Thesis Portfolio

Using Deep Learning to Classify Left Ventricular Scarring in Diverse Patient Populations

(Technical Report)

Optimizing the Integration of Computational Tools in Routine Clinical Cardiology

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

(Executive Summary)

Developing and Integrating Computational Tools in Cardiology

Diagnoses and treatments for cardiovascular diseases are evolving at an exciting rate to improve patient outcomes. The field of deep learning has weaved its way into medicine. Deep learning allows engineers and scientists to develop patient-focused computational tools while leveraging the power of medical data, cardiac physiological phenomena, and mathematical relations. Cardiovascular diseases affect millions of Americans, and several cardiovascular diseases are a result of and/or cause myocardial infarction, the dying of cardiac cells leading to scar, which often leads to heart failure. The technical portion of the thesis focuses on developing a novel deep learning pipeline to classify and segment myocardial infarction scarring in the left ventricle (LV) of the heart. The deep learning algorithm pipeline will help reduce cardiologist workload and improve patient diagnosis and treatment of diseases related to myocardial infarction. The sociotechnical portion of the thesis focuses on how engineers can better develop computational tools, like deep learning algorithms, so that they are more easily integrated into routine clinical cardiology. New technology often has difficulty integrating itself into clinical cardiology workflows due to several integration barriers, ultimately leading to the demise of novel technology before it has a chance to improve patient outcomes in the real world. Engineering does not stop once the cardiac computational tool is built; engineers and cardiologists have an ethical and social obligation to ensure that the computational tool is actively being used in the clinic to positively affect the patient. Thus, the thesis focuses on developing a unique deep learning computational tool for cardiologists and identifying ways to best integrate the computational tool into routine clinical cardiology.

The technical portion of the thesis produced a deep learning binary classification algorithm to identify LV scarring in diverse patient populations. The classification algorithm was coupled to an existing LV scar segmentation algorithm to reduce false positive (FP) and false negative (FN) segmentations created by the segmentation algorithm. Working with Carina Medical LLC, transfer learning was used to build a classification model, and the model was trained on two patient populations: acute myocardial infarction patients and hypertrophic cardiomyopathy patients. Further analysis suggested that the deep learning pipeline of the classifier and segmentation algorithm was able to reduce FPs and accurately identify scar over 88% of the time compared to only using the segmentation model. The pipeline was also found to reduce cardiologist workload by over 68% when compared to the use of no deep learning algorithms.

The sociotechnical portion of the thesis produced several guidelines for engineers and cardiologists to follow to increase the use of computational tools in routine clinical cardiology. The research uses Actor-Network Theory and technological momentum, sociotechnical frameworks, to help shape the guidelines. Four main guidelines were developed: research and development networks must educate cardiologists about new computational tools, hospitals must use a subscription-based service to purchase computational tools, engineers must design computational tools cognizant of software and hardware limitations in hospitals, and engineers must design computational tools that do not disrupt physician-nurse social dynamics. The guidelines are designed so that computational tools in clinical cardiology can best help patients.

The technical portion of the thesis motivated the need for the sociotechnical project. As an engineer, I have a social and ethical obligation to understand how the tools I develop interact with the environment they are placed in. The novel deep learning pipeline will improve segmentation practices for cardiologists, often an arduous task. Although the pipeline in its current state is not ready to be deployed into routine clinical cardiology, the sociotechnical project suggests that the design of the deep learning pipeline must satisfy the aforementioned integration guidelines while the pipeline is still in development. As the deep learning pipeline is further improved, the project is tasked with educating cardiologists about deep learning algorithms, improving algorithm computational efficiency to meet software and hardware infrastructure requirements, and understanding how the algorithm interacts with current cardiologist-nurse dynamics.

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