Image Guided Surgery for Medialization Laryngoplasty

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Laryngoplasty
- Surgical procedure designed to restore voice to patients with vocal cord paralysis and paresis
- Implant patient-specific support through window cut in the thyroid cartilage
- Present
  - Plan optimal size, shape, location by experience and intuition
  - Execution of cut guessed by looking at pre-operative CT plus laryngoscope

Computer Aided Surgery
- Surgery planning
  - Help the surgeon decide what to do where
- Image guidance
  - Help the surgeon perform procedure by giving additional visual guidance
- Robotics
  - Help the surgeon perform procedure using robots
Image-guided Surgery
- Old way: cut then see
  - Purely based on experience
- New way: see then cut
  - "see" done using MRI/CT/Ultrasound, etc.

Image-guidance
- We have 3-D information from pre-operative CT
  - "Virtual patient"
- To cut real patient while looking at virtual patient
  - Two needs to be "registered"
- In effect, give surgeon x-ray vision to determine what lies under the tissue (thyroid cartilage)

Image-guided Laryngoplasty
- Acquiring virtual patient
  - Preoperative CT
- Intraoperative registration of virtual to real patients
  - Computer vision-based registration using shape of thyroid cartilage
- Augmented visualization

Preoperative Virtual Patient
- Marching cube algorithm for iso-surface generation
  - To extract thyroid cartilage surface
**Thyroid Cartilage Surface**

- NIH Visible Human CT
- Male Cadaver CT
- Female Cadaver CT
- GW Patient CT 1 (Male)
- GW Patient CT 2 (Male)

**Intraoperative Surface**

- Stereo vision using structured light
  - Known sequence of light patterns
  - Two cameras view reflections
  - Matching pixels from same point on surface used to identify 3D location
  - Cloud of points define surface

**Registration using shape of thyroid cartilage**

- Registration of two surfaces from pre- and intra-operative stages
  - Match every point in M1 to the closest point in the M2
  - Assume that M1 and M2 is rigid object
  - \[ M2 = R \cdot M1 + T \]
  - Compute R and T that minimize
  - ICP based shape matching
Cadaver Study

- Experiment with dissected male larynx
  - Left: Photo, Right: 3D Surface from CT
- ICP based registration
  - Before (left) and After (right)
  - RMS Error: 0.891mm
- Full body scan with structured light on cadaver
  - Left: Photo, Right: 3D points

Visualization

- Augmented reality
  - Enhance real view (intra-operative) with registered virtual view (pre-operative)
- 3 types of information
  - 2D preoperative laryngoscope
  - 3D preoperative CT
  - 2D intraoperative surface view
- Projective texture mapping of 2D views on preoperative 3D isosurface

Intraoperative Visualization Interface

- Visualization
Future Work

- Additional cadaveric studies
- Clinical usability
- Clinical trials
- Extension of computer vision-based image-guided procedures to other domains
  - Laparoscopic surgery
  - General open surgery