

Preface

Recently, cardiovascular diseases are affecting the world population at a mass scale. Cardiovascular disease comprises stroke, heart attack, and ischemic stroke. These diseases sometimes lead to death as well. Early detection of the disease may prevent such events. Any effort in preventing or early detection of such events may benefit humankind across the globe. Artificial Intelligence (AI) based methods may provide an analytical and practical solution to such problems at very early stages. However, recent developments in AI-based solutions are much more challenging and are at the beginning. Challenges in this area are the source of my inspiration for this research. Recently, deep learning-based solutions are being popular in medical image diagnosis. Medical practitioners are frequently using such methods to diagnose ultrasound, CT, MRI, X-ray images for different kinds of diseases. In this thesis, I have presented a study on deep learning applications-based stroke risk assessment using B-mode ultrasound images.

The major cause of CVD events is atherosclerosis, which damages the artery. In this research, I have used B-mode ultrasound images of the carotid arteries to predict the stroke risk by measuring the atherosclerotic plaque area. The ultrasound images of carotid arteries are captured non-invasively from the patient's neck. Also, the biomarkers measured from carotid artery show high correlation with other CVD events. Therefore, carotid artery ultrasounds are big source of information of a patient's cardiac health. In this work, I have proposed some "*hybrid deep learning models*" for segmentation. Using these segmentation models, I have shown successful atherosclerotic plaque segmentation from ICA and CCA ultrasound images. ICA ultrasound images (moderate to high risk) carry a large plaque area in the far wall region; therefore, model showed high-performance numbers. However, CCA images have low to moderate plaque deposition in the far wall region, thus challenging plaque segmentation.

Further, I observed that the segmentation models show different behaviors for unknown datasets. Thus, in one of my studies, I used an unknown database to propose an "*unseen deep learning*"

model. Thus, these unseen models remove the bias originating from source, ethnicity, and device of the databases. Further in this study I presented a few deep learning based “*U-series*” segmentation models. These “*U-series*” models are faster, consume low memory in disk, and have low training parameters. Thus, these models are deployable in AI-industry for the development of web based, cloud based and android based models. Further, I used an advanced feature selection method in our segmentation model which is based on “*Attention*”. This “*Attention-Based-UNet*” model has better feature extraction capability in atherosclerotic plaque region. This presented better results in some critical images compared to previous models.

Computer based diagnostics methods can be described into four generations. In the first and second generation, manual methods and some image-based segmentation methods falls. An AI-based solution comes from third generation where some machine learning based classification and segmentation method were evolved. Modern deep learning-based methods fall in fourth generation methods, where these methods are successful due to the advancement of high-performance computing and modern graphics processing units (GPUs). Professor Jasjit S Suri has developed a cutting-edge software tool AtheroEdge™ 2.0 (AtheroPoint LLP, Roseville, CA, USA) for cardiovascular disease diagnosis. This method is based on second generation level set methods. His recent development in the same tool AtheroEdge™ 3.0 using deep learning is under development.