Autonomous Attainment of Tissue-Centricity in Electrosurgery through Data-Driven Persistently Evolving Thermogeometric Adaptivity

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Challenge:

- Electrosurgical action to achieve minimal tissue damage
- Providing safe electrosurgical guidance to surgeons in real-time

Solution:

- Monitor the status of live tissue in real-time and find the optimal electrosurgical action
- Model electrosurgical instrument interaction with live tissue via controlled experiments
- Develop safe autonomous electrosurgical systems

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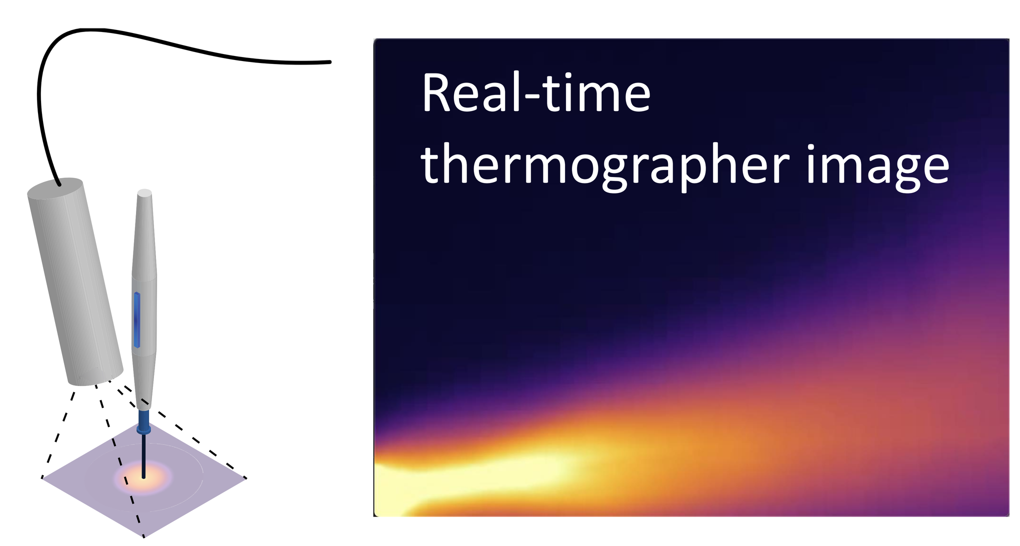
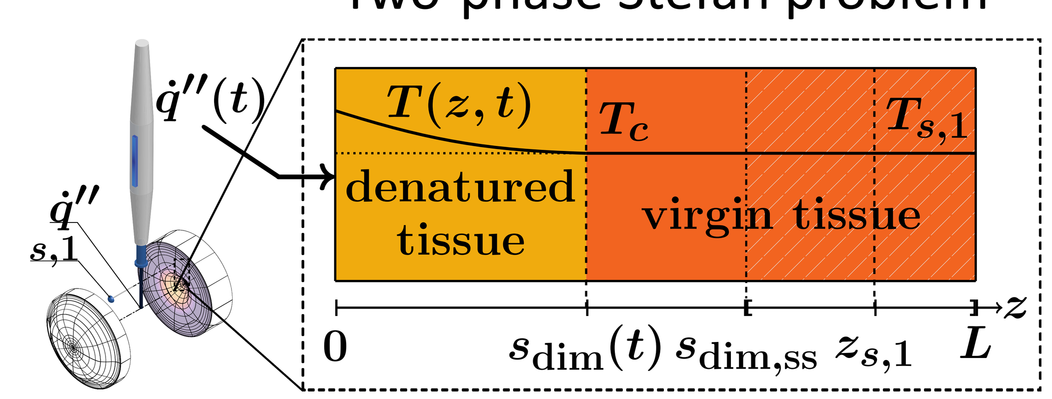
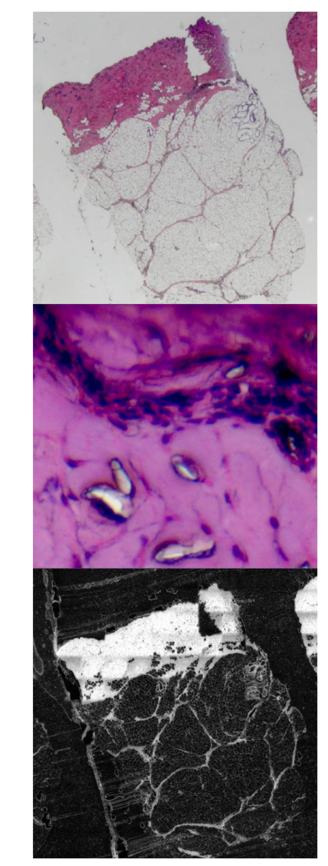
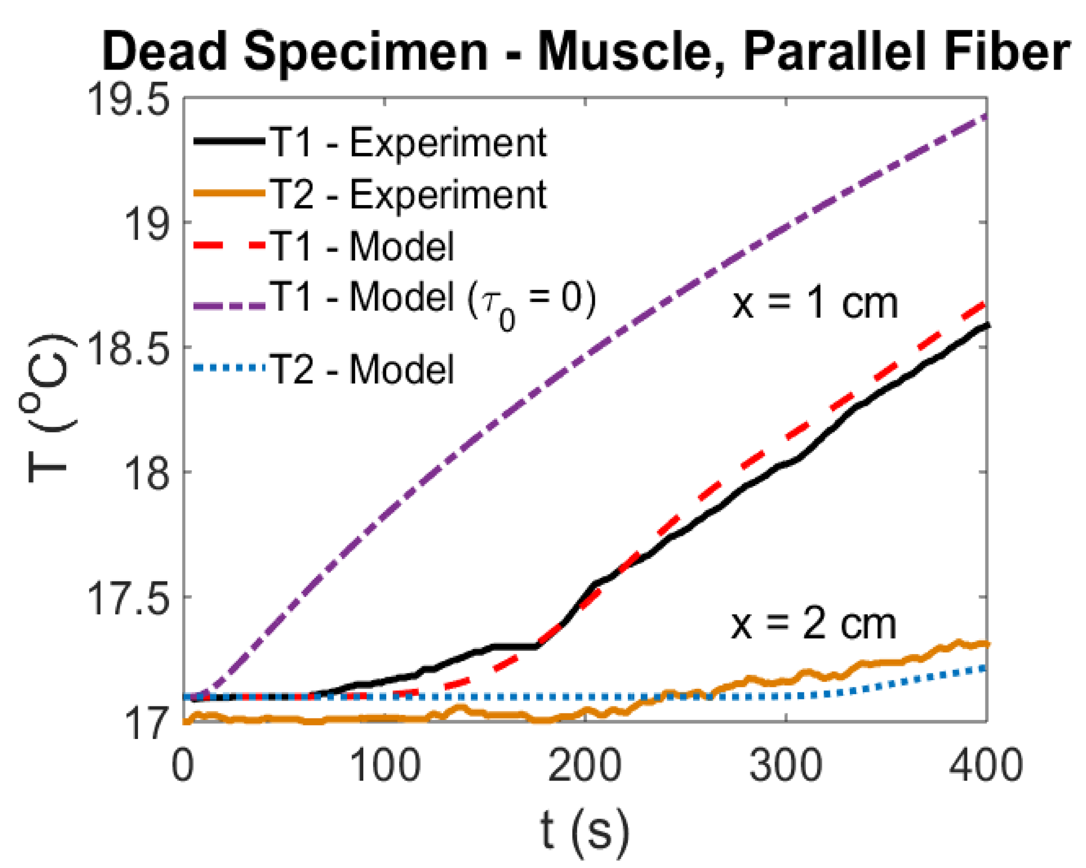


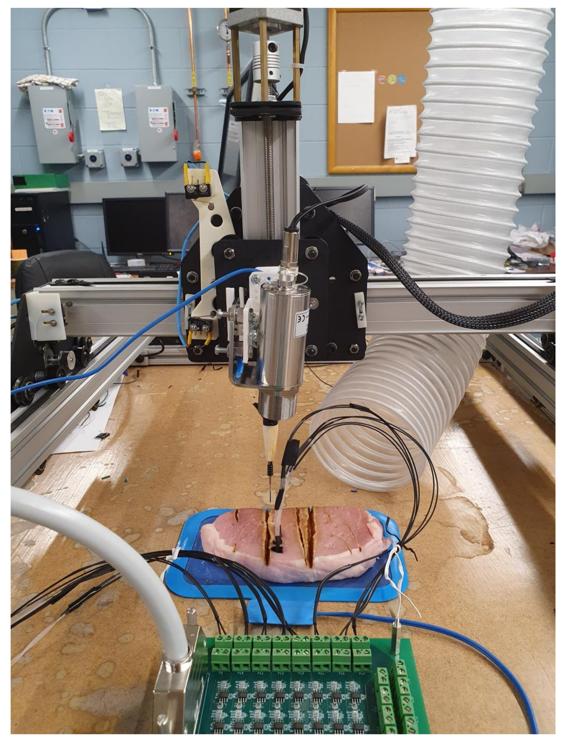
Two-phase Stefan problem





Infrared & Optical image of porcine skin tissue





Nonlinear PDE Telegraph Equation

$$c(T)\rho(T)\frac{\partial}{\partial t}T+\tau_0(T)\frac{\partial}{\partial t}\left(c(T)\rho(T)\frac{\partial}{\partial t}T\right)$$
$$=\nabla k(T)\nabla T+k(T)\nabla^2 T.$$

Achievements:

- Mechanism of electrosurgical probe interaction with live tissue
- Equations of heat propagation in live tissue
- Reliable tissue monitoring system using different types of sensors
- Control configurations to find the optimal electrosurgical action minimizing tissue damage (WIP)
- Electrosurgical actions to induce hypersonic-type heat shock wave

Scientific and Broader Impact:

- Safer and more precise electrosurgery
- Deeper understanding of tissue thermodynamics
- New methods for PDE control