Thesis Project Portfolio

Volumetric Assessment of Pulmonary Artery Thrombus Burden

(Technical Report)

The Ethical Analysis of the Integration of Machine Learning within Patient Diagnostic Imaging Procedures

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

Introduction

My technical work and STS project both focus on the use of machine learning (ML) algorithms within the field of medicine. In my technical project, my capstone team and I developed and validated an ML algorithm to quantify the volume of thrombus burden that is still present within a patient who has a pulmonary embolism (PE). My STS project focuses on how the ethical framework developed by the medical community is impacted by the use of machine learning algorithms within patient diagnostic imaging procedures. More specifically, I will determine how each of the four pillars of medical ethics are impacted by the use of ML algorithms. Both my technical and STS projects are created around using ML algorithms within healthcare, and both projects help reduce diagnostic errors by creating a more accurate, reliable algorithm that adheres to the ethical principles developed by the medical community.

Technical Project

In the United States, pulmonary embolism is one of the biggest causes of morbidity, where it affects 1-2 people for every 1,000 individuals annually (Wible et al., 2019). PE is a type of cardiovascular condition in which a blood clot (thrombus) forms in your leg and travels up to the lungs to block blood flow in the pulmonary arteries. With the current treatments of PE, it is difficult to determine a sufficient clinical endpoint because the radiologists are unable to estimate the amount of thrombus that remains within the patient. To address this issue, my capstone team and I developed an automated algorithm that accurately quantifies the volume of thrombus that is present within the patient after treatment.

To create this automated method, we first used the picture archiving and communication system (PACS) to anonymize computed tomographic (CT) scans and export these scans as a

.dcm file to represent the Digital Imaging and Communications in Medicine (DICOM) file format. We then employed the use of Python to pre-process these images by normalizing them and enhancing their contrast. After pre-processing the CT scans, we used a deep learning architecture called U-Net to automatically segment the pre-processed CT Scans. The Intersection over Union (IoU) score was then calculated to determine the degree of overlap between the automatically and manually segmented CT scans. When a high IoU score was achieved (≥ 0.9), the final trained model was then used to automatically segment new CT scans, and an additional program was written to calculate the thrombus volume using mathematical formulas.

STS Project

My STS research paper seeks to understand how the four pillars of medical ethics are impacted by the integration of machine learning into patient diagnostic imaging procedures. The four pillars of medical ethics are autonomy, beneficence, nonmaleficence, and justice. Autonomy is the patient's right to make rational decisions regarding their health (Varkey, 2021). Beneficence mandates clinicians to act in the patient's best interests, while non-maleficence obligates healthcare professionals to inflict no harm on the patient (Varkey, 2021). Lastly, the principle of justice requires all patients to be be treated fairly while ensuring healthcare resources are distributed equitably (Varkey, 2021).

In order to determine the impact of ML algorithms within healthcare, I primarily gathered secondary sources from papers within academic journals regarding machine learning and medical ethics. I then used Trevor Pinch and Wiebe Bijker's theory, the Social Construction of Technology (SCOT) to identify the relevant social groups that are impacted by ML (Pinch & Bijker, 1984). The social groups that I focused on were clinicians, engineers, and patients. I then reviewed media and journalistic accounts about these groups to learn more about how ML

healthcare applications can impact them. With this data, I then conducted an ethical analysis and found that using machine learning algorithms within patient diagnostic imaging procedures increases diagnostic accuracy, thus aligning with the beneficence principle. However, ML healthcare algorithms violate autonomy, non-maleficence, and justice principles while increasing healthcare disparities, widening the socio-economic gap, and intensifying the marginalization of minority groups. Since there is no official approval process for ML-based healthcare technologies, my analysis can help guide the Food and Drug Administration (FDA) in creating regulatory policies that ensure the integration of ML into healthcare upholds medical ethics. However, further research still needs to be conducted to explore the perspectives of the other relevant social groups and determine how ML healthcare applications impact a patient's privacy.

Conclusion

By working on both these projects, I had the opportunity to engage in hands-on work by creating a healthcare-based algorithm while assessing the ethical implications, the benefits, and the risks associated with implementing this algorithm in a real-world setting. The discussion of the non-maleficence principle in my STS research paper was particularly relevant when my team and I strived to achieve high algorithm accuracy. My STS paper helped me identify important factors that should be taken into account to achieve high accuracy, such as addressing the biases that can be introduced due to an unrepresentative training dataset. When working on our technical project, my team and I ensured that a representative sample was being used to train the algorithm. Additionally, working on both these projects simultaneously highlighted the importance of balancing scientific progress with ethical considerations. Therefore, my STS project helped me understand the importance of considering ethics when developing technologies while shedding light on the factors that need to be considered when creating a medical based algorithm.

References

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