TISSUE CHARACTERIZATION WITH SMART GRASPER ROBOT

STUDENTS: YANA SOSNOVSKAYA, HUNTER NORTH, CHUL JUNG, ETHAN SEPA, SHAHERYAR HASNAIN

GLOBAL INNOVATION EXCHANGE

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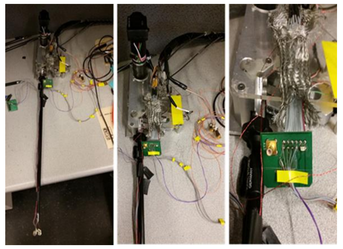
Introduction

- Minimally-Invasive Surgeries (MIS) has advantages for patients (faster recovery time, less blood loss, less trauma to tissue), however MIS also has a disadvantage – lacking tactile feedback for the surgeons. Multi-sensory laparoscopic grasper can help with this problem.

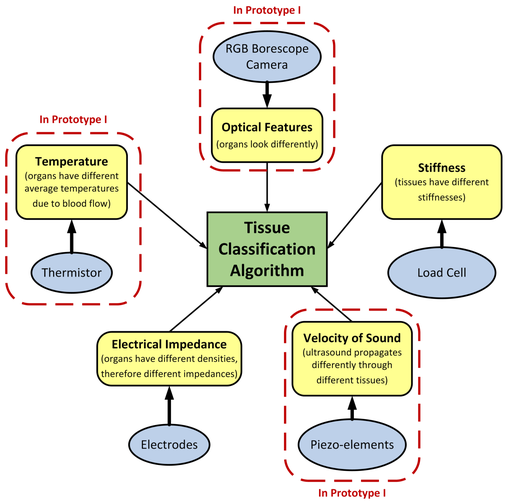


- Original "Smart" Grasper was developed by Philip R. Roan, and had optical, electrical impedance and temperature sensors on the grasper's jaws. [1]
- Modified by Astrini Sie in work [2].

Original "Smart" Grasper design developed by Philip R. Roan. A lot of wires were broken and sensors were shorted due to transportation and storage of the "Smart" Grasper robot.

- **Multi-modal surgical instrument has the following advantages:**
  - ➢ Providing real-time feedback to surgeons in MS;
  - ➢ Modeling the tissue for surgical robotics simulators;
  - ➢ The study of tissue behavior in response to surgical manipulators;
  - ➢ In-vivo and in-vitro tissue classification;
  - ➢ The diagnosis of tissue abnormalities in early stages;

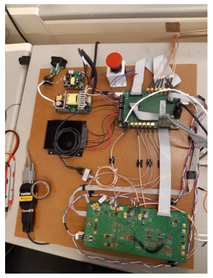
Sensor Fusion Diagram



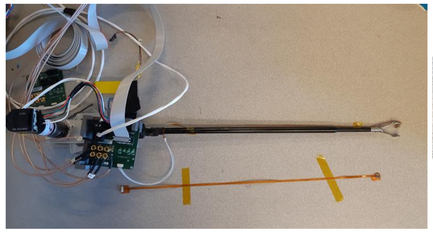
- **Sensor Fusion Algorithm (DL based) for tissue characterization** via "Smart" Grasper is based on the correlation of sensory measurements with physical, acoustical, optical, electrical and thermal properties of tissue.

Hardware Prototype: Motorized Surgical Grasper

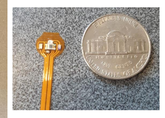
- The developed motorized surgical grasper based on original "Smart" Grasper has miniaturized sensors set: load cell, 3MHz ultrasonic transducer, RGB borescope camera, pulse-oximetry, thermistor and multi-frequency 2-point bioimpedance.



Data acquisition electronics

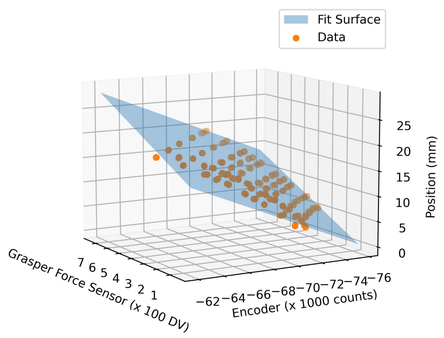


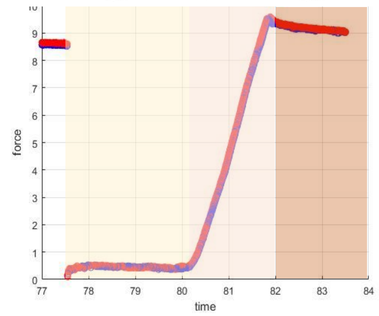
Surgical motorized "Smart" Grasper with miniature sensors



Miniature sensor set

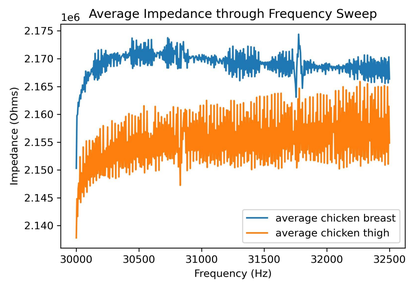
Joint Force-Position Calibration*

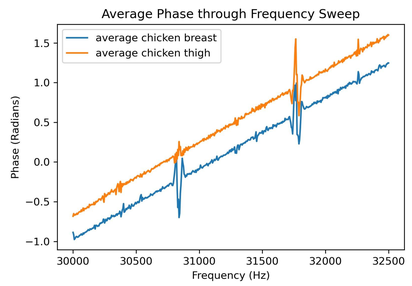




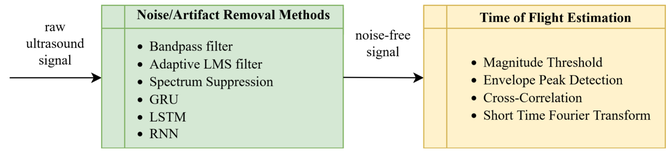
*Part of the work is presented at ISMR-21 Conference [4].

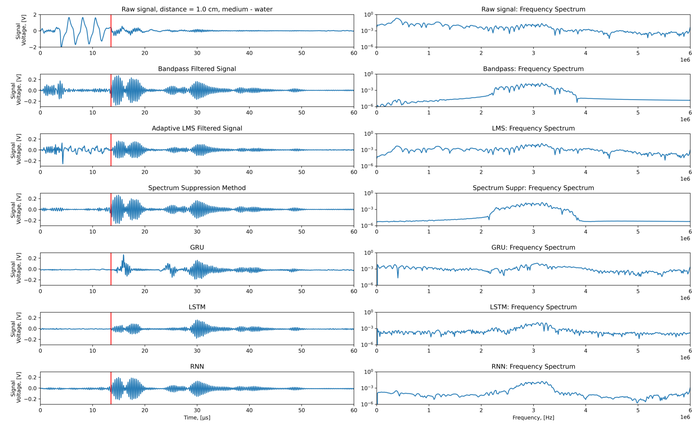
Electrical Impedance Calibration



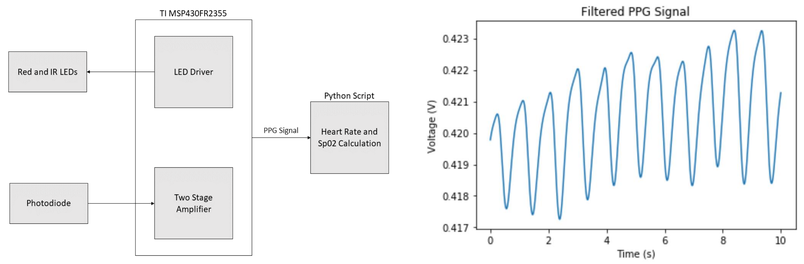


Ultrasound Sensor Calibration & Artifact Removal





Pulse-Oximetry



Future Work. References.

- Integrate all subsystems together;
- Collect data using Smart Grasper from organs: liver, kidneys, muscle, soft tissue.
- Process the data with pre-processing and deep learning algorithms to characterize the tissue.

1.Philip R. Roan, "An instrumented Surgical Tool for Local Ischemia Detection," Ph.D. Thesis, University of Washington, 2011.
2.Astrini Sie, "Online Identification of Abdominal Tissues During Grasping Using an Instrumented Laparoscopic Grasper", M.S. Thesis, University of Minnesota, 2013.
3. M. Daoud et al, "Tissue Classification Using Ultrasonic-Induced Variations in Acoustic Backscattering Features", IEEE transactions " Biomedical Engineering, February 2013.
4. J. Kaplan, Y. Sosnovskaya, M. Arnold, B. Hannaford, "Sensor Fusion for Force and Position Calibration of a Motorized Surgical Smart Grasper", ISMR21, November 2021.

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UNIVERSITY of WASHINGTON

ADVISORS: BLAKE HANNAFORD, ELI SHLIZERMAN, MIKA N. SINANAN

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