Thesis Project Portfolio

Segmentation and Quantification of the Left Ventricle to Assess the Ventricular Remodeling post Myocardial Infarction

(Technical Report)

Accessability of Robotic Assisted Gynecologic Surgery

(STS Research Paper)

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Executive Summary

An important safety problem in healthcare is diagnostic error, with major errors being found in 10-20% of autopsies, which suggests that an average of 60,000 patients die annually in the United States from error during diagnosis. Medical diagnosis is a critical task that must be performed efficiently and accurately to ensure adequate patient treatment. With the complexity and rise of data in healthcare, machine learning (ML) technology has the potential to transform many aspects of patient care including diagnosing diseases. ML is a common form of artificial intelligence (AI) that 'learns' by training models with data. This can be used for tasks like personalized treatment, robotic surgery, and medical imaging. Lack of access to certain AI technologies may be detrimental to hospitals and patients seeking treatment. Automated medical imaging, a type of AI technology, is increasingly being used in hospitals since it is cost effective. Thus, the focus of the technical project was to develop a ML model for automated imaging of the heart to classify heart dysfunction post heart attack. Unlike imaging technology, access to robotic assisted (RA) surgery varies greatly between hospitals. Therefore, the STS project analyzed disparities in access to robotic surgery technology between demographic groups in the United States. This information can be used to discuss the need for stronger robotic surgery initiatives in hospitals to target the identified disparities.

The technical project focused on developing a deep learning model to segment the left ventricle of mice heart ultrasound images. Medical image segmentation involves partitioning image data and identifying specific regions of interests such as organs or lesions. Previously developed methods using deep learning models have been used to classify heart failure, however these have a significant error rate and do not use all relevant physiological metrics. Thus, this project aimed to address these shortcomings and apply the model to quantify and classify heart

dysfunction post heart attack in mice. Previously collected mice ultrasound images pre and post heart attack were transformed to meet model requirements. U-net architecture, commonly used for biomedical image segmentation, was used for model development and this process included data loading, training, optimization, and testing to make predictions. Compared to previously developed segmentation models, our model performed moderately well, since the inner left ventricle (LV) heart wall was identified with an accuracy of 90%. The model was also used to quantify LV area and volume. To assess model performance, the LV area based on model segmented images was compared to area based on researcher segmented images. High variability was found between researcher and model segmented images with an average error of 60%. Despite the high error rate, the developed model demonstrated effective image segmentation based on calculated accuracy metrics. Thus, this model has the potential to be used for research applications, and more broadly for clinical applications.

The STS research paper worked to determine and understand factors that contribute to differences in access to robotic surgery technology for gynecologic conditions. Certain patient and demographic groups are facing barriers to treatment and potentially better outcomes since RA surgery has been found to result in shorter recovery times, and fewer post-operative complications. The information gathered can be used to target the disparities. To investigate disparities in access to robotic surgery, analysis was conducted on various case studies which examine factors that could cause differences in access. This concluded that distance to hospitals with robotic technology does not limit access to robotic surgery. However, one factor that correlated with disparities in access to RA surgery is race and ethnicity. African American women are 10%, and Hispanic women are 5% less likely to receive RA surgery compared to white women. Another study also suggested that income and insurance status affect access to RA

surgery. Women living in higher income zip codes had 60% lower odds of undergoing the more invasive abdominal surgery. In addition, women with public instead of private insurance were found more likely to undergo abdominal surgeries compared to the robotic method. Lastly, the case studies analyzed showed that there are hospital related factors which contribute to the disparity. Patients in teaching hospitals or hospitals in urban locations were 30-50% more likely to receive robotic surgery. These disparities emphasize the need for initiatives that integrate robotics into training programs and standardize pathways for surgery route. More broadly, initiatives are needed to address racism, implicit bias, and structural issues in healthcare that may cause providers to uphold the identified disparities.

Overall, we were able to achieve most of the aims outlined for the technical project. Some limitations which may have affected the accuracy of the model include the number of images used for model training. More images may have helped the model learn and make predictions with increased accuracy. For future work, the model performance can be optimized to further improve accuracy. In addition, the segmentation can be used to quantify other metrics of heart function such as heart wall thickness to classify the degree of dysfunction in mice ultrasound images. Further work could be done to explore model application to classify heart dysfunction in humans. The STS research paper was also successfully completed as different factors that contribute to disparities in access to RA gynecologic surgery were identified and discussed. There were some limitations in the approach taken to synthesize data from each case study. First, each case study made conclusions based on data collected from different states and patients, so it is difficult to apply these ideas to all demographic or socioeconomic groups. Another limitation is that this research does not include all factors or case studies related to access to RA surgery. Future work could involve looking at more case studies to determine how

characteristics such as age or past surgical history affect access. Lastly, this work can be applied to identify accessibility trends in other types of robotic surgery such as cardiac or pediatric.