Surgical Skill Evaluation in Endoscopic Sinus Surgery

Group 4
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PROJECT GOAL

Develop a mathematical model for surgical skill evaluation in endoscopic sinus surgery.
Input: Series of Surgical movements
Output: Surgical Skill Level

CIS1 Lecture slides on registration
<table>
<thead>
<tr>
<th>Milestone</th>
<th>Status</th>
<th>Planned Date</th>
<th>Date Accomplished</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recording Software</td>
<td>Completed</td>
<td>February 25</td>
<td>February 25</td>
</tr>
<tr>
<td>Registration Pre Processing Software</td>
<td>Completed</td>
<td>March 3</td>
<td>March 7</td>
</tr>
<tr>
<td>Test the Recording Software in the lab</td>
<td>Completed</td>
<td>March 19</td>
<td>March 26</td>
</tr>
<tr>
<td>Record Data from OR</td>
<td>-</td>
<td>March 24</td>
<td>-</td>
</tr>
<tr>
<td>Registration Software</td>
<td>2D-3D Registration Completed, Currently working on segmenting region of CT corresponding to the image.</td>
<td>March 31</td>
<td>-</td>
</tr>
<tr>
<td>Optimization Software</td>
<td>Completed</td>
<td>April 14</td>
<td>March 19</td>
</tr>
<tr>
<td>Surgical Skill Modeling for 1 surgeon</td>
<td>-</td>
<td>April 25</td>
<td>-</td>
</tr>
<tr>
<td>Surgical Skill Modeling for multiple surgeons</td>
<td>-</td>
<td>May 10</td>
<td>-</td>
</tr>
</tbody>
</table>
Diagrammatic representation of the system currently employed in the operating room
• Used cisstStereoVision and sawMedtronicStealthlink and the libraries these were dependent on
Synchronization Software

- Remove the phase difference between tracker data and video data
- Optical Flow
- Lucas Kanade Approach
Images from dataset of previously recorded surgery
Camera Calibration + Hand Eye Coordination

- Intrinsic Camera Parameters (focal length, principle point and lens distortion) and Extrinsic Camera Parameters (camera pose estimation) are found out using multiplanar calibration.

- Solving for $F_{EO}:: AX = XB$ method from CIS1
2D-3D Registration

• Intrinsic Camera Parameters already known
• Goal: To estimate pose of the camera (R,t) and then camera position in CT co ordinates.
• Given non collinear 2D points, p (landmarks marked on the image) and corresponding 3D points, P; estimate a transformation \( p = FP \)
• \( F \): 3 x 4 transformation matrix for the 3d points to image
• \( p \times FP = 0 \)
Image and CT scan from dataset of previously recorded surgery
Registration Optimization

Measured Values using tracker
$q = Fp$

3D pt cloud to pt cloud registration using method by K. Arun et al
IEEE PAMI, Vol 9, no 5, pp 698-700, Sept 1987

$F_{err}$

Ground Truth, Result from Video-CT Registration
$q = F^*p$ where $F^* = F * F_{err}$
Difficulties encountered so far

• Problems with OpenCV
  – Finding features to track does not work properly with version 2.2 of OpenCV (gives erroneous points), downgraded to OpenCV 2.1

• Stealthlink libraries available only for VS2005

• Debug and Release modes in Visual Studio
  – Spent a lot of time trying to debug certain errors in debug mode of Visual Studio while the program was able to run with no problems in Release Mode.
STATUS of DELIVERABLES

Minimum:
✓ Develop software to Record Data from the surgery
✓ Develop software to compute the various transformations using the tracker data
✓ Develop a software to compute Registration between camera motion and CT data using Tracker based as well as Video based registration

Expected:
✓ Minimum Deliverables
✓ Develop an algorithm to optimize registration over all frames and use it to optimize registration obtained using tracker based and video based registration.
✓ Model the different surgical movements for one surgeon.

Maximum:
✓ Expected Deliverables.
✓ Model the different surgical movements for multiple surgeons.
✓ Develop a model to classify a surgical movement into expert and novice category for different movements.
## DEPENDENCIES

<table>
<thead>
<tr>
<th>Dependency</th>
<th>Status</th>
<th>Plan for resolving</th>
</tr>
</thead>
<tbody>
<tr>
<td>CISST Library</td>
<td>Resolved</td>
<td>-</td>
</tr>
<tr>
<td>Medtronic Stealthlink libraries</td>
<td>Resolved</td>
<td>-</td>
</tr>
<tr>
<td>System with capture card to record data from OR</td>
<td>Resolved</td>
<td>-</td>
</tr>
<tr>
<td>Training for Access to OR</td>
<td>Resolved</td>
<td>Complete the training required for access to OR.</td>
</tr>
<tr>
<td>Required system (Stealthlink Tracker, endoscope, Foot pedal) in the OR</td>
<td>Resolved</td>
<td>Mentors are working on to get this system into the OR.</td>
</tr>
<tr>
<td>Camera Calibration Toolbox</td>
<td>Resolved</td>
<td>Part of CISST library.</td>
</tr>
<tr>
<td>Software for Surgical Modeling</td>
<td>Pending</td>
<td>Available in the lab. Talk to mentors for access.</td>
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</tbody>
</table>


Thank you...