Eye-in-Hand Range Image Registration for Surgical Robot

Group 9
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Mentors: Russ Taylor, Yunus Sevimli, Bernhard Fuerst
Project Mission

The goal of the project is to mount a range image camera (similar to the Kinect) onto the REMS robot to make setting up the robot and surgeries easier, quicker, and more accurate.
Background

The Robotic ENT Microsurgery System (REMS) robot is a surgical robot that uses minimally invasive techniques by utilizing the body’s natural openings to perform head and neck surgery. Currently, the surgeon must manually move and align the robot in preparation for surgery.

The range image camera from Intel provides image and depth data, which we will parse, using the company’s SDK, into point-cloud data.
Deliverables

Minimum: Register between pre-operative model and camera point cloud

Expected: Test registration accuracy on a phantom with a CT image
           Provide some type of guidance to robot operator
           AX = XB calibration to get camera position relative to robot

Maximum: Find ideal starting pose for robot and assist in initial setup
         or Track robot motions using camera throughout operation
         or Deformable registration using statistical atlas
Technical Approach: Overview

Control Unit -> CT Scan
Pre-operative model

Control Unit -> Camera
Data as a point cloud

Control Unit -> Surgeon
Audio or visual feedback

Control Unit -> REMS
Position data

Camera -> Patient
Image/Depth data

Rems -> Surgeon
Physical movement
Technical Approach: Control Unit

- Control Unit
  - Point Cloud
  - Point Selector
  - Registration Algorithm (ICP, Coherent Point Drift)
  - Video Feed
  - Pre-Operative Model (Mesh)
  - Accuracy Evaluator
  - Visualiser
Technical Approach: Accuracy Validation

To validate accuracy we will use fiducial points from the pre-operative model (such as the tip of the nose or stickers/markers) and evaluate if it aligns with point cloud data.

This evaluation could be done by moving the robot with a dummy tool until it tells us we are allegedly at the spot.
Technical Risks and Alternatives

Extreme range-image camera noise

  Try different camera models

Unaccounted physical features on patient (such as neck brace, etc.)

  Robust outlier algorithm for point cloud

No access to CT scans

  Manually construct model
<table>
<thead>
<tr>
<th>Dependencies</th>
<th>Responsible</th>
<th>Status</th>
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</thead>
<tbody>
<tr>
<td>Intel RealSense Camera</td>
<td>Bernhard Fuerst</td>
<td>Completed</td>
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<tr>
<td>Camera to Robot Mount</td>
<td>Yunus Sevimli</td>
<td>Incomplete (2/22)</td>
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<tr>
<td>Camera SDK</td>
<td>Bernhard Fuerst</td>
<td>Incomplete (2/22)</td>
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<tr>
<td>Access to REMS Robot</td>
<td>Dr. Taylor</td>
<td>Completed</td>
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<tr>
<td>CT Scans for Phantom</td>
<td>Dr. Taylor</td>
<td>Incomplete</td>
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## Milestones

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
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</thead>
<tbody>
<tr>
<td><strong>Minimum Deliverables</strong></td>
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<tr>
<td>Mount Camera to Robot</td>
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<td>Construct Phantom from CT Scans</td>
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<td>Perform a Registration</td>
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<td>Spring Break</td>
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<tr>
<td>Validate Accuracy</td>
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<td><strong>Expected Deliverables</strong></td>
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<td>Implement Guidance/Feedback System</td>
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<td>Decision on Max Deliverables</td>
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<tr>
<td><strong>Maximum Deliverables</strong></td>
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<tr>
<td>Deformable Registration</td>
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<tr>
<td>Patient and Robot Motion Tracking</td>
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<tr>
<td>Define Ideal Starting Pose</td>
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Management Plan

- Weekly Meeting with Mentors: Monday 5:30
- Group Meeting:
  - Wednesday 9-11 am
  - Similar Schedules, so more time added as necessary/available
- Git + Github Private Repo for code control
- Progress tracked on Wiki
Skills / Responsibilities

Both CS majors and strong coders

Zach: Robotics minor, will handle more of interfacing with hardware and other implementation details

Joe: Stronger math background, will handle details concerning algorithms and mathematical approach
Project Readings


