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UNSTRUCTURED GRIDS FOR SOFT TISSUES AND BIOIMPEDANCE MODELS

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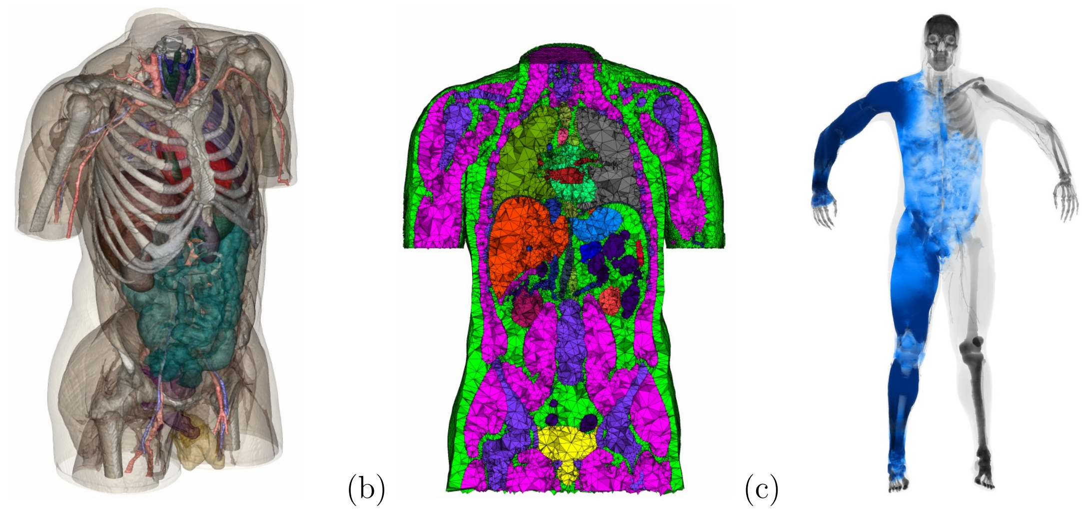
Bioelectrical impedance analysis (BIA) is commonly used for body composition and abdominal adiposity assessment in clinical medicine, dietology and sports medicine. BIA is also used in monitoring of body fluids redistribution under various physiological and pathological conditions, e.g. in intensive care [1]. The computational analysis of the existing measurement schemes is essential for accurate data interpretation and the development of new efficient electrode schemes. One of approaches is based on calculation of relative soft tissues contribution to the result of bioimpedance measurements of the particular body segment. In our work we aimed at computational analysis of segmental BIA, which is used for body composition assessment. We developed a numerical model for computation of the human body bioelectrical impedance for low frequency electric signals. We propose techniques for construction and visualization of sensitivity field distributions for segmental BIA using anatomically accurate 3D model of the human body from Visible Human Project (VHP).

The workflow for high-resolution efficient numerical modeling of bioimpedance measurements includes 3D image segmentation, adaptive mesh generation, finite-element discretization, and the analysis of simulation results. Using the adaptive unstructured tetrahedral meshes enables to decrease significantly a number of mesh elements while keeping model accuracy. In this work we propose several techniques for personalized model adaptation, including anthropometrical scaling, control points mapping and geometrical modification of the body extremities positions [2].

Our first segmented model of the human torso was created for Visible Human man data. The data were clipped and downscaled to an array of $567\times305\times843$ colored voxels with the resolution $1\times1\times1$ mm. Segmentation was performed using semi-automatic techniques from ITK-SNAP software. Special attention was paid to filling the remaining gaps between soft tissues and final segmented data smoothing [3].

Delaunay triangulation algorithm from the CGAL-Mesh library [4] is used for mesh generation. This algorithm enables defining a specific mesh size for each model material. In order to preserve geometrical features of the segmented model while keeping a feasible number of vertices, we assigned a smaller mesh size to blood vessels and a larger mesh size to fat and muscle tissues. The segmented model and the generated mesh for the human torso are presented in Fig. 1 (a, b).



(a) (b) (c)

Figure 1: Human torso: (a) segmented model, (b) tetrahedral mesh. Sensitivity analysis: (c) conventional tetrapolar scheme at 50 kHz frequency.

We used the proposed techniques to construct the computational mesh for the whole body model based on VHP data. The generated mesh contains 574 128 vertices and 3 300 481 tetrahedrons, effective model resolution is 1 mm, 30 materials are used for different soft tissues. High sensitivity area for conventional tetrapolar scheme is presented in Fig. 1 (c).

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