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Automatic 3D Geometry Reconstruction and FE-Mesh generation of Abdominal Aortic Aneurysm Rupture

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ABSTRACT

Abdominal Aortic Aneurysms (AAAs) are pathological localized dilations of the abdominal aorta. Untreated AAAs may enlarge until they rupture; an event with a mortality rate of 70-95%. The indication of medical interventions is directly linked to an assessment of the formation's risk of rupture, which, up to date is based on simple (geometrical) diagnostic parameters. However, there is scientific evidence [1], that a biomechanical Finite Element (FE) analysis provides much more reliable determinants in that respect. To clinically evaluate this approach, i.e. to explore a statistically significant number of AAAs, an automatic analyzing tool is required.

This paper presents a highly automatic software tool, which extracts 3D-morphological models from a set of Computer Tomography (CT) angiography images and accounts for the major mechanically relevant tissue components, such as the vessel wall and the Intra-Luminal Thrombus (ILT). The proposed method is based on deformable models, which are known to be highly accurate and insensitive to image artifacts [2], and hence, frequently used in medical image processing [3]. After initializing the algorithm, where the region of interest and the vessels to be examined are defined, it works fully automatic. The algorithm segments 3D-geometries of the different tissue components and generates hexahedral dominated volume meshes. The discrete grids are tailored for FE computations and tissue in-homogeneities, e.g., calcifications can directly be passed from the set of image data into the FE computation. Likewise, the discrete 3D representation of the tissue components facilitates the derivation of sophisticated geometrical determinants, such as the ILT thickness, see Figure 1, and the ILT volume, which might be used for diagnostic purposes [4]. The proposed algorithm has been developed to analyze sets of CT data; however, an application to Magnetic Resonance (MR) data seems to be straight forward.

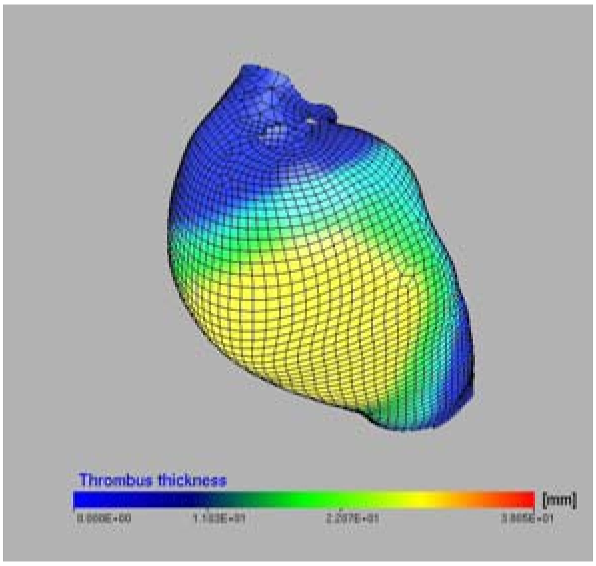

Figure 1: Color coded representation of the ILT thickness of a patient specific AAA, where a hexahedral dominated volume mesh is used for the discrete representation of ILT geometry.

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