Sociotechnical Synthesis

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Ramiz Akhtar

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Signature ____________Ramiz Akhtar____________ Date __04/27/21_

Ramiz Akhtar

The objective of engineering is to iteratively design a product that improves the way we interact with the world in an ethical manner. Recent advances in the field of deep learning, which is a subset of machine learning that uses algorithms to progressively extract key features from input data, have made patients' medical data even more informative for physicians making a diagnosis. Cardiovascular disease is the leading cause of death for men and women in the United States (CDC, 2020). It is often responsible for causing myocardial infarction, which results in the death of cardiac cells and ultimately cardiac scarring. The technical portion of the thesis aims to develop a novel deep learning pipeline that combines a scar segmentation algorithm with a newly developed classification algorithm to assist cardiologists in identifying myocardial scarring in the heart's left ventricle (LV). The pipeline's objective is to improve health outcomes for cardiovascular disease patients while simultaneously reducing the workload of cardiologists. In deep learning and machine learning in general, limited dataset diversity reduces the generalizability of a deep learning pipeline (Faruqi & Singh, 2021). Therefore, a more diverse training dataset is critical to creating algorithms with high overall accuracies. The STS research portion of the thesis discusses the need for more accountable data handling practices within the realm of healthcare wearables and health insights. Healthcare wearables are becoming increasingly ubiquitous and advanced in their feature sets. As a result, healthcare manufacturers have more health data at their disposal than ever before. However, the rate of advancement in health data privacy standards has failed to match the rapid advancement of new health data collection methods. Engineers have a duty to ensure that the tools they create are transparent in their data collection and data interpretation to foster an environment of accountability and trust.

The technical portion of the thesis produced a deep learning binary classification algorithm to identify LV scarring. The classification algorithm was coupled with an existing LV scar segmentation algorithm by Carina Medical LLC in order to decrease false positive (FP) and false negative (FN) segmentations. The classification algorithm utilized an Xception transfer learning model. The training dataset consisted of two separate patient populations: hypertrophic cardiomyopathy patients and acute myocardial infarction patients. Our novel classification and segmentation pipeline successfully reduced FPs. The pipeline had an 88% accuracy for scar identification compared to a 76% accuracy when using only the scar segmentation algorithm. The pipeline also reduced cardiologist workload by 68% when compared to a standard workflow that lacks a deep learning pipeline.

The STS research portion of the thesis identified prior, current, and forthcoming data privacy issues with the new generation of wearable health technologies. Actor network theory's (ANT's) in-depth exploration of relational ties was used to analyze the complex interplay between wearable technologies and smartphones in addition to wearable device manufacturers and consumers. The analysis produced two key findings: (1) increasing the processing power of wearable devices would allow for on-board insight generation and result in greater health data security, and (2) wearable device manufacturers need to explicitly state how user data is being used post-collection in a readable, accessible, and interpretable privacy policy. Technological momentum was used to supplement ANT and emphasize that the window for action in regards to modernizing healthcare wearable privacy is still open but rapidly closing. National legislation such as the Health Insurance Portability and Accountability Act (or HIPAA) must be updated to broadly include protections for "biometric information," ultimately resulting in sustainable data handling practices that promote accountability of health wearable manufacturers to their users.

Both projects highlight the need for a crucial value within engineering: transparency. For the technical portion of the thesis, the decision making of the myocardial scar identification pipeline must be clear in order for the cardiologist to be confident in the pipeline's results. The pipeline aims to reduce the cardiologist's workload which cannot truly be done without full trust in its myocardial scar identification capabilities. For the STS research portion of the thesis, healthcare wearable users should have the right to know how their personal health data is utilized after health insights are provided to them. Without transparency, users' health data can potentially be used against them in scenarios such as increased insurance rates for sleeping less than the healthy standard (Allen, 2018). Transparency in data collection and data interpretation are critical in ensuring that engineered technologies provide solutions that improve the quality life without unnecessary tradeoffs that take away from the brilliance of these creations that are pivotal to advancing mankind.

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