Geometric Deep Learning for the Assessment of Coronary Artery Dynamics

PIs: Anja Hennemuth, Marc Dewey, David Manuel Leistner/Ulf Landmesser

Theme: Mechanics/fluid transport

Background: Motion and shape of the coronary arteries are known to be predictive for the location of plaque and cyclic stretches influence [1]. CT imaging enables the analysis of the heart and coronary vasculature as well as the quantitative assessment of effects of vessel wall pathologies. Catheter-based imaging modalities such as X-ray angiography, IVUS and OCT on the other hand enable a more accurate assessment of local vessel properties such as diameters and vessel wall constitution. Previous work on image-based assessment of coronary artery motion properties stressed the need for accurate and comparable geometric representations of the vasculature at different timepoints [2, 3].

Hypothesis: Machine learning approaches using geometric representations enable a domain-adapted analysis of tree structures and provide interpretable results.

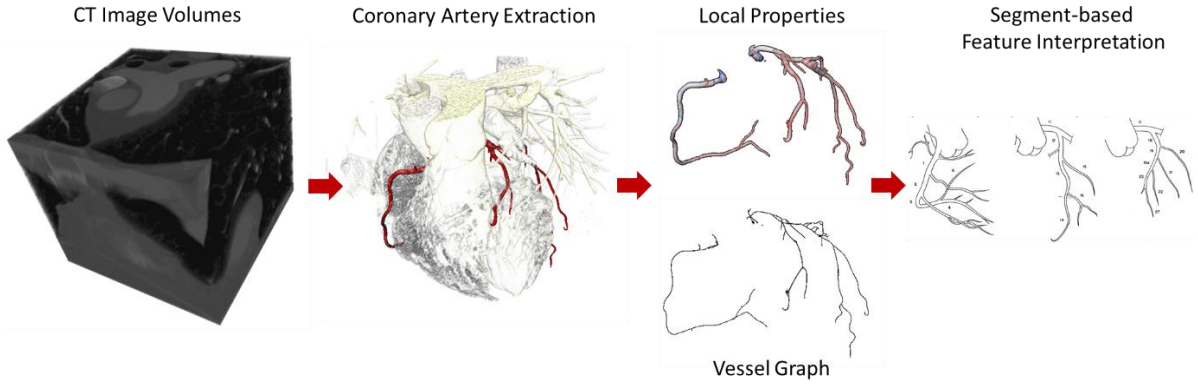

Figure 1: Processing of CTCA volume data for local artery property assessment. The graph and surface based representations enable the analysis of local motion properties and their impact on coronary blood flow.

Methods: Well-established CNN architectures such as the u-net are widely applied in image classification and segmentation tasks [4]. In addition to these voxel-based approaches, neural networks considering geometrical representations such as graphs and meshes enable the encoding of domain-knowledge and the structure-aware representation of analysis results [5]. In order to enable the visual and quantitative assessment of local motion and shape properties of the coronary arteries based on CT and X-ray data we aim at investigating the potential of graph neural network approaches to extract coronary artery trees and surface meshes and analyze the local motion properties.

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 clinical cardiologists, who will support the method design and evaluation. Hospitation will provide insights into clinical data usage and requirements.

Impact: The methods developed by this project have the potential to support and extend diagnostic approaches such as the SYNTAX score as well as coronary artery intervention planning.

References:

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3. Wu, X., et al., Angiography-Based 4-Dimensional Superficial Wall Strain and Stress: A New Diagnostic Tool in the Catheterization Laboratory. Front Cardiovasc Med, 2021. 8: p. 667310.
4. Anwar, S.M., et al., Medical Image Analysis using Convolutional Neural Networks: A Review. J Med Syst, 2018. 42(11): p. 226.
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Please contact Anja Hennemuth (anja.hennemuth@charite.de) for any further questions on this project.