Thesis Project Portfolio

Anatomically personalized ML model predicts target temperature in focused ultrasound brain treatments

(Technical Report)

The Accesibility of Uterine Fibroid Treatments for Understanding Sociotechnical Setbacks for Focused Ultrasound Technology

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Charlotte Edwards

Spring, 2024

Department of Biomedical Engineering

Table of Contents

Sociotechnical Synthesis

Anatomically personalized ML model predicts target temperature in focused ultrasound brain treatments

The Accesibility of Uterine Fibroid Treatments for Understanding Sociotechnical Setbacks for Focused Ultrasound Technology

Prospectus

Sociotechnical Synthesis

The uniting goal of my Science, Technology, and Society (STS) research project and my technical project is a greater understanding of the patient-centered areas for improvement for focused ultrasound treatment technology. Focused ultrasound is a medical technology that focuses multiple high-intensity ultrasound beams to a single point to destroy problematic tissue. My STS research project and technical projects differ in the focused ultrasound use case studied. While my technical work focuses on the development of a machine learning algorithm to predict eligibility for focused ultrasound brain treatments, my STS research project studies the accessibility barriers to receiving focused ultrasound treatments for uterine fibroids.

For my technical project, my team and I developed a machine learning algorithm that predicts the temperature reached in the target region for focused ultrasound brain treatments. Focused ultrasound treatments are an attractive area of research for brain diseases because the individual ultrasound beams are harmless and only destroy tissue at the combined target point, meaning the procedure is nonsurgical. Treatment success is defined by the cumulative time the target region is heated to above 55℃, so by predicting the temperature reached in the target region, we predict treatment success before the procedure and identify eligible patients who are likely to respond well. Predicting success before treatment is crucial because focused ultrasound treatments entail so much uncertainty that they are currently performed in repeated short bursts until patients experience pain or symptom improvement. By customizing a machine learning model to multiple anatomical parameters, we can more accurately predict the likelihood of success before treatment, saving ineligible patients pain and time and saving eligible patients suffering and the risks of brain surgery.

My STS research moves out of the realm of brain treatments into women's health, exploring accessibility barriers to receiving focused ultrasound treatments for uterine fibroids patients. I use Thomas Hughes's theory of technological momentum to illuminate sociotechnical hindrances that slow the adoption of focused ultrasound technology among these patients. Specifically, I claim that focused ultrasound treatments are underutilized for uterine fibroid patients because of the socioeconomic hindrances of provider workplace pressures and prohibitive treatment costs for patients. Through this research, I hope to illustrate the importance of considering not only technical, but social areas for improvement for focused ultrasound to expand its accessibility for all potentially benefiting patients.

The concurrent development of these projects enriched both with unique insights. My work on the technical project enhanced my understanding of how focused ultrasound technology functions, allowing me to understand both technical and social arguments about influences on the utilization of focused ultrasound for uterine fibroids patients. Additionally, my STS research revealed how great of an impact the clinical socioeconomics of focused ultrasound have on its utilization. While detailing the barriers to treatment accessibility of focused ultrasound for my STS research, I implemented multiple design aspects to improve accessibility of the predictive model for my technical project, such as development in a free-to-use programming language, visually outputting the model's decision process to facilitate trust of a new technology in a medical setting, and a graphical user interface to facilitate ease of use.