Thesis Portfolio

Machine Learning-Assisted Pulse Wave Analysis for Heart Failure
(Technical Report)

Implicit Bias Effects of Artificial Intelligence Implementation in Cardiovascular Care
(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

This undergraduate thesis portfolio presents an exploration of the incorporation of machine learning into a novel diagnostic cardiology device and an analysis of the ethical considerations related to implementation of artificial intelligence (AI) in cardiovascular care. The purpose of this work is to further the application of AI technology in clinical settings and promote ethical engineering in this space.

The technical project, titled "Machine Learning-Assisted Pulse Wave Analysis for Heart Failure," tested a diagnostic system geared to noninvasively collect pressure waveforms from patients, derive aortic waveforms from this data, and classify these waveforms into heart failure and non-heart failure categories with the ultimate goal of improving noninvasive diagnostic capabilities. The impact of a portable and easy-to-use diagnostic device is affording patients the ability to detect heart failure at earlier stages, subsequently offering time and cost savings for patients, physicians, and hospitals. The results of this project revealed a 49.96% accuracy in aortic waveform derivation as measured by augmentation index and a 77.8% accuracy in machine learning algorithm detection of heart failure.

The STS paper, titled "Implicit Bias Effects of Artificial Intelligence Implementation in Cardiovascular Care," viewed the ethical issues posed by AI implementation in healthcare through the lens of technological momentum and utilized the historical method to analyze COVID-19 vaccine distribution in the state of Virginia as a case study. Statistical analyses were conducted on the vaccine doses per capita and vaccine representation across the ten counties with the largest AA population (group 1), the smallest AA population (group 2), and the highest average income (group 3). Vaccine representation was measured as the difference between the percentage of African Americans (AA) in the total population and vaccinated population. The results of this case analysis showed greater vaccine doses per capita in the group 1 counties than in both the group 2 and group 3 counties, though this difference was only statistically significant between the group 1 and 3 counties. However, the group 1 counties showed significantly higher underrepresentation of AA in vaccinated populations than group 2 and group 3 counties. This case study revealed the complexities accompanying healthcare resource distribution reliant on historical usage data, which forms the basis of many resource allocation algorithms and decision-making processes.

This thesis aims to not only propose a novel diagnostic device for heart failure that incorporates artificial intelligence, but also vouches for the importance of algorithm training set

data transparency in such future AI applications in cardiovascular care – a clinical area displaying many historic disparities similar to those fueling the resource distribution inequity highlighted above. Both methods used above followed similar goals of utilizing findings from a subset to better understand a characteristic of the population; in the technical paper, a few patients were studied to apply the findings to all future patients, whereas in the STS paper, one case involving the healthcare system was examined to hypothesize the future of the cardiovascular care overall. Though the methods differ in their specific execution, together they serve as a powerful tool to promote ethical development and implementation of AI in cardiovascular care and eventually better the lives of millions across the globe.