing a paradigm shift in health care delivery. Presently, most people are either unaware that computer interaction is used in their health care delivery or simply view the computer as a tool used by their physician to assist him or her in their care. Few individuals are actually aware of the impact that this technology will have on the future of their health care.

As the equipment used for virtual reality becomes more sophisticated so too will the applications for use in medicine. As individuals begin to experience less face to face interaction with their personal physician, they will begin to realize that medicine is turning from a human to human interface to a human to computer interface. Soon the computer will possess all of the secrets once held by human health care professionals. The day will come when many health care professionals will simply become computer technologist. Their health care delivery goal will be to create and manage medical virtual environments in which patients receive both preventive, acute and chronic health
care.
IV. ETHICAL CONSIDERATIONS IN THE VIRTUAL REALITY HEALTH CARE FRONTIER

Under the quise of technological progress, those that support the technology of virtual reality highlight the benefits of innovation while hiding the potential toxic side-effects. As society has witnessed with most technological innovations not only do scientific innovations enhance our lives in some purposeful way, but sometimes these same innovations also pose new challenges to society that must be reconciled. The fast paced momentum of change brought to the health care setting in the form of the virtual health care environment has begun. Our society has the unique and awesome responsibility of establishing an ethical theory that can be applied to the use of the virtual reality technology in the health care setting.

Equal Access and Distributive Justice

Modern society is engaged in continuous discussions of what is the definition of health, equal access and the allocation of scarce resources in the health care arena. There is also opposing views regarding the obligation of
society to provide the tools needed for the application of virtual reality in the health care environment. My purpose is not to debate whether a citizen has the right to equal access but rather to show that there are opposing views regarding modern societies obligations to provide equal access and distributive justice in the health care arena. The technology of virtual reality has the potential to bridge the growing gap between the haves and have-nots in obtaining state of the art health care intervention.

The concept of human rights, or natural rights, was first introduced to the civilized world by Aristotle. Aristotle spoke of natural justice and of equal treatment before the law for all men, while noting that unequal merit should result in unequal reward. Thomas Aquinas expanded Aristotle’s work by describing the existence of a natural law from which arose natural rights. (Beauchamp and Walters p. 386)

Our society and the medical community has long been engaged in the debate over what constitutes equal access to health care. We are faced not only with the dilemma of the allocation of scarce resources, but also with the ethical question of how distributive justice of these scarce resources can best be achieved. According to Tom Beauchamps, from an ethical standpoint, their are several
ways that the principles of distributive justice could be considered:

1. To each person an equal share.
2. To each person according to individual need.
3. To each person according to individual effort.
4. To each person according to societal contribution
5. To each person according to merit (individual ability). (Beauchamp and Walters p. 381)

In many nations there is a firmly established legal right to health care goods and services for all citizens. However, the prevailing legal view in the United States seems to be that even if there are solid moral reasons for no constitutional constraints against enactment of a right to health care, there is no constitutional right to health care, although there is also no constitutional obstacle to the Congress's providing some type of health care to citizens. (Beauchamp and Walters pp. 381-383)

Thomas Jefferson and the founders of the American Republic followed John Locke's ideology:

The law of nature...which obliges everyone, and reason which is that law, teaches all mankind who will but consult it, that being all equal and independent, no one ought to harm another in his life, health, liberty, or possessions. (Beauchamp and Walters p. 386)

The Declaration of Independence speaks of "inalienable rights," and the Constitution of 1787 made the United
States the first major government founded on the explicit proposition that rights of the people are not granted by the state, but arise from the nature of man, and are beyond the right of the state either to grant or to withhold.

Serious modern discussions about the rights to health and health care in the United States date from the quarantine laws of 1796. Health care rights on an international level can be traced roughly to the December 10, 1948, "Universal Declaration of Human Rights" of the United Nations General Assembly. Article 25 of this document specifically mentions a right to medical care and a right to a standard of living adequate to provide for ones health and well-being. (Beauchamps and Walters p. 390)

The Democrats, in their 1972 platform, promised to secure the right of the American people to health. Not to health care, but to health itself. (Beauchamp and Walters pp. 386, 387)

Some people view the 1972 Democratic platform promise as an absurd notion. Individuals such as Robert Sade maintain that the concept of medical care as the patient’s right is immoral because it denies the most fundamental of all rights, that of a man to his own life and the freedom of action to support. Sade views medical care as neither a
right nor a privilege: it is a service that is provided by
doctors and others to people who wish to purchase it.  
(Beauchamp, Walters p. 387)

Others such as Tom Beauchamp and Ruth Faden argue that
if there is a right to health care goods and assistance it
is only because there already exists an obligation to
allocate resources for the goods and assistance. They
maintain that the major issues about rights to health and
to health care turn on the justiciability of social
expenditures rather than on some notion of natural
inalienable, or preexisting rights. (Beauchamp, Walters,
p. 394)

Many individuals would disagree with the views of
Sade, Beauchamps and Faden. Instead, many members of
society support the ideologies founded in The Declaration
of Independence which speaks of "inalienable rights". Many
members of society support the notion that good health is a
right of all Americans. Many citizens have come to expect
medicine to improve not only health, but life more
generally, and have come to see a longer and better life as
not simply a benefit of technological advances, but as a
basic right.

Equality, in terms of access to health care and
distributive justice is a principle that the medical
community strives for, but has not yet achieved. Through the alliance of human beings and the application of virtual reality in the health care environment, through telemedicine, the vision for equal access in the delivery of health care and enhanced quality of the health care received could be realized. This is an accomplishment that neither can achieve alone. Societies challenge will continue to be the acceptance of the limitations of this alliance and embrace the possibilities.

The Principle of Autonomy and Informed Consent

It was at the Nuremberg trials when the notion of consent first came to the forefront of public debate. At the time, the emphasis was on the subjects' consent being truly voluntary and uncoerced. Subsequently, in judicial decisions dealing with medical care rather than research, the term "informed consent" was coined, to give equal attention to the disclosure of all facts that would be important for a patient's reaching a free and knowledgeable decision. (Beauchamp and Walters p. 506)

Each element of the concept raises its own issues. The "information" aspect of informed consent may refer to "reasonable" disclosures by physicians and nurses about
various features of the medical treatment, or it may refer to the requirement that the prospective subjects actually comprehend what they have been told. The consent component refers to an uncoerced decision to take part in the already disclosed or comprehended procedure or project, but there remains the question whether voluntariness is to be judged by objective standards (of an ideal, reasonable person) or subjective standards that refer solely to a particular individual. (Beauchamps and Walters p. 506)

The concept of valid consent has come to play a larger role in medicine than in any of the other professions. This is due in part because medical patients often know less about the alternatives to, and consequences of, the courses of treatment suggested to them than do the clients in other professions. In some cases, due to a patient's condition, it is more difficult for him/her to understand the information provided. In the medical environment, the consequences of the courses of treatment are often more serious than are the consequences of actions involving other professions. Lastly, the medical profession has a history of making decisions for patients without their valid consent. (Beauchamp and Walters p. 184)

Ideally, a patient should know everything that would affect his decision concerning which of the courses of
medical treatment available to him that he should choose. All would agree that it is the patient’s life, health, time and money that are most directly affected by his/her decision, and therefore the patient is entitled to made the decision regarding his/her own health care. (Beauchamp and Walters pp. 184-186)

However, it is often impossible to give the patient every possible scenario of his condition. There are often an indefinite number of very small risks that many in the health care profession do not feel that they are required to inform the patient about. For example, issues of the rate of mortality and morbidity for the contemplated type of procedure done by one particular physician or in a particular hospital is often not readily available and therefore not given to the patient.

What counts as information the patient should have before giving consent has usually been determined not by legislation but by court decision. Some courts determined that the information required for valid consent is determined not by the standard practice of physicians to tell, but by what reasonable persons would want to know. (Beauchamp and Walters p. 184-186)

Often the physicians do not want to take the time to provide the kind of information required for a patient to
make a truly informed consent. The consent is often left to the nurse to obtain. However, regardless of whether a nurse or doctor obtain the consent, despite one's efforts to the contrary, it is based on subjective bias as well as objective information, knowledge and experience.

After being given an explanation of the procedure or treatment that they are about to receive, nine times out of ten when a patient is asked to sign a consent form, he/she does so without any questions. Only later does the health care provider realize that, often due to the circumstances under which a consent is obtained, the patient classically exercises selective hearing. Perhaps for fear of the answers, the patients often do not ask all of the questions that the explanation of treatment has raised. Often when it comes to ones own health care decisions, many individuals, perhaps for fear of making the wrong decision, do not take the time to enhance their knowledge base so that they can appropriately exercise their autonomy in decision making. These individuals rely solely on the doctors and nurses knowledge base and personal bias to guide them through some of the most important decisions that they will be faced with during their life time.

One's own consent for their health care decisions in
non-emergency situations must be taken out of the doctors and nurses hands and placed in the hands of the educated patient or the patient’s power of attorney. The virtual medical environment has the potential to unlock the mysteries of medicine and impartially map out the virtual medical frontier for all of society who have the curiosity and desire to learn. The virtual environment can offer simple explanations about diagnostic test, treatment options and statistics on morbidity/mortality outcomes. The virtual reality environment lends itself to a means of true informed consent.

Accountability Man or Machine?

The use of virtual reality in the health care setting causes a unique situation in terms of liability issues. Who is responsible, the manufacturer of the computer program or the medical professional operating within the virtual environment?

People are quick to blame the computer for errors or malfunctions. However, the mistake is usually human error; a defective program, a command or data entry error, or neglect of a hardware failure. Prepackaged programs can be viewed as a product and therefore laws are already in place
that apply to product liability and negligence. (Barbour p. 159, 160) One must remember that the virtual environment is a tool, and that the ultimate responsibility of the operation of that tool belongs to the person within the virtual environment.

Liability standards are also one of the biggest barriers to interstate telemedicine. Currently a physician wishing to practice in a particular state must be licensed to practice in that state. We now have the broadband networking in a distributed environment regardless of distance and boundaries however this important issue has yet to be resolved. (Sandberg pp. 30, 31)

Some proponents of telemedicine suggest that a national licensing system similar to that used by the U.S. military be adopted. Others believe that physicians who wish to practice telemedically, should be treated as consulting physicians rather than primary physicians thereby avoiding the state licensing requirements. (Sandberg pp. 30, 31)

States such as California are beginning to take the first steps in establishing guideline for the practice of telemedicine. California is in the process of establish telemedicine standards concerning privacy, data transmission and storage and peer-review monitoring.
(Sandberg p.30, 31)

Hopefully other states will follow California's lead. Telemedicine is beginning to become an accepted form of health care intervention and is presently being practiced in many areas of the country. The lack of regulatory oversight at the state and federal level is a prime example of how society does not keep pace with technology in terms of demanding standards of practice which will provide protection for all citizens.

Privacy Issues

Privacy means that each of us has the right to be undisturbed by intrusions into our personal affairs. Today, through the use of computers, we are seeing our privacy being invaded in subtle ways through the use of bar codes and credit cards. On each of us there is an enormous variety of records, such as academic grades, medical histories, insurance claims, and personnel dossiers. Various branches of government keep separate files on law enforcement, tax returns, welfare payments and census surveys. It has been proposed that the merging of all government records into one national data bank would enhance administrative efficiency, the detection of tax and
welfare fraud, and the data base for police work and national planning. This would represent a further increase in the power of the state over its citizens. (Barbour p.160)

What if a person's medical record was available to everyone? What about the possibility of someone tampering with medical information? These frightening thoughts have become a real possibility. The same channels of communication that enable citizens around the world to communicate with one another also allow government and private interests to gather information about them. High-bandwidth interactive networks can be used in conjunction with other technologies as a means of surveillance, control, and disinformation as well as a conduit for useful information. When people use the convenience of electronic communication or transaction, we leave invisible digital trails; now that technologies for tracking those trails are maturing, there is cause to worry. The spreading use of computer matching to piece together the digital trails we all leave in cyberspace is one indication of privacy problems to come. (Reingold p. 280)

Within the history of ethics the most extensive and detailed references to the principle of medical confidentiality occur within codes of professional ethics.
The affirmation of the principle of confidentiality in the Hippocratic Oath exerted a strong influence on the formation of subsequent codes of medical ethics. Medical confidentiality is provided by law which establish communications between physician and patient as privileged communications and which thereby exempt the physician from the normal obligation to testify before a court of law. The confidentiality of the information given to doctors and other health care professionals is a prerequisite for trust and self disclosure. (Barbour p. 161)

There are two very important reasons that the medical confidentiality of an individual must be maintained. The utilitarian argument supports the fact that without such confidentiality the physician-patient relationship would be seriously impaired. The promise of confidentiality encourages the patient to make a full disclosure of his symptoms and their causes, without fearing that an embarrassing condition will become public knowledge. The non-utilitarian argument for the principle of medical confidentiality is that the right to a sphere of privacy is a basic human right. (Beauchamp and Walters pp. 198-200)

The issue of confidentiality and personal privacy in the medical environment cannot be underestimated because the lack of these basic principles has the potential to
destroy ones life. Through the use of the virtual reality technology, the medical secrets held within our bodies will leave little to the imagination. The knowledge held in ones medical chart might lend itself to inferior labels and stereotypical images. This labeling could affect many aspects of ones life; such as who one could marry, if a person will become disabled later in life, if a person would qualify for health insurance or even if a person would be suitable to work in a particular environment. As the science of virtual reality becomes more sophisticated as a means for genetic alteration at the cellular level, information about who is genetically prone to particular behaviors such as alcoholism, childhood hyperactivity and schizophrenia will be held in ones medical chart.

The efficiency of automated system, lends itself to easier violations of medical confidentiality. Because of the amount of data which may be included in a comprehensive patient file, the damage to the patient whose confidentiality is violated may be proportionately greater. (Beauchamp and Walters p. 202)

The computerized medical environment lends itself to potential abuses if access to this information is not strictly restricted and some type of oversight of those who access files is not instituted. However, with regulations
that put into place oversight mechanisms that limit access and provide a quick reference as to who has accessed our personal health care records our privacy will become more protected.
V. COST BENEFIT-TO-RISK-RATIO OF THE VIRTUAL HEALTH CARE FRONTIER

Virtual reality is a means of communication, an extension of knowledge, and precision, and as with any technology, the efficacy of the use of this technically superb application must be questioned.

Ongoing discussion among those involved in this research can be compared to a debate on the use of life-support systems, sure, its available, but is it worth it? As developers drive to make virtual worlds more realistic and technically elegant, they must re-examine them at various stages to determine if the return on investment is, indeed worth the expense and intensity of effort. One needs to ask the question of whether there is a pressing human problem that can be solved by this application of expensive, intellect-intensive technology. If the answer is yes, only then the energy and resources poured into the application of this science will be worth it. (Larigani pp. 15, 16)

Yes, we do have human pressing problems that can be solved by the application of virtual reality in the health care environment. The health care environment is in the process of undergoing rapid change. By the year 2000,
there will be an overall surplus of about 165,000 patient care physicians; the requirement and supply of primary care physicians will be in relative balance; and the supply of specialists will outstrip the requirement by more than 60%. There will be a surplus of 2.2 million nurses. Technology will play a part in this downsizing, however the major reason for this surplus is the trend toward managed care and the discounted fee-for-service. (Weiner p. 222)

The major challenge faced by academic health centers, such as Georgetown University Hospital, is how to maintain the structures and funding required for high-quality teaching and research programs while developing a service delivery system that is competitive with the private sector. Research and education challenges and strategies include:

1. Enhance research infrastructure.
2. Maximize efficiency.
3. Promote areas of research excellence.
4. Increase industry and government partnerships.
5. Expand endowment efforts.
6. Focus faculty recruitment.
7. Graduate medical education.
8. Improve information and technology systems.
If the above goals are achieved, the academic health center will benefit through:

1. Opportunities for institutional alliances.
2. Improved education.
3. Good reputation of the institution.
4. Improved patient care.
5. Cost recovery. (Kralewski pp. 867-872)

The hospital environment is no longer simply a service oriented institution; it has become a service oriented business. Hospitals are awaiting the potential medicare reimbursement restructuring and are now facing increasing competition for managed care contracts. The application of virtual reality can help academic health centers meet their challenges of delivering cost effective health care while meeting their goals for quality patient care outcomes.

Reengineering is one of the most important directions for a health care center because the most successful and promising health care centers must develop new techniques that will allow them to survive in an increasingly competitive climate. To reengineer a health care center it is necessary to rethink these procedures and redesign the business processes to achieve improvements so that the health care employees change from specialists to generalists in order to improve productivity. The
hospitals must develop marketing strategies that take a close look at the competition, know what customers want before they know themselves, and develop innovative services. Virtual reality has the potential to make a health care institution a leader among health care centers.

This vision will take a great deal of commitment on the part of the institution. It will require an OR and hospital that is not only worthy of this advanced technology, but also one capable of supporting it. An entirely new environment must be created based up radically different concepts and the implementation of surgical and minimally invasive or non-invasive therapies. Entirely new space configurations, the use of smart materials and intelligent equipment, and the integration of information infrastructure, knowledge based decision support, imaging systems and advanced therapeutic modalities will be required to support the new generation of interventional therapists. Advanced technology is enabling many aspects of medicine, and the ultimate direction and outcome will not be determined by the state of the technology but the intangibilities of personal, social and political will. In this atmosphere, the challenge is to ensure that the beneficiary of these remarkable technologies is the patient, not the system or bureaucracy. (Satava et al.
The patient, the facility and attending physician will benefit from the technology of virtual reality in the medical environment. The patient is subject to less risk for error, less internal manipulation during surgical procedures, fewer side effects and a quicker recovery time. The attending physician benefit from this new alliance in terms of enhanced precision which leaves less room for error, and decrease opportunity for lawsuits. The facility benefits from a better reputation, increased business and cost recovery.

Facilities that invest in the tools necessary to support telemedicine will find that their cost for initial outlay will soon be recovered. This means of treating patients is cost effective in several ways. A smaller group of health care professionals will be able to treat a larger population.

For instance, in North Carolina, the cost of bringing medical specialist into the prisons is high, partially due to adverse working conditions. It is also costly in terms of transporting patients outside the prison for medical attention. At least two guards are required for security, plus a state vehicle, in addition to the medical fees. The average cost nationally is $700 per prisoner trip to a
medical facility. The service that is provided through telemedicine is $75 per consultation. (Satava et al. p. 15)

Telemedicine in dialysis units across the country could be very cost effective in terms of the decreased number of physicians that would be needed to support the patient population in each dialysis unit. Instead of the physician traveling daily to each hospital or chronic dialysis unit, telemedicine at each site could become an safe, effective alternative.

Current surgical simulations run on computers that cost over $150,000. While this price may seem prohibitive, it represents a significant change from the need to use a computer that cost over $200,000 just two years ago. As processor capabilities increase and the cost of the computers continue to drop, it is anticipated that desktop computers with price tags of less than $5,000 will soon have adequate capabilities to allow for realistic surgical simulation. At this price, these simulations will be available for every area in health care from the surgeon to the nurse. (Merril et. al. p.5)

In approximately five years, managed care companies will loose their clout. Due to the forced closings of fiscally troubled health care centers, there will be fewer
facilities to choose from and therefore managed care will not be able to contract a standard fee for service. Managed care will begin to take an even closer look at issues such as, a patient's length of stay, patient outcomes and the feasibility of the center to provide quality patient care through telemedicine. Those medical centers who possess the foresight, the commitment to change and develop a trust in the growing alliance of the virtual reality technology will have the advantage.
VI. GOVERNMENT RESPONSIBILITY

Government’s Role in the Development of the NET

The role of government has three broad functions in relation to technology. First, it provides funds for research and development. In 1989, 47 percent of all research and development in the United States was government funded. Because the public supports the research of technology with taxes and is affected by the results, society has the right to establish the research and development priorities that will influence the direction of development of technology toward socially desirable goals. (Barbour p. 213)

Second, the government cooperates with industry to encourage the growth and diffusion of technology. Many economic and trade policies are designed to promote technologies that are likely to contribute to productivity, competitiveness, and economic growth. The government also exert some influence on industry by the procurement of equipment, but their main supporting role is through tax and trade policies. (Barbour p. 214)

A third function of government is the regulation of technology in the interests of health, safety, and
environmental protection. Some of the impacts of technology are visible and dramatic, but many are delayed and uncertain. The assessment of such risks and the design of strategies to reduce them require the use of scientific and technical information. But in decisions about regulatory standards, the public also has a right to be heard because public health, safety, employment, and economic development are affected. (Barbour p. 214)

In the 1980’s, a report from the Office of Science and Technology emphasized the possibility of falling behind in the field of U.S. military and industry losing a competitive edge in super computer and networking technologies. By 1987, then President Reagan successfully cut public funding for research in energy and agriculture and allocated these funds to defense. The portion allocated to defense rose from 50 percent during the 1970’s to 74 percent in 1987. Industrial competitiveness especially in electronics, biotechnology, and other high-tech fields was given priority over social and environmental issues. (Barbour p. 215)

In the late 1980’s, the High Performance Computing Act began to be discussed in Congress. Then Senator Albert Gore advocated a "national superhighway for information". This would ensure not only the upgrading of INTERNET, but
would also enable schoolchildren to access the Library of Congress and provide the ability for rural physicians to upload CAT scans to metropolitan medical centers. The High Performance Computing/National Research and Education Network bill, signed by President Bush, authorized $650 million of new spending by the National Science Foundation, $388 million by the Department of Advanced Research Projects Agency and $31 million by the Departments of Commerce’s National Institute of Standards and Technology. (Reingold 11, 86, 89, 250)

The NET poses a unique challenge to the government. By the late 1980’s, the NET began to outgrow the government’s ability to manage. It was time to hand off the wider-access networks to private industry. But serious questions remain about the appropriate way to privatize this publicly funded technology. Is CMC (computer-mediated communications) a publishing medium or a communication service or an informal public space? What degree of public regulation is appropriate in an industry in which the citizens’ right to communicate about matters of public interest is staked to the price of access? Now some of the same commercial outfits that were not interested in developing the technology twenty years ago are competing
for contracts to provide it in the future. What rights do citizens have to determine the way this tool is handed off from the public to the private sector? (Reingold pp. 86-89)

In the 1990's, the role of government and private industry in the creation and regulation of the next level of the INTERNET and the National Research and Education Network is becoming the focus of increased public debate. How should the government manage that convergence? As commercial organization, including two of the biggest corporations in the world, IBM and AT&T, take over management of the NET from government institutions, who will gain access and who will be denied access? Who will make policy about what users can say or do in the Net? Who will arbitrate disagreements about access or online behavior? This technology was developed with tax money. Should there be a cap on the amount that private companies will be allowed to charge us in the future for using a technology that public tax dollars were used to develop in the past? Citizens need to be remind elected policymakers that these technologies were created by people who believe that the power of computer technology can and should be made available to the entire population. (Reingold p.85)

In early 1993, a press release electrified the Net.
The National Science Foundation announced that it was turning over three of the most important administrative functions of Internet management to Network Solutions, AT&T and General Atomics. The function of assigning INTERNET addresses as a means of controlling the gateway to joining the NET, maintaining directory and database services and maintaining information services provided to INTERNET users are now under private contracts. The political and economic structure of the NET for decades to come will be decided in the next five years. The questions of access, pricing, censorship, and redress of grievances will be answered in practice, in law and in executive order or legislative action. It will be up to each of us to support democracy in cyberspace. (Reingold p. 70, 86-89)

The information superhighway is quickly emerging into the "global information highway." Two powerful forces drove the rapid emergence of the superhighway notion in 1994. First the proposed mergers of multibillion-dollar companies are always being highlighted on the latest economic news. Secondly, the Clinton-Gore administration began to present their vision, to be backed up by legislative and regulatory actions, of a "National Information Infrastructure," (NII). In 1993, Gore pledged the Clinton-Gore administration to five "guiding
principles":

1. The administration, would act through legislative and regulation, to provide open access to the network.

2. Provide and protect competition.

3. Provide open access to the network

3. Avoid creating information "haves and have-nots.

4. Encourage flexible and responsive government action.

5. Encourage flexible and responsive government action. (Reingold p. 304)

Government Oversight of Privacy Issues

The most important kind of protection for citizens against technology-assisted invasion of privacy is a set of principles that can help preserve individual autonomy in the digital age. Laws, policies, and norms are the various ways in which such principles, once articulated and agreed on, are enforced in a democratic society.

Gary Marx, a professor of sociology at MIT, suggests:

1. There must be no personal-data record keeping whose vary existence is secret.

2. There must be a way for a person to find out what information about him is in a record and how it is being used.

3. There must be a way for a person to prevent information that was obtained for one purpose from being used or made available for other purposes
without his consent.

4. There must be a way for a person to correct or amend a record of identifiable information about himself.

5. Any organization creating, maintaining, using, or disseminating records of identifiable personal data must assure the reliability of the data for their intended use and must take precautions to prevent misuses of the data. (Reingold p. 294, 295)

In the 1990's, the power to invade ones privacy appears to have become democratized. Society embraces laws or absence of laws that enable improper uses of information technology to erode what is left of a citizens right to privacy. (Reingold 292) In the United States, some privacy-protection laws have been passed, but their scope has been very limited and their enforcement ineffective. For instance a 1971, law requires that a credit agency must, upon request, send a individual a copy of its records and a list of the places to which copies have been sent in the six months. The 1974 Privacy Act gives citizens access to the records of government agencies (except those in intelligence or law enforcement) and provides procedures for challenging errors. (Barbour p.162)

Currently law does not protect a patients' privacy or their personal medical records on either paper or in the electronic environment. This fact presents major challenges for the virtual reality environments of
telemedicine. How can we create a base-level of privacy protection across interstate boundaries? (Sandberg p. 30) 

Senator Robert Bennett (R-Utah), chairman of the Senate Republican Health Care Task Force, introduced the Medical Records Confidentiality Act of 1995 to Congress on October 24, 1995. As of March 10, 1996 this bill is still pending. If passed, the act will be the first federal law governing the health treatment and payment records, assuring that all healthcare providers and health information users operate under one statute on confidentiality, according to the American Health Information Management Association. The key provisions of the bill will:

1. Establish uniform, comprehensive federal rules governing the use and disclosure of patient-identifiable health information.

2. Specify the responsibilities of those who collect, use and maintain health information.

3. Define a patient's rights regarding health information.

4. Provide mechanisms to enforce a patients rights, including criminal and civil penalties. (Braly p. 40)

In terms of access to information, this bill gives patient a great deal more protection of personal privacy and autonomy than they now have.

The democratic governance of technology is not easily achieved because policy decisions require information from
experts and because the structures of economic and political power favor particular technologies. However, citizens must remember that they too have a channel in which to have their voices heard. This channel is through their elected representatives and the government agencies accountable to them. The weighing of costs, benefits and risks, and issues of justice in their distribution are never simply scientific questions. Society must share in the responsibility of formulating policies and regulatory standards that represent the wide range of values held by the diverse stakeholders. (Barbour p. 240)

Technology has proven itself a strong engine for change in society. This change has come in the form of both political and economic power. The old Industrial Revolution shifted this power from the landed nobility to the industrialists. The Information Age is facilitating widespread communication, which has the potential to fortify democratic political control in the advanced industrial nations. The government needs to be involved in the economic policy which affects the information technology, however much of the public is aware of technology's importance to society, now and in the future, so it would be beneficial if an alliance could be drawn between government oversight and public control. (Guile
VII. CONCLUSION

Which path to our future? Technology has proven to be the driving force behind society. Each new invention has influenced change in our society. Sometimes this change is barely noticeable and only minimally affects society. However sometimes the technological change impacts society with a radical force.

We are about to witness an exciting time in health care delivery. A time in which only one thing is for certain, over the next ten years society will witness a rapid change. The paths of technological development will result in a two-way interaction between technical possibilities and the health care environment.

John Mayo once stated, "Humans were given capable and inquisitive minds, so they endlessly seek better ways of doing things. This drive, coupled with an innate curiosity and a strong drive to unlock the secrets of nature, has created a steady stream of technical innovations over the ages." A single technological feat, no matter how much attention is showered upon it, does not by itself institute a complete technological transformation. Indeed, one of the characteristics of a true technological revolution is that a great many innovations
take place at about the same time. Their coming together creates a synergistic, indeed, explosive, impact upon the production of goods and services. This impact is apparent in the social matrix of our society. The Information Age parallels the classical Industrial Revolution and its impact on society. The industrial revolution took the burden off man’s back. Now through the use of computerized devices not only do we have the capability of taking the burden off a man’s back, but society now has the capability of taking the burden off man’s mind. (Guile pp. 1-44)

Initially, the health care community will be excited over the possibilities and technological feats that will be achieved through the application of virtual reality. Only after the application of virtual reality is firmly in place will many individuals realize that the new technology will impact on their job security. The health care industry will experience a restructuring similar to what we are presently seeing in other cooperate environments.

Health care professionals will see their power slowly dwindle away. As this vision becomes a reality, society will begin to hear ominous warnings about the technology of virtual reality in the health care environment. Issues that focus on the alienation of health care delivery will
come to the forefront of public attention. Concerns over the lack of accountability and liability will be raised. Even though we now occasionally hear about privacy issues, these issue will be addressed in a manner that may alarm many individuals. Due to their own feelings of vulnerability brought on by the increasing applications of virtual reality technology in the health care arena, some pessimistic individuals will strike fear and anger many members of society. They will quickly point out the increasing gaps between the information rich and the information poor. They will bring to societies attention what they perceive as the increasing gaps between the health care received by the rich and that given to the poor. They will point out that this is do in part by the increased feasibility that the rich will have to travel to the medical centers that have the capabilities to provide treatment using the latest virtual reality technologies.

However, there will be those individuals who realize that the future excellence in health care delivery can only be achieved through this new alliance between health care professionals and the application of the virtual reality technology in the health care setting. Through the use of virtual reality, all of society will have an opportunity to explore the wonders of humanity. Individuals will be
empowered through knowledge and therefore able to regain their autonomy over their own health care decisions.

The virtual reality health care frontier will offer technologically enhance treatments for diseases that are more precise and therefore much safer. The health care team will use virtual reality to improve the accuracy of patient diagnosis of the disease process, and also as a tool which will enhance precision during surgical procedures. This will lend itself to better patient outcomes in terms of quicker recovery and in improved patient morbidity outcomes. Through improved rehabilitation techniques, individuals that have been severely disabled can now communicate and truly have hopes for a better tomorrow.

Through the virtual reality health care frontier, society has the potential to achieve greater equality in health care. Through this new alliance, telemedicine can provide health care to remote areas of the U.S. in a cost effective manner.

Society will soon form an awareness of the paradigm shift created by the applications of virtual reality in the medical environment. Medicine is on the verge of taking on an important new direction. In the medical virtual frontier, we are witnessing that the new technologies do
not immediately and completely replace older forms of treatment. Instead, the new technologies are being superimposed upon them and in many cases are used to augment the older capabilities. (Guile p.45)

Technology has proven to be the mold for society. With each new invention, comes a new face and direction for society. This direction is influenced by societies values, however it is the technical mold which comes first. Often the mold is reformed many times before society is satisfied and then it is only because we have learned to tolerate the mold that we accept it.

Michael Crichton once said, "Morality must keep up with technology, because if a person is faced with the choice of being moral and dead or immoral and alive they'll choose life every time." (Chrichton, p.31) Society must remember that it does have a voice on how the technology of virtual reality will impact health care. Society must demand that safeguards be placed immediately to insure the ethical applications of this science. Societies challenge will be to overcome their fear through knowledge, to realize and accept the limitations of the virtual reality technology and embrace the possibilities of this new paradigm in health care delivery.
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