OVERVIEW

Education and Training
Current medical education and training is through traditional didactic lectures and field training. This program has explored leveraging military simulation advances into the medical domain, using VR for procedural (or partial task) training and team training, with the focus being upon combat casualty care, the medic, and the combat surgeon. The partial task training involves individual procedures or operations which a medic or surgeon must perform in lifesaving. Integration of the program has been insured by using a singular model, which is the Visible Human of the National Library of Medicine. Representative tasks that are encountered in combat casualties were chosen for simulators, matching the level of the current technologies to the ability to create a realistic simulation. Simulations are not ultra realistic but rather credible enough that the scenario is completely understood and the student can repeatedly rehearse specific procedures. Since there was no historical basis for surgical simulation, the entire program had to be created from the beginning, including the infrastructure.

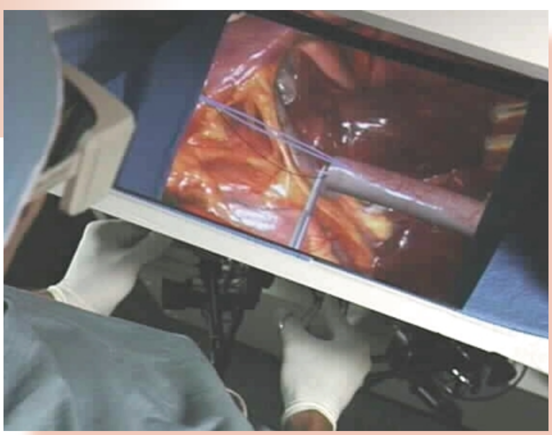
VR EDUCATION/TRAINING

Tissue properties had to be acquired and measured as by Cuschieri of the Ninewells Hospital in Dundee Scotland and Hannaford of the University of Washington. Devices were constructed by Salisbury of MIT and Hannaford of the University of Washington and Son of Pressure Profile Systems both to acquire the haptic (touch) sense from the tissue, and to be able to display that feeling back onto the hand of the student. In addition, a new way of displaying
with Dimensional Media Associates' 3-D holo
image display. For the first time, a 3-D image
space and manipulated as if it really existed.

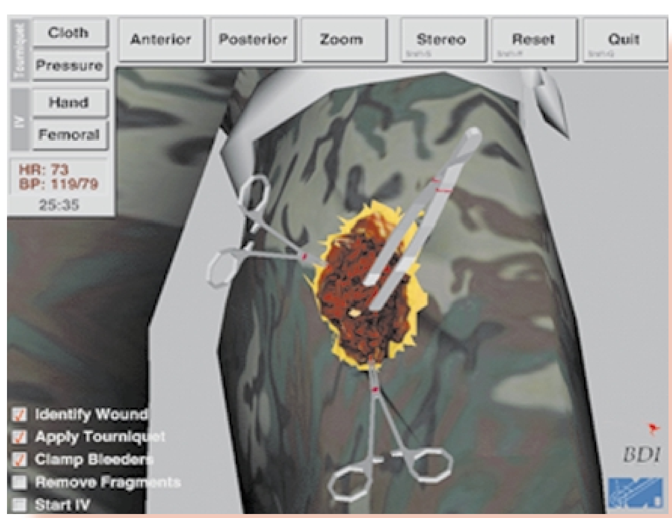
Focusing upon specific tasks for the partial ta
MusculoGraphics' Limb Trauma Simulator whi
wounding model to the Visible Human to cre
for training medics on the basic principles of
Anastomosis: Simulator of Boston Dynamics, I
basics of suturing skills. This system also inco
track the motion and pressures of the hand, s
of the manual skills of the student can be tabulated at the end of the training session. Other simulations to incorporate the skills of starting an intravenous (IV) line or performing endoscopy have been completed by HT Medical Inc. Both the Limb Trauma Simulator and the Anastomosis Simulator have completed development and are currently undergoing evaluation and testing as well as incorporation into an educational curriculum at the

Uniformed Services University of Health Sciences (USUHS) by COL Christoph Kaufmann, MD, director of the National Capitol Area Medical Simulation Center at Forest Glen, MD. The Dimensional Media Inc. holographic display system and the tactile feedback system of Salisbury of MIT have also been incorporated into the Anastomosis Simulator for a higher level of realism.

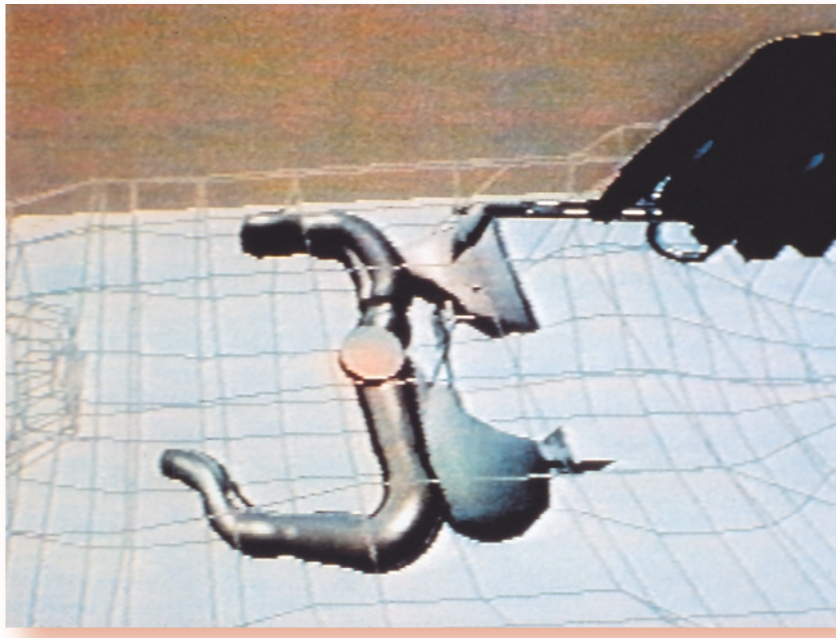
Battlefield casualty team training requires cr ating a battlefield scenario and then insertin wounded soldiers and a medic. This effort brought the medic into the existing military s ulation network (SIMNET) as an integral part combat simulation referred to as the Simulat Corpsman (SIMCOR). Using the simulated soldier (JACK) from the University of Pennsylvania with a newly created wounded soldier scenario created by Sandia National Labs and connected over SIMNET by Mike Zyda of the Naval Postgraduate School, a medic had the opportunity to participate in terrain-based battlefield training, and then practice lifesaving skills when a soldier was wounded. A preliminary attempt to incorporate the sense of smell into the environment was perfomed by Kruger of Artificial Reality Corporation, to add an additional level of realism to the battlefield. During the Association of U. S. Army annual meeting in 1997 a combined, integrated scenario was demonstrated with a medic on a treadmill using a head mounted display to view the networked battlefield. When a soldier was wounded, the medic would "run" to the side of the wounded soldier and train to give the casualty initial resuscitation. He had to identify a collapsed lung and institute proper therapy. When the patient was stabilized, the medic needed to place the casualty in a simulated life support for trauma and transport (LSTAT) to be evacuated by a helicopter. Although quite simplistic in the rendering and integration, the demonstration proved that such a large-scale team training system could be developed. These technologies are awaiting further development and improvement before undergoing testing and evaluation by the U.S. Army Center and School for combat training.



Two other interesting projects addressed the simulation of psychological and perceptual results of minimal brain injury (the DETOUR project of Addison) and the creation of an infrastructure medical education curriculum entitled virtual reality multimedia (VRMM) system by Hoffman of the University of California, San Diego. This is now transitioning to a commercial product called VisualizeR and is being incorporated into the USUHS medical curriculum.



Abdominal Surgery Simulator



A VIRTUAL Reality based Simulator of Abdominal Surgery

Project Summary

As virtual reality was emerging, the first pioneering steps for surgical simulation appeared in 1992. One of the earliest of these simulators was an abdominal simulator for cholecystectomy. During this initial Phase 1 project, individual abdominal organs were created using simple graphics programs—no other graphics tools were available. In order to create interactive 3-D simulations, an entire new programming language was created, with the commercial title "Body Electric". This initial software program was the first "object oriented programming language" for graphics. This permitted creation of objects such as individual organs or surgical instruments to be linked to one another for interactivity. The technique of "morphing" and structural deformation was to come two years after completion of the project. Contact detection algorithms combined with low resolution, low polygon graphic representations resulted in working but relatively crude simulations of organs and instruments. The frame rate was slow (12-16 frames per second) and the interactivity inaccurate, however as the first step the abdominal simulator validated the concept that virtual environments could provide a platform for surgical education.

VPL, Inc., was the first commercial virtual reality company, and introduced the first head mounted display (based upon NASA-Ames technology of McGreevy, Fisher and Ellis). VPL also created the first interactive "glove", called the "DataGlove". The abdominal simulator was a true, completely virtual reality based surgical simulator. The student wore the head mounted display and viewed the virtual organs (see above) and used the DataGlove to pick up instruments or "hold" the organs. The student could also "fly" around and through the organs (simulating endoscopy procedures), which years later led to virtual endoscopy as a clinical tool.

Technology Transfer

The company was in the process of rapid expansion when a combination of financial instability, newer emerging technologies and competing markets resulted in bankruptcy. The technology was not transferred, rather newer, more advanced imaging processing, and lighter weight and smaller head mounted displays were created by competing companies. The abdominal simulator is of great interest in the historical evolution of virtual reality for surgical simulation, pre-operative planning, and virtual diagnosis.

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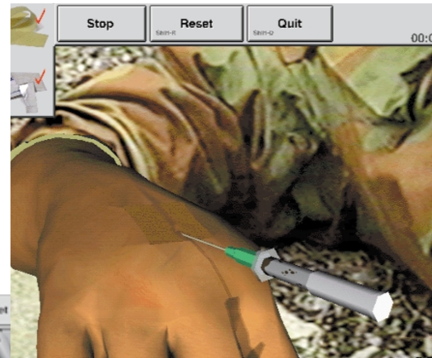
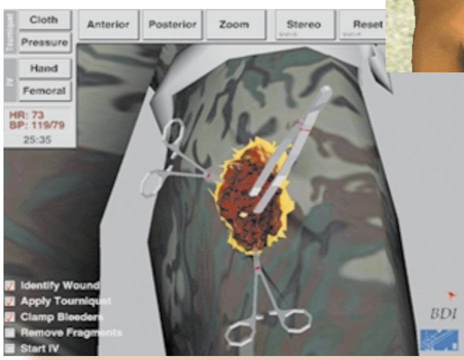
Limb Trauma Simulator

Surgical Simulation for Limb Trauma Management





Project Summary
The Lamb Trauma Management Training Simulator is designed to improve the skills and efficiency of first responders (combat lifesavers, combat medics, paramedics) and combat surgeons. The system integrates high-resolution 3-D graphics and force-feedback devices with training software that teaches fundamental trauma management skills. The system was developed for the U.S. Army as a realistic alternative to animal-based and cadaver-based training, and to augment traditional field training.

3-D computer models of the human anatomy are at the core of the training simulator. The system also includes a set of virtual surgical instruments—forceps, hemostats, and intravenous (IV) catheters—that let students manipulate and interact with the simulated casualty to learn and practice trauma management techniques. The physics-based elasticity and bleeding algorithms incorporated with the computer models add realism to the simulator by mimicking the behavior of human tissue.

The current version of the simulator models a gunshot wound to the leg. In this training scenario the student must characterize the extent of the gunshot injury and control any bleeding by clamping blood vessels. Next, the student inserts an IV catheter into the casualty to replenish the patient's fluids. The student must also identify and remove shrapnel and loose bone fragments from the wound. At the end of the simulation, the computer evaluates the student's performance and displays the final score and elapsed time.

Technology Transfer
Four training simulators were developed for this contract. One was delivered to the Special Operations Medical Training Center at Ft. Bragg, NC. Two were delivered to the Uniformed Services University of the Health Sciences in Bethesda, MD. One unit remains at MusculoGraphics to support the three units in the field. The company is currently looking for partners to commercialize the system.

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IV & Bronchoscopy Simulator

Simulation Assessment for Surgical Trauma

Project Summary

There is a need to train medics, physicians, and other healthcare providers in the basic skills for combat casualty care and for the fundamental procedures needed in diagnosis and treatment of traumatic injury. In the past, medical procedural training involved learning on the job (putting the patient at risk). Virtual reality (VR) technology offers medical personnel the opportunity to practice in an environment where mistakes do not adversely affect patients.

HT Medical Systems set out to develop innovative surgical simulation technology. The project advanced the overall medical simulation industry through in-depth study of real-time computer-based deformable objects, simulated cutting and bleeding, and tactile feedback robotics. HT Medical Systems transferred breakthroughs in these technologies to the development of simulation products that are advancing training in both military and civilian healthcare. These simulators cover three procedural areas; vascular access, endoscopy, and endovascular therapies.

The use of this technology on an ongoing basis will help maintain skills and provide a basis for evaluation of quality of care. Enhancements in training and evaluation have the potential to save significant costs by reinforcing best practices. (This technology improves outcomes, reduces waste, and improves morbidity and mortality.)

Technology Transfer

This project provided the initial opportunity to develop surgical simulation and create the first commercial surgical simulation software. HT Medical Systems' simulator products are currently being used worldwide in both military and civilian facilities to train medical personnel. The first of these simulators were installed in the National Capital Area Medical Simulation Center of the Uniformed Services University of Health Sciences (USUHS) in Forest Glenn, MD. Systems are commercially available from HT Medical Systems; Gaithersburg, Maryland, U.S.A.

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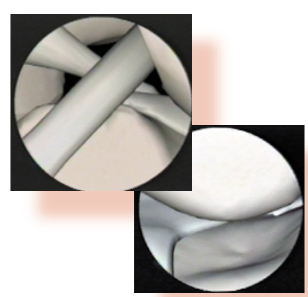
Anastomosis Simulator

Look and Feel: Haptics Interaction for Biomedicine

Project Summary
Combat surgery requires a high level of technical and cognitive skills. Current training methods require the use of animal or cadaveric models, or actual training on patients. In order to provide basic skills training, an anastomosis simulator was created. This required the incorporation of high-resolution graphics, fully interactive 3-D modeling with tissue interaction, provision of the sense of touch through the use of a novel haptics interface called the Phantom, and intelligent software to track hand motions and provide an objective assessment of the manual dexterity of the student. A second simulator to train in arthroscopic procedures was developed based upon the programming and haptics infrastructure developed for the anastomosis simulator. They have built high performance training simulators for vascular anastomosis, knee arthroscopy, catheter insertion, wound debridement, and vascular stent placement.

Anastomosis Simulator
The Boston Dynamics Anastomosis Simulator lets you see, touch, and feel real-time simulated vessels. It is used to practice curved needle suturing technique. Simulated vessels move realistically in response to manipulation and suturing. The system quantifies performance and delivers a “Surgical Report Card”. A skill assessment study reporting testing of the simulator appears in the Journal of the American College of Surgeons, July 1999.

Knee Arthroscopy Simulator
Working with the American Board of Orthopaedic Surgery, Boston Dynamics developed a simulator for arthroscopy of the knee. The user surveys the interior of the knee using standard techniques that require coordinated manipulation of the knee, hip and arthroscope. Force feedback quides interactions between the arthroscope and tissues of the knee joint. The system provides damaged tissues to test the user’s ability to detect abnormalities.



Technology Transfer
Boston Dynamics offers the leading interactive surgical simulators. It was the first company to combine quantitative surgical skill assessment with rich computer graphics, and high-performance force feedback. Boston Dynamics has worked with a range of customers, including medical device manufacturers, the American Board of Orthopaedic Surgery, Hershey Medical Center, and others. Simulators are available directly from the company.

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Sinusoscopy Simulator

The ENT Surgical Simulator Project

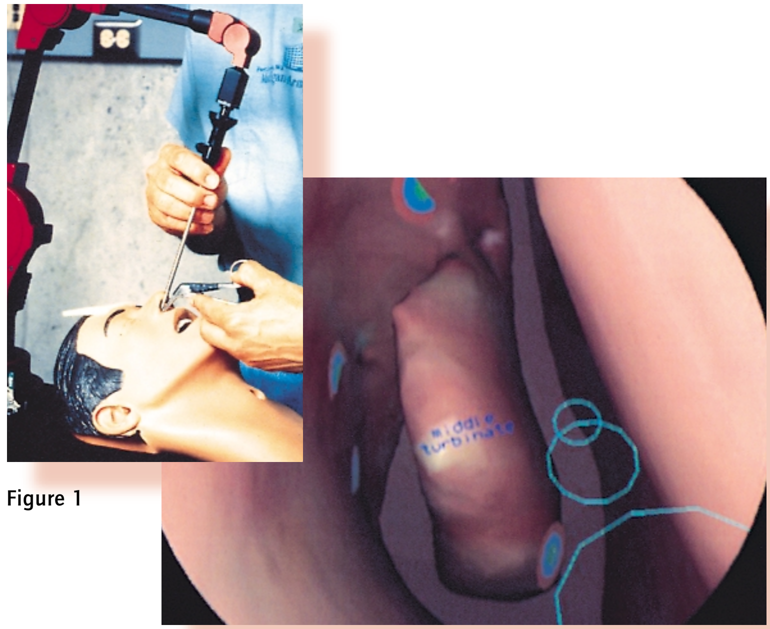

Figure 1

Project Summary

Lockheed Martin's endoscopic sinus surgery (ESS) simulation trainer, an electro-mechanical, software-driven mannequin (Figure 1), re-creates an operating room environment to simulate a procedure and stimulate the learning process at many experience levels. This hybrid mannequin and virtual anatomy simulator incorporates an intelligent tutoring database. The images are displayed upon the monitor in a virtual reality (VR) interactive environment. This responsive simulation trainer challenges users as they evaluate new techniques, handle instruments, and review anatomy.

As a challenging and potentially risky procedure, endoscopic sinus surgery is a prime candidate for VR simulation training. The ESS simulator is a collaboration of Lockheed-Martin (formerly Loral Training and Simulation), the Ohio Supercomputer Center, and Immersion Corp., under the direction of Major Chuck Edmond, an otolaryngologist at Madigan Army Medical Center and a Human Interface Technology Lab (HIT Lab) medical advisor.

Practicing surgeons and surgical interns take hold of instruments and conduct a sinus surgery procedure. They feel the anatomy via tactile feedback through selected instruments. They view, from the perspective of the endoscope, the selected surgical instrument as it manipulates or dissects the interactive patients's tissue. They hear the patient's heart rate respond to the effects of drug injection. Using the VR simulator, a trainee will progress from a simplified "novice" task aimed at training basic endoscope navigation and instrument skill, through a more complex anatomical model enhanced with visual and auditory cues (the "intermediate" level), to an unassisted simulated procedure (the "expert" level). All trials are automatically scored by the system and can be replayed for further feedback and instruction.

The virtual patient models accurately represent human sinuses (Figure 2), which were derived from the National Library of Medicine's Visible Human Project. In addition to standard models, instructors can select from anatomical variants such as paradoxical turbinate, concha bullosa, deviated septum, and polyps.

The HITLab team evaluated the utility of the haptic display and of the visual and auditory training aids, the correlation between performance on the simulator and performance in the operating room, and the relative impact of experience with the simulator on various components of surgical skill.

Technology Transfer

The Endoscopic Sinus Surgery Simulator was developed as a Technology Reinvestment Project with full participation and cost sharing with Lockheed Martin. It is now a commercial product available from Lockheed Martin.

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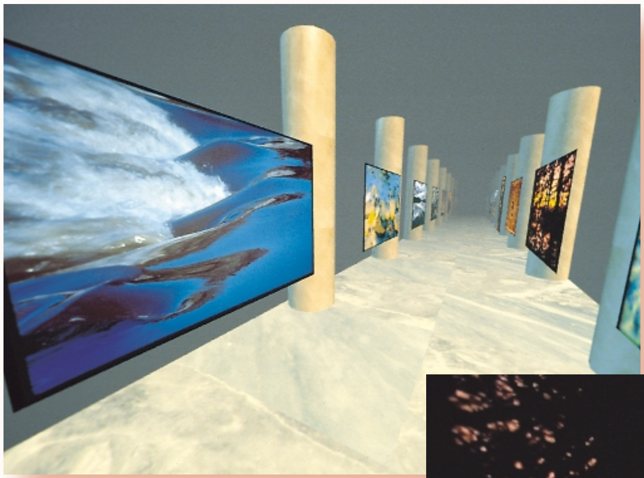
DETOUR



Brain Deconstruction Ahead

Project Summary

Artist Rita K. Addison and partner, artist, and programmer Marcus Thiebaux tell the true story of how a car accident left Rita with brain damage and a sense of desolation which she soon discovered was shared with many other traumatic brain-injured survivors. She proposed to Electonic Visualization Laboratory (EVL) of the University of Illinois that virtual reality might be just the medium in which to attempt an experiential walk through of altered perceptions, including visual, auditory, and balance distortions. Addison relates "My goal was to evoke empathy for those with seemingly invisible injuries, i.e., brain trauma changes one's life forever, yet to an onlooker there are no visible casts for broken bones, no bandages, no obvious stitches holding together a broken brain." Audiences around the world have responded positively to the award-winning DETOUR and it has been heralded as a breakthrough application in combining a very personal story of physical and psychological trauma with the most advanced computer technology available today.

Technology Transfer

Rita and David Zeltzer are currently developing a commercial product, "Empathy Learning Virtual Environment System"(ELVES). They continue to lecture and publish about DETOUR and their related work. DETOUR was created and presented in the CAVE at SIGGRAPH '94 and is now a permanent installation at the CAVE at the National Center for Supercomputing Applications (NDXA) in Illinois.

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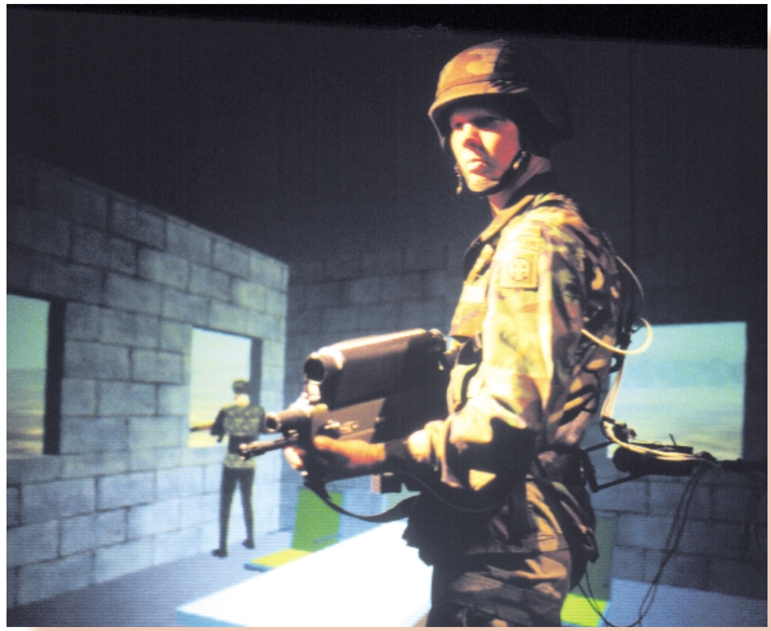
SIMCOR

The Simulated Corpsman for Medical Forces Planning and Training



Project Summary

SIMCOR is targeted primarily at training battlefield medical personnel whose responsibility is to triage and stabilize multiple casualties for evacuation to field hospitals where patients will receive focused medical care. This focus differentiates SIMCOR from other VR-based medical trainers whose primary goal is to train a specific procedure or task. Such systems provide highly realistic anatomical visualizations and/or multi-modal interfaces that address the visual and haptic cues involved in carrying out specific procedures utilizing appropriate medical instruments. The goal of the SIMCOR trainer, in contrast, is to train rapid situational assessment and decision making under highly stressful conditions. Thus, SIMCOR looks to train the medic not to insert an IV, but rather to understand the circumstances under which an IV is required. The former is referred to as task training, while the latter is referred to as situational training. The adage "practice makes perfect" is quite apropos to situational training. Lectures, books, videos, etc. are no substitute for hands-on-experience— we often learn more from our mistakes than from our successes. Unfortunately, it is difficult to provide such training for large-scale emergency medicine. Current methodology is to use live training exercises: medics practice stabilization and wound care on animals (e.g. producing a gunshot wound in a goat) or via moulage (a training exercise where live soldiers are given highly realistic "fake" wounds). The shortcoming with the latter is that the medic does not get to practice wound care, while with the former it's the growing concern over using animals for such purposes. Virtual Reality has the potential to augment current training by providing a dynamic, hands-on simulation of a battlefield environment with casualties that both manifest the physiology of a given wound dynamically over time and who also respond, positively or negatively, to the medic's actions.

SIMCOR is a prototype Virtual Reality system developed by Sandia National Laboratories to support training/rehearsal for battlefield medics and other emergency first responders. SIMCOR immerses the trainee in a high resolution synthetic environment consisting of a virtual world, consisting of the participants, and virtual casualties. Each participant wears a VR head-mounted display and a set of position trackers that permit him to view and interact with the virtual world. The system also has a voice recognition capability. Multiple participants may share the simulation via a local area network (LAN) utilizing standard multicast protocols. Open-sourced multicasting was developed by the Naval Postgraduate School (NPS) to support a fully networked, distributed interactive virtual environment called NPSNET-IV. Participants are represented within the VE as full graphical figures called Avatars. These avatars provide a high fidelity representation of the actions and motions of the participants. The simulation itself consists of several components. Casualties are modeled using virtual humans who manifest the symptoms of the injuries being modeled as well as the changes brought about by the intervention of the trainee. The trainee must assess and stabilize the casualty. If the

diagnosis is incorrect, if the wrong procedures are performed, or if the trainee is not fast enough, the casualty will die. Researchers at the University of Pennsylvania developed the initial tension pneumothorax injury model. Head trauma injury models have subsequently also been developed. BioSimMER, also funded by DARPA, is an extension of SIMCOR to multiple casualties and a bio-terrorism scenario. Trainees are presented with agent exposure casualties and psychological trauma in addition to conventional injuries. Two additional capabilities were briefly explored for the SIMCOR project. The first was the integration of the high fidelity SIMCOR trainer into the larger, but lower fidelity, Distributed Interactive Simulation (DIS) simulation environment used by the military for training large-scale actions, such as the Dismounted Warrior Battle Labs at Ft. Benning, GA. The second was to show a proof-of-concept demonstration utilizing the simulation environment to explore the use of prototype medical devices before a functioning real-world device is built.

Technology Transfer

The virtual environment system of Sandia National labs has undergone human performance evaluations at the National Emergency Response and Rescue Training Center in College Station, TX, and will be fielded in FY00. The University of Pennsylvania's JACK virtual avatar software for the medical simulation is now commercially licensed by Engineering Animation, Inc., and is used worldwide for human figure animation and human factors analysis. NPSNET-IV and the papers associated with that project remain on our web site although we are no longer funded by anyone to continue working with that source code. The project did allow us to collect knowledge about networking virtual environments such that we could produce a book "Networked Virtual Environments—Design and Implementation," ACM Press, July 1999. That book is the major work on net-VEs.

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I-Port

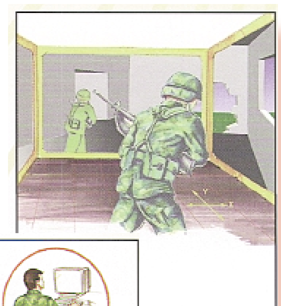
Individual Portal into the Virtual Battlefield

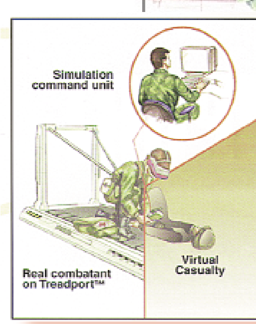
Figure 1

Figure 2

Project Summary

There is a need to train medics in battlefield triage and casualty care in an environment that contains the stress and "fog of war", known as situational training. Virtual environments, such as SIMCOR, are being created that have the potential to augment current training by providing a dynamic, hands-on simulation of a battlefield environment with casualties that both manifest the physiology of a given wound dynamically over time and who also respond, positively or negatively, to the medic's actions.





I-Port is a suite of mechanical display systems in which human-like icons (avatars) can be driven through the environment using hands-off user steerable navigation. I-Port provides resistance proportional to the rate of travel, slope, the type of terrain that is being crossed, and the type of task being performed. The system permits the avatar to assume a kneeling and prone position, and provides realistic feelings of acceleration for walking, running, and crawling. I-Port meters exertion in proportion to the task as it would be performed in the real world, allowing military tradeoffs between risk and work. The system is compatible with the NPSNET simulation networking software, allowing several soldiers and medics to enter the same virtual environment, see body postures, locomotion, hand/arm signals and casualty scenarios. This offers new possibilities to insert the warrior into the virtual battlefield for the purpose of simulation-based design, workspace evaluation, exercise, training, and rehearsal and performance assessment. The system is available in a number of different configurations: the UniPort unicycle style interface (Figure 1), a Tread-Port unidirectional flat surface (Figure 2), and individual Soldier Mobility Simulator (ISMS) similar to a stepping exerciser.

Technology Transfer

The I-Port was demonstrated at the Association of the United States Army (AUSA) annual meeting in 1997. It is available as a commercial product from Sarcos, Inc.

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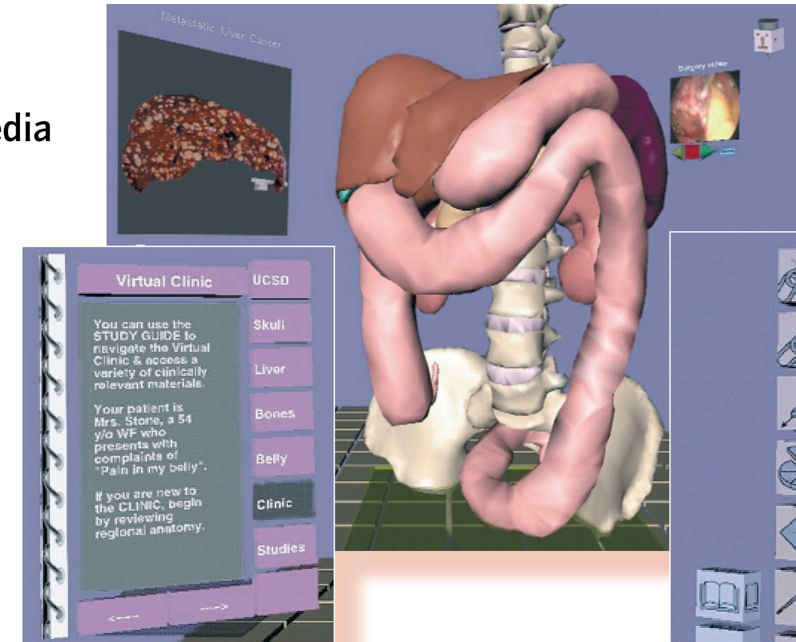
Virtual Reality Multi-Media

Virtual Reality/Multimedia Synthesis, Phase II: Prototyping and System Evaluation



Project Summary

The University of California San Diego (UCSD) School of Medicine has been actively exploring the role of VR for education and has focused on the potential synergism arising from combining VR with traditional curricular resources. This research and development effort has produced "Anatomic VisualizeR", a multimodal 3-D environment where VR serves both as the lesson core and as the interface to diverse learning resources and reference materials. The program provides an intuitive virtual workspace where students are able to "dissect" 3-D anatomic models while accessing a broad range of supporting resource elements (diagrams, images, text, video, MEDLINE, etc.). Anatomic VisualizeR includes a faculty-authored Study Guide which provides key concepts, suggested exercises, and links to a wide variety of clinical correlates and contextually-linked domains of medical science (histology, pathology, radiology, etc.). It can support lessons which are case-based, anatomy dissector-based, or a mixture of both. The Study Guide, as well as Toolbars, provide the syntax for users to navigate, manipulate, and interact with the application and its resources. A broad range of virtual exploratory tools and options are available which enable users to investigate structures in ways not possible in the real world. Students are able to repeatedly "dissect" structures and regions, or to reconstruct any area from its component parts. The options available to users include: link/unlink models, change opacity or size, dynamically create cross-sectional views using a clipping plane, measure sizes and distances with a virtual ruler, label structures with a flag marker, identify structures using a probe tool, and draw lines and simple objects using a Space Draw tool. Anatomic orientation can be maintained regardless of view or magnification and anatomic position reestablished through a Toolbar option. Anatomic VisualizeR is based on the UCSD's VisualizeR architecture and thus can support multiple types of visual display (monoscopic CRT, stereoscopic CRT, and full-immersion) and input options (gloves, 3-D trackball, and mouse). Anatomic VisualizeR currently utilizes models derived from the NLM's Visible Human dataset, but it is capable of utilizing a variety of other 3-D polygonal models as well.

Technology Transfer

Anatomic VisualizeR learning modules have been successfully piloted by both high school and medical school students. With commercial or grant support, Anatomic VisualizeR will be able to complete the transition from prototype to product. In addition, multiple spin-offs of the underlying architecture are being considered, including a multi-user, collaborative version of VisualizeR configured for use on the Internet. The final prototype is undergoing testing, evaluation, and validation at the Uniformed Services University of Health Sciences (USUHS).

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Virtual ER

Advanced Human Interfaces for Telemedicine: The Virtual Emergency Room

Project Summary

The emergence of the electronic patient record will radically change the way clinical information is accessed and used. At the same time, new technologies for displaying and interacting with data are emerging in various markets. Wearable computers with wireless data links can provide mobile access to the patient record. See-through head-mounted displays and voice recognition systems provide hands-free interaction, and in combination with viewpoint position tracking, can enable augmented reality overlay of data onto objects in the world. Handheld "ubiquitous computing" devices, such as wireless tablet terminals, PDAs and large-scale flat screens, also expand the universe of possibilities for clinical data interaction.

The Virtual Emergency Room at the University of Washington's HIT Lab (Human Interface Technology laboratory) was created as a tool for exploring the many possible ways of displaying and interacting with the electronic patient record in the clinical environment of the future. In the Virtual ER, physicians are immersed in any of several simulated clinical settings, and they are free to grab and place data objects in the environment while performing a clinical task. Data objects range from simple images to live numeric and image data streams. Placement can be "stabilized" with respect to the patient, the room, the physician's body, or the physician's field of view. Novel data representations and interaction techniques can also be simulated and tested for their ease of use and clinical utility. One extension of the Virtual ER is currently being used to train surgical residents in the proper placement of instrument ports for various laparoscopic procedures. Another has been used to test the viability of a 3-D technique for displaying EKG data.

Technology Transfer

While the Virtual ER is not intended to be commercialized directly, it does provide a design environment and testbed for a variety of clinical products, in addition to clinical informatics software and interface methods. User interfaces to a variety of clinical devices can be simulated, along with candidate device form factors. Experiences of physicians in the Virtual ER can also be used to suggest new directions for future clinical product development. Research sponsors and product development partners are being sought to utilize and expand the capabilities of the testbed.

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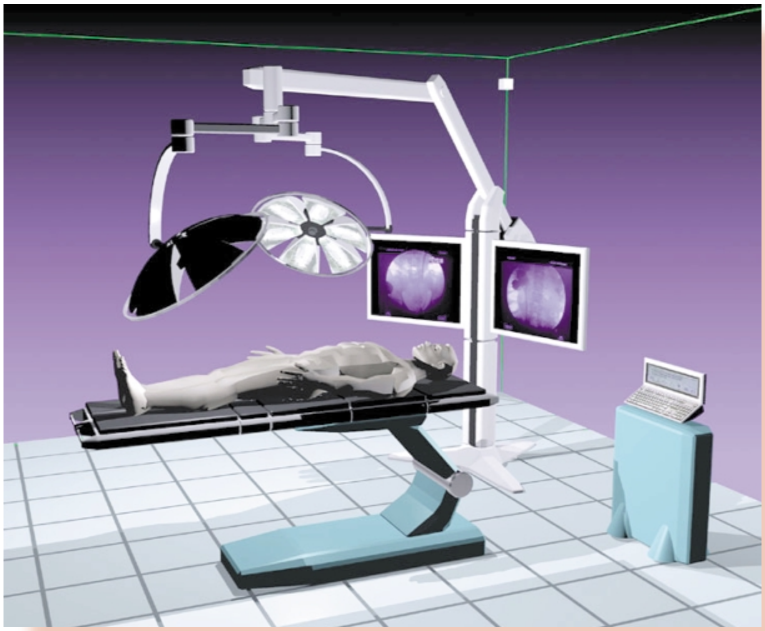

Operating Environment of the Future

Project Summary
The purpose of the OEF project was to develop the next-generation, multi-platform, tri-service military integrated medical environment. The scope of the project encompassed three principal systems within the OEF: 1) the Intuitive Display and Command System (IDACS) providing real-time information management through integrated displays, hands-free interface, local / remote connectivity, and a wireless, multi-media environment; 2) the Smart Surgical System (SSS) integrating physiological sensors with the surgical platform, incorporating advanced materials, and optimizing ease-of-use, mobility, and deployability; and 3) the Intelligent Virtual Patient Environment (IVPE) employing modified actual surgical instruments and a simulated patient for the improvement of surgical skills, training in battlefield procedures, and automation of performance measurement.

The results of this initial phase were demonstrated to DARPA, and included: (1) a real-time video image of the Smart Surgical System surgical table and separately generated graphical images of a patient heart rate trace were combined by IDACS and wirelessly transmitted for display on a large screen monitor; (2) stored patient data (including heart rate, temperature, and blood pressure), transmitted wirelessly from the IDACS to the large screen monitor; (3) a mock-up of a body-worn Surgeon Interface Unit (SIU) with a stereo see-through visor display, stereo audio, speaker-independent voice recognition, wireless voice/video receiver, and wireless data transceiver; (4) a hands-free command-and-control capability, demonstrated in re-positioning the video camera above the Smart Surgical System surgical table and in calling up archived patient data for display on IDACS monitors and (5) developing software to filter and interpret acoustic signals from the Smart Surgical System to provide the current heart rate and associated waveform on IDACS monitors. During the demonstration, this capability was demonstrated using a handheld acoustic sensor.

Technology Transfer
Progress was demonstrated on the other two components of the OEF, as well. For the Smart Surgical System, a conformal antenna was used to wirelessly transmit the signal from the acoustic monitor embedded in the composite surgical table. For the Intelligent Virtual Patient Environment, cognitive abilities associated with endoscopic surgery were identified, as were initial voice-recognition and anesthesia requirements, and a front-end requirements generation and analysis "decision support system" software tool was developed (essentially a high fidelity, qualitative and quantitative relational database).

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