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ARTERIAL DYNAMICS COMPUTATION WITH SURFACE-EXTRACTION MEDICAL-IMAGE-BASED TIME-DEPENDENT ANATOMICAL MODELS AND ELEMENT-BASED ZERO-STRESS ESTIMATES

Takafumi Sasaki[1*], Kenji Takizawa[1], Tayfun E. Tezduyar[2], Hirokazu Takagi[1], Keiichi Itatani[3], Shohei Miyazaki[3] and Kagami Miyaji[3]

[1] Department of Modern Mechanical Engineering and Waseda Institute for Advanced Study, Waseda University, Tokyo, Japan, Takafumi.Sasaki@tafsm.org
[2] Mechanical Engineering, Rice University, Houston, TX, USA, tezduyar@tafsm.org
[3] Departments of Hemodynamic Analysis and Cardiovascular Surgery, Kitasato University, Kanagawa, Japan

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A method for coronary arterial dynamics computation with medical-image-based time-dependent anatomical models was introduced in [1]. The method has two components. The first one is element-based zero-stress (ZS) state estimation [2], which is an alternative to prestress calculation. The second one is a "mixed ZS state" approach [1], where the ZS states for different elements in the structural mechanics mesh are estimated with reference configurations based on medical images coming from different instants within the cardiac cycle. In [1], a curve-extraction technique [3] was used in obtaining the time-dependent anatomical model from the medical images. The curve-extraction technique is based on minimizing the strain energy for a curved-beam representation of the artery, and from that the arterial model is constructed by associating time-averaged cross-sections to the points along the curve. Here we introduce a new method for arterial dynamics computation with medical-image-based time-dependent anatomical models. We use a surface-extraction technique for obtaining the time-dependent anatomical model from the medical images. In this technique, the arterial surface geometry is extracted from the medical image by using a NURBS representation of the extracted surface, and the surfaces associated with different instants of the cardiac cycle all have a common parametric space. At each instant, the spatial control mesh is created by least-squares minimization of the difference between the NURBS representation of the surface and the surface coming from the medical image (see Figure 1). The strain-energy minimization is for the arterial volume, with the arterial wall thickness treated as a dependent parameter from the material incompressibility, and the resulting equations are solved over the arterial surface. We apply the method to a human aorta, with 20 medical images in the cardiac cycle.

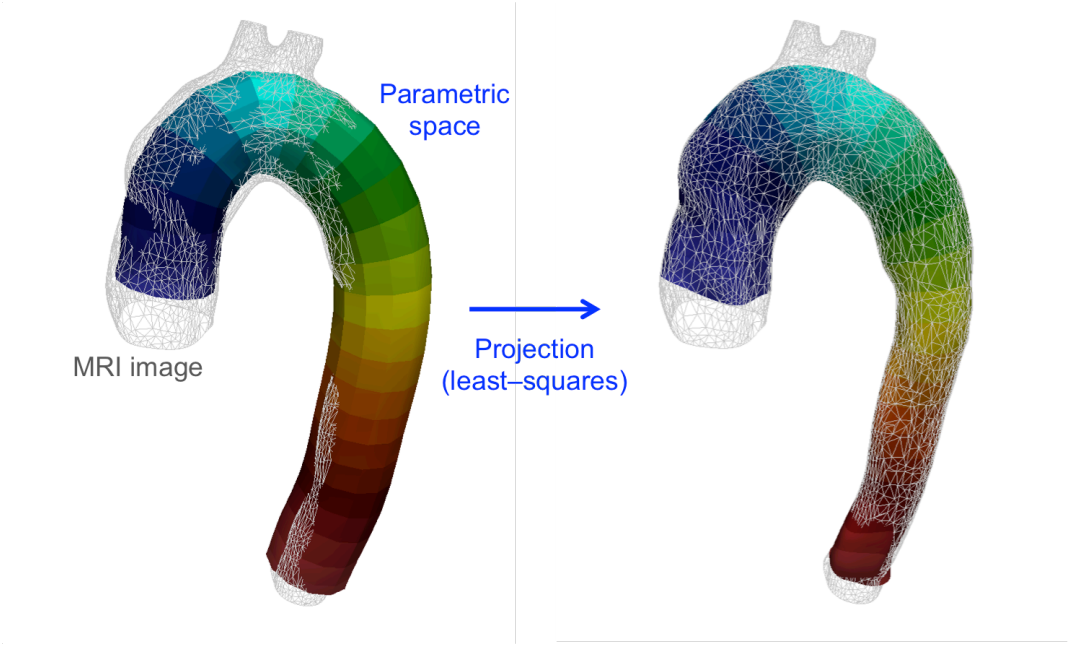

Figure 1. Surface extraction at an instant during the cardiac cycle. The spatial control mesh for the extracted surface is created by least-squares minimization of the difference between the NURBS representation of the surface and the surface coming from the medical image. The colored surface represents the control mesh prior to (left) and after (right) the least-squares projection. The surfaces associated with different instants of the cardiac cycle all have a common parametric space.

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