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Mapping of Flow Information to Three-Dimensional Rotational Angiography Images

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This thesis presents a complete framework of non-interactive algorithms for the mapping of blood flow information to vessels in 3D-RA images. The prototype software implementation of the developed algorithms interacts with existing 3D-RA imaging software and enables the radiologist to use the flow reconstruction method in the clinical environment. With the presented tool, mapping of flow information to 3D-RA images is done automatically. So far, radiologists had to perform this task by extensive image comparisons.

In the presented approach, flow information is reconstructed by forward projection of vessel pieces in a 3D-RA image to a two-dimensional projection series capturing the propagation of a contrast agent bolus. For accurate image registration, an efficient patient motion compensation technique was introduced. As an exemplary flow related quantity, bolus arrival times were reconstructed for the vessel pieces by matching of intensity-time curves. A plausibility check framework was developed which handles projection ambiguities and corrects for noisy flow reconstruction results. It is based on a linear programming approach to model the logical vessel structure and feeding relations.

The presented flow reconstruction method was applied to phantom and patient data. Phantom measurements showed the method to be accurate. Moreover, twelve clinical cases consisting of stenoses, aneurysms and AVMs were processed. The propagation of the injected contrast agent was reconstructed and visualized in three-dimensional images. In cases of stenoses, the reconstructed images allow for an estimate of the degree to which blood flow is impeded by the stenosis. The feeding arteries of AVMs can be depicted, and blood flow velocities can be derived. The processing queue, which is composed of vessel segmentation, vessel structuring, patient motion compensation, flow reconstruction, plausibility checks and visualization, handles any of the problems imposed by clinical demands and technical requirements. Single modules can be replaced easily to test the

Especially in the context of computational fluid dynamics simulation techniques, the potential of the presented flow reconstruction method is high. Flow reconstruction results could be used both as boundary conditions for simulations and as a reference for the verification of simulation results. Computational fluid dynamics provide useful information such as arterial wall stresses and complex flow patterns in aneurysms. Another challenge is the transfer of the flow reconstruction framework to cardiac applications.