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IMAGE-BASED NUMERICAL SIMULATION OF HEART WITH PRESCRIBED DISPLACEMENTS ON THE HEART SURFACE

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It is a need to have accurate numerical models for better understanding of heart behaviour in cardiomyopathy and other heart diseases. These computational models can include variety of different processes such as transport, electrophysiology and muscle mechanics [1]. In this work we focus on deformations of the heart walls, in order to get the displacements field of the insides of the heart and velocity/pressure field within the heart. Displacements of the heart's epicardium (external surface) can be generated from imaging, which is then used to compute the heart wall deformation and the blood flow field.

In our methodology we track motion of the heart along selected curves on the surface using images. We generate finite element model, prescribe displacements at appropriate nodes of outer surface and then use mesh-based shape deformation method called polyharmonic deformations. This method is used to propagate prescribed deformations to the rest of the model surface smoothly, where shape deformation problem is reduced to quadratic energy minimization [2]. After mesh is deformed, we pass the displacements and velocities at the selected nodes to the finite element solver which provides us complete displacements/velocities and stress field of the wall and blood flow field within the heart. Using this approach we can run image-based simulations relying on realistic conditions and generate complex deformation patterns and blood flow for the patient-specific data.

The presented methodology is implemented to real 3D heart models, with using linear elastic and recently developed orthotropic material model based on the Holzapfel experiments. This approach has a potential to be used in modelling the heart mechanical behaviour in order to give accurate prediction of heart beat for different heart diseases.

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