Tissue differentiation

The surgeon’s intraoperative tissue appraisal is based on his subjective evaluation of the visual aspect and digital impression of the considered tissue, and it is subject to the accumulated experience of the surgeon. An intraoperative in situ real-time diagnostic tool could be exceedingly valuable, supporting the surgeon’s decision on tissue resection.

This is especially relevant in neurosurgery, when a tumor reaches eloquent areas, and the resection procedure become increasingly imprecise, due to misguidance of the location of tumor boundaries caused by brain shift effect. Here, an inappropriate tissue resection could risk patient’s neurofunctional integrity

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A tactile sensor is a device that measures information arising from physical interaction with its environment. Tactile sensors are generally modeled after the biological sense of cutaneous touch which is capable of detecting stimuli resulting from mechanical stimulation, temperature, and pain (although pain sensing is not common in artificial tactile sensors). Tactile sensors are used in robotics, computer hardware and security systems. A common application of tactile sensors is in touchscreen devices on mobile phones and computing.

Tactile sensors may be of different types including piezoresistive, piezoelectric, capacitive and elastoresistive sensors.

Mechanical characteristics of tumor and healthy tissue in the brain differ but slightly. The task of designing a system that is able to differentiate tissue dignity with high sensitivity is of great importance in neurosurgery. Even when localization of tumor by use of preoperative imaging techniques provides the surgeon with valuable information to decide where and what to resect, the brain shift due to change in pressure during skull opening demands the surgeon to define the limits of the tumor using tactile and visual differentiation. This paper contains a general description of the tactile sensor system based on a piezoelectric bimorph. The main parts of the measurement system are described and the selection of the electrical parameters for tactile differentiation is justified. Results are discussed for a series of measurements at different concentrations in gelatin phantoms [1)].

Reliable intraoperative delineation of tumor from healthy brain tissue is essentially based on the neurosurgeon's visual aspect and tactile impression of the considered tissue, which is-due to inherent low brain consistency contrast-a challenging task. Development of an intelligent artificial intraoperative tactile perception will be a relevant task to improve the safety during surgery, especially when-as for neuroendoscopy-tactile perception will be damped or-as for surgical robotic applications-will not be a priori existent.

Stroop et al. from the Department of Neurosurgery, Academic Hospital Cologne-Merheim, Department of Engineering Technology (INDI), Vrije Universiteit Brussel, Brussels, Belgium, presented the enhancements and the evaluation of a tactile sensor based on the use of a piezoelectric tactile sensor.

A robotic-driven piezoelectric bimorph sensor was excited using multisine to obtain the frequency response function of the contact between the sensor and fresh ex vivo porcine tissue probes. Based on load-depth, relaxation and creep response tests, viscoelastic parameters E1 and E2 for the elastic moduli and η for the viscosity coefficient have been obtained allowing tissue classification. Data analysis was performed by a multivariate cluster algorithm.

Cluster algorithm assigned five clusters for the assignment of white matter, basal ganglia and thalamus probes. Basal ganglia and white matter have been assigned to a common cluster, revealing a less discriminatory power for these tissue types, whereas thalamus was exclusively delineated; gray matter could even be separated in subclusters.

Bimorph-based, multisine-excited tactile sensors reveal a high sensitivity in ex vivo tissue-type differentiation. Although, the sensor principle has to be further evaluated, these data are promising [2].

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Uribe DO, Stroop R, Wallaschek J. Piezoelectric self-sensing system for tactile intraoperative brain tumor delineation in neurosurgery. Conf Proc IEEE Eng Med Biol Soc. 2009;2009:737-40. doi: 10.1109/IEMBS.2009.5332409. PubMed PMID: 19963471.
2)
Stroop R, Nakamura M, Schoukens J, Oliva Uribe D. Tactile sensor-based real-time clustering for tissue differentiation. Int J Comput Assist Radiol Surg. 2018 Oct 6. doi: 10.1007/s11548-018-1869-5. [Epub ahead of print] PubMed PMID: 30293172.