A New Tactile Sensing System for Minimally Invasive Surgical Tumour Localization

Background and Motivation

Minimally Invasive Surgery (MIS) reduces collateral damage by entering the patient’s body through small (<10 mm) incisions. Open surgery for tumour resection involves a large incision. Unfortunately, the small incisions used in MIS prevent direct manual palpation of organs to localize underlying tumours.

Tactile Sensing System (TSS)

The TSS is composed of:

- Tactile sensing instrument (TSI) = sterilisable capacitive-based sensor array mounted on a hand-held minimally invasive probe.
- Visualization interface: provides an active pressure colour-contour map of the contact surface.

The TSI uses a pressure sensing pad (PSP, Inc.) based on 60 distinct capacitive elements.

Hypothesis

Hypothesis: The TSS will perform better than laparoscopic ultrasound and endoscopic graspers when localizing underlying tumours.

Materials and Methods

Phantom Tumours
- made from a mixture of agar, barium sulphate, and water
- 10 mm in diameter, hemispherical objects.

Ex vivo bovine liver
- purchased from local store
- approximately 3 mm thick
- phantom tumours embedded underneath tissue.

Ex vivo porcine lung
- collapsed before incision
- approximately 10 mm in thickness
- phantom tumours sutured in dorsal side of tissue.

A medical practitioner was asked to localize tumours in the tissue. Subjects were blind to the location and number of tumours located in the tissues.

Experimental Setup

Performance Assessment

Radiographic images of the tissues were acquired and used to determine the localization distance and the success rate of tumour identification.

Performance measures:
- Localization distance
- Maximum pressure, and
- Success rate required to determine the statistical experimental results of accuracy, sensitivity, and specificity

Results

Results of experiments with the TSS compared to standard MIS localization methods. The performance was tested on ex vivo tissue using liver as an ideal tissue model, and lung as a realistic tissue model.

Conclusions

The TSS demonstrated:
- 70% decrease in applied pressure when compared to an endoscopic grasper.
- 14% and 22% increase in detection accuracy when compared to ultrasound and endoscopic graspers, respectively.
- No significant change in performance when palpating different tissues.

The TSS can offer an improvement over current MIS techniques by allowing the surgeon to regain some of the tactile information lost during MIS.

The research institute of London Health Sciences Centre and St. Joseph’s Health Care, London.