Possible projects (examples)

- Extensions to interactive environment for surgical robots (RHT/Kazanzides)
- cisstTracker (Anton Deguet)
  - General-purpose software package for navigational trackers (Anton)
  - Extensions to navigation
- Snake Robot projects (RHT/Kapoor/Flint)
  - Experimental teleoperation evaluation
- Prostate brachytherapy robot project (PKAZ)
- Telerobotics control paradigms (Kumar)
- Collision detection and compensation strategies for surgical robots (Kumar)

Possible projects (examples)

- Programming package for daVinci wrist motor package & smart instruments (RHT/PKAZ)
  - Basic package
  - Palpation motion for robotic ultrasound instrument
- Ultrasound elastography vs manual palpation (Boctor, Taylor, Su)
  - Experiment on phantoms (chicken meat with lesions) at JHU
  - IRB protocol at SoM
- Photo-acoustic imaging setup
  - Basic setup
  - Phantom experiment at CSEB lab
  - (possible) in-vivo experiment
- 3D thermal imaging using 3D wobbler probe
  - Monitor thermal energy deposition from RF or HIFU ablation probe
- 3D strain imaging toolkit (software packaging & GUI)
- Cooperative manipulation for robotically-assisted ultrasonography (RHT, Emad)

Possible projects (examples)

- Microsurgical force sensing & control (Marcin + Iulian + RHT + Surgeons)
  - Integrate fiber-optic force sensor with tool
  - Calibrate tool
  - Test on retina tissue
  - Integrate with Eye Robot
- Scanning spectroscopic probe in & virtual fixtures for micro vessels using our microsurgery robot
- Cannulation with bent pipettes (Marcin + Iulian + RHT + Surgeons)
  - Chick embryos at CSEB lab (compare human vs robot)
  - Rabbit pilot study at Wilmer
- Smart spectroscopy probe on Lap instrument (RHT + Jin Kang + surgeons)
- Biomanipulation (Rajesh Kumar)

Possible projects (with APL)

- Image registration to support research on computer-aided hip osteotomy with intraoperative biomechanical feedback (Armand, Taylor, Arminger)
- Computer aided navigation system to support research on computer-aided hip osteotomy with intraoperative biomechanical feedback (Armand, Taylor, Arminger)
- 2D/3D registration for image-guided bone augmentation with intraoperative biomechanical feedback (Armand, Taylor, Arminger)
- Fiducial design for Image-guided bone augmentation with intraoperative biomechanical feedback (Armand, Taylor, Kazanzides)
- The development of the volumetric model of the augmented bone for Image-guided bone augmentation with intraoperative biomechanical feedback (Armand, Taylor, Kazanzides)

Image registration to support research on computer-aided hip osteotomy with intraoperative biomechanical feedback.

- NIH R01 project, potential for summer support and/or MS project through APL.
- What Students do:
  - Segmentation algorithm for the development of volumetric model of the acetabular cartilage from MRI data
  - Extend the existing Matlab code for MRI/CT co-registration of bone and cartilage
  - Support cadaver trials in latter part of April
  - Publication
- Deliverables:
  - Working Matlab Code, participation in experiments
- Size group: 1-3
- Skills: Matlab, (Knowledge of Matlab GUI and C/C++ are useful), math, experimentation
- Mentors: Mehran Armand, Russ Taylor, Robert Armiger (APL Engineer), and (Gouthami?)

Computer aided navigation system to support research on computer-aided hip osteotomy with intraoperative biomechanical feedback.

- NIH R01 project, potential for summer support and/or MS project through APL.
- What Students do:
  - Extend the existing navigation system (code written in matlab) to Plan, identify and and track the lines of osteotomy and the fragmented bone during the surgery using Polaris tracker and by modifying a volumetric tetrahedral model of pelvis developed preoperatively.
  - Experimental validation on phantom
  - Support cadaver trials in latter part of April
  - Publication
- Deliverables:
  - Working Matlab Code, participation in experiments
- Size group: 1-3
- Skills: Matlab, (Knowledge of Matlab GUI and C/C++ are useful), math, experimentation
- Mentors: Mehran Armand, Russ Taylor, Robert Armiger (APL)

2D/3D registration for image-guided bone augmentation with intraoperative biomechanical feedback.

- NIH R01 project, potential for summer support and/or MS project through APL.
- What Students do:
  - Develop volumetric model of femur from segmented CT data
  - Registration of the femur to the volumetric model using optical tracker
  - affine 2d/3d registration of fluoro images to the femur using a fiducial
  - Experimental validation on cadavers
  - Publication
- Deliverables:
  - Working Matlab Code, participation in experiments
- Size group: 1-3
- Skills: Matlab, (Knowledge of Matlab GUI and C/C++ are useful), math, experimentation
- Mentors: Mehran Armand, Russ Taylor, Robert Armiger (APL)

Fiducial design for Image-guided bone augmentation with intraoperative biomechanical feedback.

- NIH R21 project, potential for summer support and/or MS project.
  - What Students do:
  - Design and build a fiducial for affine 2D/3D registration of fluoro to CT images
  - Validation on phantom
  - Experimental validation on cadavers
  - Publication
- Deliverables:
  - Working Matlab or C Code, participation in experiments
- Size group: 1-3
- Skills: Matlab, (Knowledge of Matlab GUI and C/C++ are useful), math, experimentation
- Mentors: Mehran Armand, Russ Taylor, Peter Kazanzides

The development of the volumetric model of the augmented bone for Image-guided bone augmentation with intraoperative biomechanical feedback.

- NIH R21 project, potential for summer support and/or MS project.
- What Students do:
  - Segmentation and the development of a volumetric model of femur prior to injecting bone material
  - Registration of the 2D fluoro images to the volumetric model
  - Augmentation of the femur by injecting bone material
  - Segmentation of the bone material using fluoro images of the femur after injecting the bone material
  - Modification of the volumetric femur model to incorporate the patterns of injected bone material.
  - Validation on phantom
  - Support experimental validation on cadavers
  - Publication
- Deliverables:
  - Working Matlab or C Code, participation in experiments
- Size group: 1-3
- Skills: Matlab, (Knowledge of Matlab GUI and C/C++ are useful), math, experimentation
- Mentors: Mehran Armand, Russ Taylor, Peter Kazanzides

Possible projects (examples)

- Measure EM tracker distortion in different environments (RHT)
- EM Tracker / X-ray co-registration for tracking needle (RHT)
- Evaluation of tool motion in daVinci using EM tracker (RHT)
- Tissue stiffness measuring device (Choti, RHT?)
- US to MRI Registration (Emad + …)
- Informatics & 4D analysis for Radiation Oncology (Wong, McNutt)
- Radiology IT projects (Philbin)
- Atlas of capsule endoscopy images (Kumar)
- Bone atlases (RHT)

Projects with Radiology IT

Mentor: Jim Philbin, Radiology [+ RHT]

1. Using Voice Recognition to control the display and manipulation of Medical Images. Likely use in the OR - also useful in settings like dentistry. I can supply the the software components necessary for this.
2. Using gestures to control the display and manipulation of Medical Images. We could use Greg's software and the API for Emageon's UltraVisual. This would be useful for Radiologists, Cardiologists, ...
3. Comparing the efficacy of VR and gesture based systems and possibly combining their features for specific applications. This might be a follow on to the first two.

CIS-2 Project

A Surgical Device for the Characterization of the Elastic Properties in In Situ Human Tissue

Goal: To develop simple surgical device to measure tissue elasticity in living human tissue.

Mentors: Michael Choti, MD (Dept of Surg), Russ Taylor PhD

Aim 1: Assess the theoretical foundation and design a smart surgical device to measure tissue elasticity at the device tip.

Aim 2: Simulate the system to verify the accuracy and reliability.

Aim 3: Build a prototype and test in a phantom.

Potential of application:

- Aid in diagnostic assessment of normal and diseased tissue during minimally invasive surgery (e.g. liver stiffness due to cirrhosis, pancreas firmness)
- Measure elasticity parameters (e.g. Young's modulus) in normal and diseased human tissue to validate capability of strain imaging systems for clinical use.

CIS-2 Project

Intraoperative control of prostate brachytherapy robot (PKAZ)

Summary: We have developed and clinically tested a robot system for prostate brachytherapy, which is a procedure in which radioactive seeds are implanted in the prostate to treat cancer. The robot positions a needle guide, thereby replacing the conventional fixed template. The advantage of the robot includes more flexibility in placing the needle and/or correcting its position. The current interface requires the medical physicist to adjust the position of the needle guide. This project is to develop a hardware and software interface that allows the surgeon to perform these tasks, thereby streamlining the workflow.

Skills: Programming in C++ and/or Python; ability to integrate hardware, such as keypad, footswitch, or joystick, with a computer.

Collision detection and compensation strategies for surgical robots

---

In surgical environments, any experienced haptic feedback causes disruption of surgical flow. This project will investigate methods for detecting collisions between manipulators by modeling the manipulator geometry, manipulator control laws, and assessing user goals by measuring motion parameters. If the developed methods are proven to be efficient and accurate, an extension will examine algorithms to increase user awareness, as well as methods to avoid collisions, including manipulator configuration adjustments, and modification of the manipulator control laws

Surgical navigation for hip osteotomy

- Extend the existing navigation system to support research on computer-aided hip osteotomy with real-time biomechanical feedback.
- NIH R01 project (PI is Mehran Armand, APL) potential for summer support, MS project.
- What Students do:
  - Extend the existing Matlab code for MRI/CT co-registration of bone/cartilage, planning and tracking the lines of osteotomy and the fragmented bone during the procedure using Polaris tracker, integration with the existing navigation and biomechanical planning code.
  - Experimental validation of the system on phantom
  - Support cadaver trials on latter part of April
  - Publication
- Deliverables:
  - Working Matlab Code, participation in experiments
- Size group: 1-3
- Skills: Matlab, (Knowledge of Matlab GUI and C/C++ are useful), maths, experimentation
- Mentoring:
  - Mehran Armand, Russ Taylor, Robert Armiger (APL Engineer), and Dr. Simon Mears (Orhtopaedic Surgeon, Bayview Medical Center)

Note: The team requires to go to APL once per week