

SYSC 4907 M1

Design and Development of Smart Surgical Needles with Impedance Sensors for Tissue Biopsy



Group size: 3 or 4 students.

Suitable for: Students with interest in instrumentation and machine learning, Biomedical, Electrical Engineering, Computer Systems, and Software Engineering students. A multidisciplinary team with students from different programs is preferred.

Desired background: Instrumentation, signal processing, machine learning, software engineering. A background in biomedical engineering is not required.

Supervisor: Prof. C. Rossa: carlosrossa@cunet.carleton.ca

Lab information: <https://www.biomechatronics.ca>

Before joining the project, please form a group of 3 or 4 students and contact Prof. Rossa by email. Approval is required before joining the project.

Project Description: The goal of this capstone project is to design, develop, and experimentally validate a new class of surgical needles equipped with integrated electrical impedance spectroscopy sensors capable of identifying and classifying tissue at the needle tip in real time during biopsies (e.g., fat, muscle, normal tissue, lesions). Conventional needle-based biopsies rely on clinician experience and imaging, which can lead to non-diagnostic samples, repeated insertions, and increased patient risk. Integrating impedance-based sensing at the needle tip will provide real-time tissue characterisation, allowing the clinician to differentiate tissue types and confirm accurate needle placement within suspicious lesions before biopsy sampling. The project will involve selecting suitable sensors, integrating micro-electrodes without compromising mechanical integrity, and developing a compact system for real-time signal acquisition and AI-based tissue classification. Prototypes will be fabricated and tested in tissue phantoms and animal tissues, followed by data analysis.

Anticipated deliverables: A fully functional prototype including sensor design, signal processing unit, AI classification algorithm, user interface, and supporting documentation.