Automated Deep Learning Pipeline for Accurate Segmentation of Aortic Lumen and Branches in Abdominal Aortic Aneurysm: A Two-Step Approach

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***Abstract*— Abdominal Aortic Aneurysm (AAA) is a serious medical condition characterized by the abnormal enlargement of the abdominal aorta. If left untreated, AAA can have life-threatening consequences. Accurate segmentation of the aorta in Computed Tomography Angiography (CTA) images plays a vital role in treatment planning for AAA. However, manual and semi-automatic segmentation methods suffer from limitations in terms of time and accuracy. This study presents a deep learning pipeline that aims to fully automate the precise and efficient segmentation of the aorta and its branches within CTA images. A two-step approach is proposed for the segmentation of the aorta and its branches in contrast-enhanced CTA scans. The first step involves utilizing a UNet++ model to perform aortic segmentation across the entire set of CTA axial slices. In the second step, a post processing algorithm is employed to track the continuity of the segmented aorta while effectively discarding false positive (FP) objects. The assessment of the fully automated method revealed remarkable outcomes, with a mean Dice coefficient of 0.941 on a test set consisting of 10 CTA scans. The automated segmentation results are utilized to create a comprehensive 3D model. The study results indicate that the utilization of the proposed deep learning-based pipeline is highly effective in achieving accurate segmentation of the aortic lumen and its branches. The practical implications of this approach extend to pre-operative planning. This highlights the valuable contribution of the proposed method in improving the management and treatment of patients diagnosed with aortic aneurysm.**

Keywords—Deep learning, Aorta segmentation, UNet++, Abdominal Aortic Aneurysm.

I. Introduction

Abdominal Aortic Aneurysm (AAA) is characterized by the weakening and expansion of the abdominal aorta [1]. AAA represents a significant public health concern, with varying prevalence rates across different populations. This condition contributes to approximately 1% of deaths among males aged 65 and older, resulting in over 175,000 fatalities worldwide. The mortality rate associated with aneurysm rupture is alarmingly high, estimated to be between 60% and 80%. Consequently, early detection and timely treatment play a critical role in preventing rupture and mitigating its devastating consequences [2].

In recent years, surgery has been superseded with less invasive endovascular aneurysm repair as the surgical management of abdominal aortic aneurysms (EVAR). During the intervention, the surgeon inserts one or more stent grafts into the aneurysm sac using a catheter that is inserted through an access channel, such as the femoral arteries. By reducing the aneurysm sac's pressure, EVAR lowers the chance of wall rupture [3].

The primary diagnostic imaging modality for aortic aneurysms is Computed Tomography Angiography (CTA), although ultrasound imaging is the preferred screening modality for this condition. The primary uses of CTA are in treatment planning and aneurysm progression assessment. With the aortic arch down to the femoral arteries, it offers a thorough imaging picture of the whole aorta. Reconstructing orthogonal pictures of the vessel, segmenting the aorta, and creating three-dimensional models of the aorta are all done using commercially available treatment planning software. For the purpose of EVAR planning and treatment choices, this makes it possible to assess vascular diameters, lengths, and volumes precisely [4].

During EVAR planning, accurate aortic branch segmentation is essential since it directly influences the measures needed to choose the appropriate stent graft [5]. Aortic segmentation could be labor-intensive and prone to human mistake, though. Furthermore, the degree of expertise of the readers affects the precision of aortic volume measurement made by hand segmentation [6].

When segmenting vessels using automated or semi-automatic approaches, at least one expert is needed to complete the segmentation or evaluate the accuracy of the results. The vast number of articles published each year on this subject indicates that, in spite of these difficulties, automatic or semi-automatic blood artery segmentation is a topic of great interest in medical research and has the potential to benefit physicians [7].

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