Developing Multitask and Multimodality Deep Learning Methods for Automated and Quantitative Image Assessmentof Coronary Artery Plaques

PIs: Marc Dewey, Wojciech Samek, Sebastian Stober, Marc Kachelriess

Theme: Tissue structure/fluid transport

Background: We developed a multi-task deep learning (DL) model for the simultaneous segmentation of calcified coronary plaques on non-contrast computed tomography (CT) using coronary artery region segmentation (weak annotations) and coronary artery calcification segmentation (strong annotations) (Föllmer et al. *Med Phys* 2022, https://aapm.onlinelibrary.wiley.com/doi/10.1002/mp.15870, **Figure**). Developing multimodality DL of coronary plaques on non-contrast CT and CT angiography (CTA) imaging data would be an important technical advancement to provide further benefits for patients.
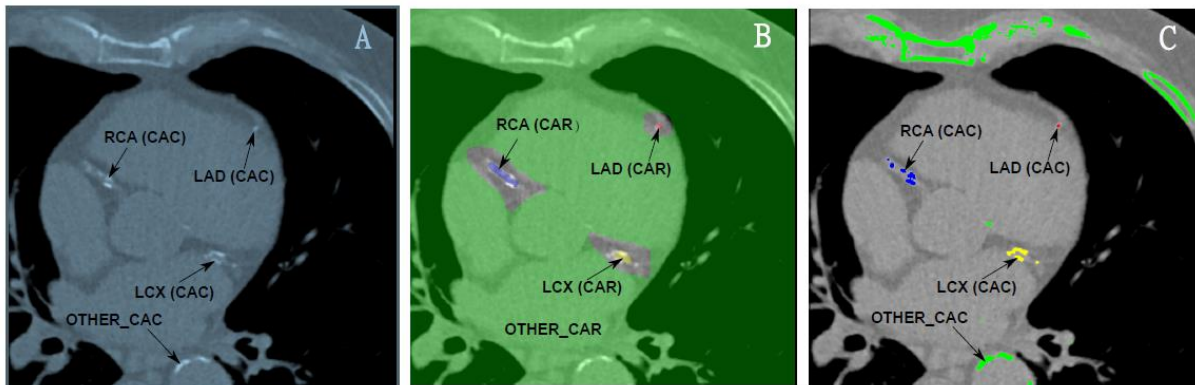

Figure Multi-task annotations of a non-contrast CT image with coronary artery calcifications (CACs) in the left anterior descending artery (LAD), left circumflex artery (LCX), and right coronary artery (RCA) (A). Weak annotations of coronary artery regions (CARs) for the LAD - red, LCX - yellow, RCA - blue and OTHER CAR - green (B). Strong annotations CACs in the LAD - red, LCX - yellow, RCA - blue and other objects with attenuation ≥130 HU (OTHER CAC) - green (C). From Föllmer et al.

Hypothesis: A multitask and multimodality DL model will be developed and applied to existing non-contrast CT and CTA data as a realistic representation of coronary artery plaque components.

Tandem team: Following the successful tandem team of a PhD and an MD/PhD student in the 2nd BIOQIC cohort, we envision the same strategy for the 3rd BIOQIC cohort. The appointed PhD student will work closely together with the MD/PhD student (project 10 'Combined Quantitative Assessment of Calcified and Noncalcified Coronary Plaques on CT for Improved Prediction of Clinical Events').

Methods:

1) Registration of coronary plaques from existing non-contrast coronary CT and coronary CTA data of 1500 patients will be performed.
2) A multitask (coronary artery region and calcification segmentation) and multimodality (non-contrast and CTA) DL model will be developed and tested for its clinical representation.

Relevance: This project addresses novel DL approaches (e.g., for automated segmentation and joint assessment of different plaque types) for improved multimodality coronary plaque assessment.

Impact: The methodological approaches described above will each have their own impact being: 1) Facilitating accurate registration of different plaque imaging data and 2) Creating new approaches to multimodality (non-contrast CT and CTA) assessment of coronary artery plaques.

Please contact for any questions Prof Marc Dewey at marc.dewey@charite.de or +4930450527296 and review https://aapm.onlinelibrary.wiley.com/doi/10.1002/mp.15870 for additional information about the multitask model. You may also contact Bernhard Föllmer (PhD student in the 2nd BIOQIC cohort) at bernhard.foellmer@charite.de or +4930450627309.