Quantitative Assessment of Carotid Artery Wall and Dynamics for Disease Course Prediction

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Background: The identification of risk factors for the progression of pathological changes of the vessel walls is of high interest in research towards stroke prevention. Complementary MRI imaging such as Blackblood, Time-of-Flight, and 4D Phase Contrast provide information about vessel walls, tree structure and hemodynamics. The assessment of the interplay between anatomy and flow properties have been addressed in several studies but the accuracy and applicability of multimodal carotid artery analysis are still limited due to low image resolution, motion and high efforts for image annotation [1]. Recent publications have shown the applicability of machine learning-based segmentation [2] and classification approaches for the assessment in high-risk plaque [3]. Machine learning approaches have also been successfully applied for the improvement of 4D flow measurements [4]. However, there are no 3D/4D approaches for a comprehensive vessel wall assessment available.

Hypothesis: Machine learning models developed with sparse user annotations and physics-informed learning enable the extraction or vessel wall features for disease course prediction.

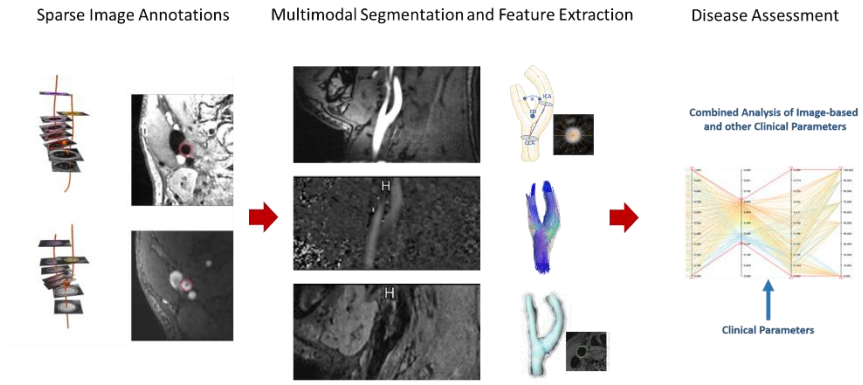

Figure 1: MRI imaging sequences such as Time-of-Flight angiographies, 4D Flow MRI and Blackblood MRI provide complementary information on anatomy, blood flow, and vessel walls. Clinical data annotations are provided for vessel cross sections and can be used to train 3D segmentation and extract comprehensive feature information for disease classification.

Methods: Sparsely annotated datasets from previous and ongoing studies are available for the evaluation of machine learning approaches for the extraction of relevant local vessel wall properties. As a first step we aim at the development of 3D/4D segmentation approaches based on sparse cross-sectional annotations considering anatomical priors and adapted loss functions as suggested for related medical domains [5, 6] . In a second step we aim at the evaluation of explainable feature representations for disease characterization tasks. Radiomics features, which describe shape, intensity distribution, and tissue texture, are already successfully applied for vessel wall analysis. We will further investigate the relevance of features describing flow profiles and motion patterns in multiple dimensions.

Collaboration The PhD students will be part of the interdisciplinary team of engineers, computer-scientists and clinical experts at the Institute for Cardiovascular Computer-assisted medicine. There will be regular meetings with the neurologists, who will support the method design and evaluation and explain disease patterns and datasets.

Impact Early assessment of atherosclerosis risk factors is of high importance for stroke prevention

Please contact Anja Hennemuth (anja.hennemuth@charite.de) for any further questions on this project.

References

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