ing objectives as guides. Effective scenarios contain "trigger" events that lead to an opportunity for trainees to perform the desired competencies and tasks. For example, in order to train an intern on the recognition of hypertension, an abnormal vital sign showing high blood pressure (the "trigger") could be embedded into the scenario. Alternatively, the SP could complain of headache, dizziness, blurry vision and nausea. Effective scenarios are always realistic.

The next component is to determine how to measure the events. Without measurement, there is no learning. Measures and metrics are needed to evaluate both outcomes (e.g., successful completion of an intubation) and processes (e.g., choosing the correct procedure to perform on the patient), at the individual and team levels. Considerations are given to both task (e.g., applying sutures) and team (e.g., mutual support) outcomes and processes. Observational protocols are developed. In an effective simulation, measures are always developed with training objectives in mind.

The next step of an effective SBT system involves actually measuring the simulation, observing and diagnosing performance. The measures created earlier are put to use. The information collected in this step allows for determining the impact of the training. Additionally, this step serves to govern what feedback will be given to trainees. Lastly, diagnostic feedback is given, and given in a timely manner. In an effective SBT system, trainees are debriefed after each simulation.

Simulation can be beneficial in many areas of healthcare. One example of where its use should be considered is to supplement medical team training. For instance, an operating room team may undergo a simulated operation scenario in order to practice team skills and processes that are vital to performing a successful surgery, such as coordination, back-up behavior, and strategy formulation. While this one example is used to illustrate the use of SBT in healthcare, simulation can be adapted to almost any aspect of healthcare training and team training.

SBT creates learning only if the system is designed, planned, and implemented properly. By following the components mentioned previously, you will help ensure that the training is impactful, and that you have gone "beyond the bells and whistles."

**Eduardo Salas, Ph.D.**
**Megan E. Gregory, Ph.D.**
Department of Psychology,
Institute for Simulation & Training
University of Central Florida
Orlando, Florida

esalas@ist.ucf.edu



# A Medical VR Simulator in Laparoscopic Rectum Surgery

*"Recently, with the rapid growth of computer technology and power, Virtual Reality simulators have become a viable alternative [to traditional surgical training methods], allowing the trainee to hone their skills by operating on a virtual patient."*

By Jun J. Pan et al.

The last two decades have seen some of the most exciting developments in medicine with the advent of minimally invasive surgery (MIS) including both laparoscopic and endoscopic techniques. MIS reduces the surgical trauma to the patient, thereby dampening the surgical stress response. This results in better outcomes with less postoperative pain, a shorter hospital stay and a quicker return to normality.

Colorectal cancer is the third most common cancer in the UK, with approximately 40,000 new cases diagnosed annually. Surgery remains the mainstay of treatment and is the primary intervention in 80% of cases. Although it is estimated that 90% of cases are suitable for a laparoscopic approach, there has been a relative lack of surgeons trained to perform such a demanding surgery. This is particularly true for rectal cancer surgery which is the most complex and technically challenging for the laparoscopic colorectal surgeon. The learning curve of a laparoscopic surgeon can be influenced in a number of ways.

Laparoscopic training boxes provide the junior surgeon with training on inanimate objects, but offer only mundane tasks and lack the feel of handling human tissue. Animal tissue can be used but differs in anatomy to humans, and although cadaveric courses are available they are expensive and do not allow repetitive practice. In addition, the tradition of training in animal tissue is particularly criticized and can pose ethical dilemmas. In reality, trainees in many countries, including the UK, develop their laparoscopic skills by operating directly on patients under the supervision of senior surgeons. Recently, with the rapid growth of computer technology and power, Virtual Reality (VR) simulators have become a viable alternative, allowing the trainee to hone their skills by operating on a virtual patient. Compared with traditional surgical training on patients, VR-based methods have the following advantages:

**Figure 1:** VR simulator in laparoscopic rectum surgery.

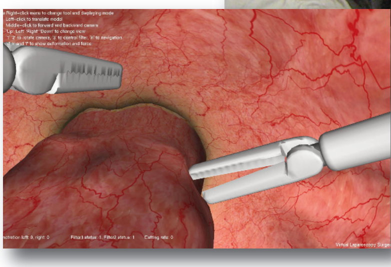

**Figure 2:** Interface of VR simulator in laparoscopic rectum surgery.

- Repetitive tasks: A VR-based system can be reused many times without risk to patients.

- Variable complexity: Different scenarios can be simulated including extreme situations, allowing the response to be rehearsed.

- Surgeon responses can be recorded: Skills and training progress can be objectively recorded, measured and evaluated.

Our researchers have developed a VR simulation system for laparoscopic surgery on the rectum, perhaps the most challenging surgery encountered by the laparoscopic surgeon. The hardware of our system includes a computer, a display screen and two haptic devices (Phantom Omni). These devices can be used as grasping tools, as well as dissecting instruments or energy sources depending on the function selected, and are interchangeable between the two haptic devices (Figure 1). The haptic device provides 3-DOF navigating parameters (pitch, yaw, insertion) and force feedback when there is a collision detected. The user interface (Figure 2) also permits the user to use the haptic device as a navigation camera. We created the surface mesh model of a rectum and its surrounding tissue using data from a Magnetic Resonance Image (MRI) of the rectum and by referencing real surgery videos, as it is simple and efficient in deformation computation. Run-time operations include soft tissue deformation, collision detection, cutting, rendering and communication with the haptic devices. Some novel techniques are applied in this system. A haptic force filter based on the radial basis functions can adjust the force adaptively according to the mesh density of the contact surface. A cosserat rod model has been introduced to cope with frequent collision detection and substantial soft tissue deformation. It parameterizes the centerline of the intestine with material coordinates. Rigid spheres are attached to the cosserat rod, approximating the 3-D shape as bounding volumes of the intestine model. This approach meets the system requirement of real-time graphic performance and high deformation accuracy.

Two consultant surgeons, from hospitals in Bournemouth and Poole, have been closely involved in the development of the system from the outset. They both provide regular input, advising our researchers about the medical aspects of the VR model and help to evaluate the results. The tactile feedback has been modified a number of times as a result and has been developed using their experience of operating on patients to provide a realistic feel. Our aim with this haptic rendering is to provide trainee surgeons with a VR tool with which they can familiarize themselves with the anatomy and steps of a procedure, at the same time giving them a realistic tactile feeling and real-time visual outputs. The ultimate aim is to shorten the surgeon's learning curve in an era where the length of surgical training is being reduced.

**Jun J. Pan, Ph.D.**
**Jian Chang, Ph.D.**
**Xiaosong Yang, Ph.D.**
**Jian J. Zhang, Ph.D.**
National Centre for Computer Animation Media School
Bournemouth University
**Tahseen Qureshi, MBBS FRCS**
Poole Hospital
**Robert Howell, MBBS DM FRCS**
**Tamas Hickish, M.D.**
The Royal Bournemouth and Christchurch Hospitals
United Kingdom

pjunjun@bournemouth.ac.uk