
Mechanics and Modelling of Brain Tissue Interaction with a Slender Ribbon-Shaped Neural Probe

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Abstract

Understanding the mechanics of brain tissue interaction with minimally invasive neural probes is critical for developing safer and more effective neurosurgical interventions. This work investigates the insertion behavior of a steerable, slender ribbon-shaped neural probe in brain tissue.

Ex-vivo experiments were conducted using porcine brain tissue to investigate the mechanics of probe-tissue interaction during insertion. A custom-built robotic platform was developed to facilitate these studies, including precision force sensing, imaging, and automated manipulation of the probe. This setup enabled the characterization of the mechanical response of brain tissue, including the fracture behavior and contact forces during insertion, providing valuable insights into the mechanics of interaction between probes and the brain.

In parallel, we developed a computational framework to model the interactions between the ribbon and soft tissue. A one-dimensional mechanical model of the ribbon was coupled with a simplified soft tissue model to simulate the stress distribution during insertion of the ribbon. This model provides a deeper understanding of the tissue-probe interactions, enabling the refinement of probe design and insertion strategies to minimize tissue damage. With our combined experimental and computational approach, we aim to better understand the mechanics of brain-probe interactions and to help design safer and more agile neural probes for clinical applications.

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