Medical Robotics: Reality-based Modeling of Soft Tissue

Vicki L. Baker, 2004 RET Fellow, Overbrook High School, Philadelphia, PA
Graduate Student: Tie Hu (Drexel University)   Faculty Mentor: Dr. Jaydev P. Desai (Drexel University)
Research Experience For Teachers Program (RET)

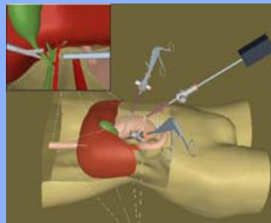
Program for Robotics, Intelligent Sensing, and Mechatronics
Laboratory, Department of Mechanical Engineering and Mechanics

Research Goal:

To develop a reality-based biomechanical model for minimally invasive surgical training and simulation. Soft tissue models are derived from experimental measurements. These models are used for robot assisted surgery and developing medical simulations.

What is Minimally Invasive Surgery?

Minimally invasive surgery (MIS) is a method of surgery that reduces the overall trauma to the patient compared to open surgery. One common means of MIS is through the use of laparoscopic tools, which are long, thin surgical instruments that can be used for grasping, cutting, and dissection tasks. These tools are inserted into the body through small openings and are less invasive than traditional open procedures, which require a large incision. Therefore, several advantages exist, including less trauma to the patient, faster recovery time, lower morbidity, and lower health care costs.



Organ model
http://robotics.stanford.edu/groups/manips/projects/softTissues

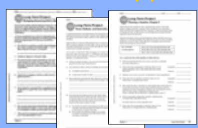
What is Medical Robotics?

Medical robotics is relatively new, but within the medical community, it is seen as an important advance in clinical methods. Medical robotics can be defined as programmed, electronic equipment used to aid doctors in surgical procedure planning and/or implementation. Known as medical robotics and computer assisted surgery (MRCAS), these special instruments became critical as robotically-assisted surgeries began to replace traditional open and minimally invasive surgeries for certain procedures. As a result, surgical equipment offering remote imaging, data processing, feedback and robotics has been developed. Successfully designed equipment benefits surgeons and patients by increasing safety, lowering or eliminating side effects, lowering risks of infection, shortening recovery time, increasing precision, and decreasing surgical costs.

Overbrook High School Classroom Applications

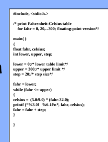
Reality-based Learning: Real-Life Problems

- Students will apply Algebraic principles to solve real-life problems



Logic: "C" Programming

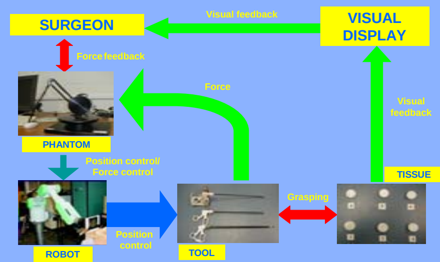
- Students will learn to solve simple math problems using "C" program language



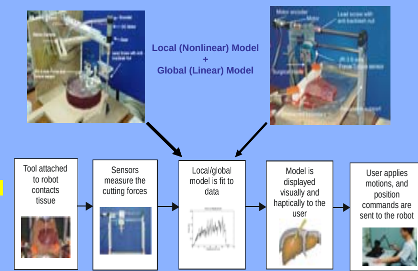
REALITY-BASED MODELING FOR SURGICAL SIMULATION AND TRAINING

❶ Research Flow

Reality-based modeling for surgical simulation consists of a continuous cycle. The surgeon receives visual and haptic (force and tactile) feedback and interacts with the haptic interface to control the surgical robot and instrument. The robot with instrument then operates on the patient at the surgical site per the commands given by the surgeon. Visual and force feedback is then obtained through endoscopic cameras and force sensors that are located on the surgical tools and are displayed back to the surgeon.



❷ Soft Tissue Modeling

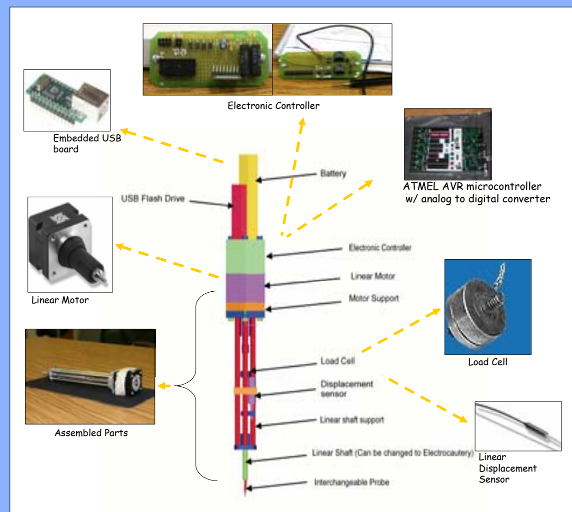


The PRISM Laboratory previously developed an experimental apparatus to measure the force and displacement during tissue cutting and probing. The data obtained from experiments involving cutting and probing pig liver was input into a finite element model. The Local Effective Elastic Modulus (LEEM) values with respect to the displacement were derived from the model. Finally, a reality-based soft tissue model will be developed on the base of the local (nonlinear) model and the global (linear) model. The medical simulator will use this model to provide haptic feedback to the user.

Currently, a battery powered portable probe is being developed in the PRISM Lab. The goal of this probe will be to eventually collect in vivo data of forces and displacements of soft-tissue during probing. A compact mechanism was designed to make the probe convenient and light weight. The subminiature load cell and miniature displacement sensor was chosen to fit the limited space. A compact linear motor provides the thrust force. The core of the controller is a AVR microcontroller, which communicates with an embedded USB board. The experimental data will be saved on the flash drive through the USB board. The data can then be transferred to the computer and the model can be tailored for each individual patient.

❸ Probe Prototype

Circuit boards convert analog signal to digital signal. Atmel RISC microprocessor is programmed in "C" language. RISC is faster due to fewer steps per instruction.



Hand-held probe prototype CAD rendering with real components

Support from:
NSF 0227700
Dr. Mary Poats
Program Manager