Development of Automatic Quality Assurance in Cardiac MRI

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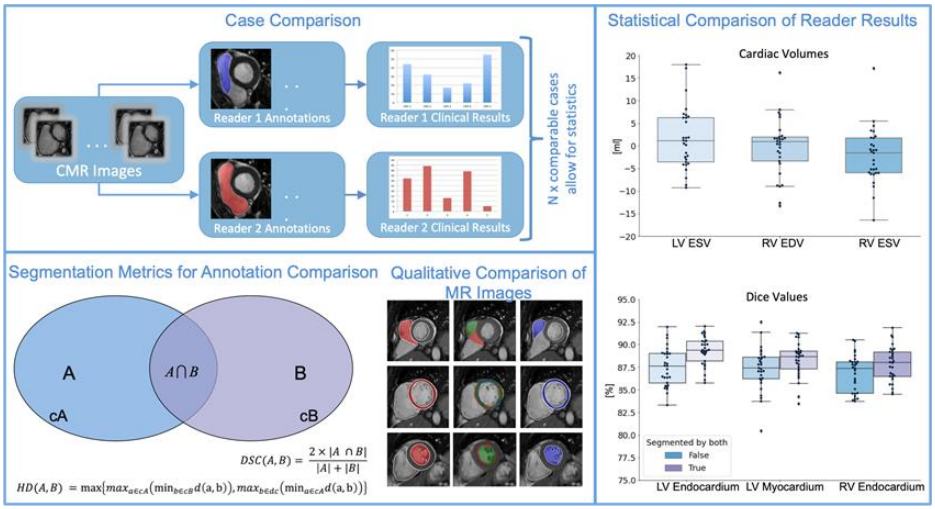
Theme: Tissue structure

Background: Quantitative Cardiovascular Magnetic Resonance (CMR) has a significant impact in research and in clinical decision making as is reflected in several guidelines. The unique capability of the CMR is non-invasive detection of different diseases such as myocarditis by differentiation of myocardial injury based on quantitative measures. Myocardial injury may include scarring and/or edema. A large variety of technical CMR parameters, the used postprocessing software as well as human factors influence the quantification, make reproducibility and its precision major challenges. Currently, state of the art artificial intelligence (AI) based segmentation algorithms show promising assessments of clinical parameters. However, AIs are prone to a set of different challenges damaging their trustworthiness. These challenges may impact clinical diagnosis as well as research results. AIs can be optimized for robustness to several confounders by influencing their architectures and postprocessing their outputs.

In this project a next level automatic software will be developed which allows a quantitative comparison of different segmentation procedures enhancing precision and quality assurance in CMR and beyond. Furthermore, an automatic feedback system should be developed. The flexible libraries will allow a usage in different parts of CMR and beyond. The tool should also be able to provide support to the augmentation of AI algorithms in a long-term vision to support the AI's training algorithm.

Methods: Integrating 3D sequences into a comparison software requires accurate representations of geometrical annotations in a three dimensional space. This requires fast and precise 3D rasterize as well as the construction of a 3D meshes from 2D segmentations. Evaluation of reliability of such methods constitutes a prerequisite of their integration into software.



Own Preliminary Work:
Reader comparison software (Lazy Luna – s. figure) was developed to allow for comparison on different analysis levels, such as clinically relevant values as well as different metrics such as DICE (Hadler et al. Scient Rep 22).

Research Plan: WP1: Myocardial scar imaging is usually based on contrast enhanced techniques such as Late Gadolinium Enhancement (LGE). Fibrosis distribution is predictive of excitation and tissue mechanics, but myocardial tissue pathology assessment is typically based on segmentwise quantification or visual pattern detection. AI-based approaches (convolutional neural networks and threshold-based methods) are on the way to automatically quantify 2D and 3D images. A thorough 3D comparison methodology will be developed to allow the effective evaluation of AI quantifications vis-à-vis expert readers

WP2: Fat in and around the heart is recognized as a risk factor for patient outcome but difficult to quantify based on manual segmentation. An AI based approach could improve the results based on a new 3D sequence. A new application of Lazy Luna will be developed based on WP1. Assessing contour methods for reproducibility of individual contours as well as quantitative fat assessments ought to be offered as Lazy Luna outputs.

WP3: Lazy Luna's outputs will be integrated to establish a feedback algorithm to optimize the imaging chain. This includes using validation sets during training to optimize the training steps on multiple levels simultaneously. Whereas segmentation metrics are routinely used for loss functions, other conceivable information such as general difficulties with certain pathologies are typically not used in the training pipeline. Lazy Luna's outputs can be used for reweighting of cases during training time.

Clinical translation: The PhD students will take part in regular meetings to get continuous clinical feedback on any developed techniques. The results will be challenged based on clinical as well as on research data. There will be a close interaction with the teams at PTB as well as of the Hennemuth lab. The PhD has the chance to perform research in a clinical research environment and to influence quality of research and clinical work.

Please contact Jeanette Schulz-Menger (jeanette.schulz-menger@charite.de) for any further questions on this project.