Finite element analysis of a human body model with smooth organ boundaries in the high-frequency electromagnetic field

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Abstract

This study deals with a high-frequency electromagnetic field simulation for the hyperthermia treatment that is the electromagnetic heating of deep-seated tumors. To consider the size of tumors, a high-resolution human body model is required and then a large-scale numerical analysis is performed. As a high-resolution human body model, realistic high-resolution whole-body voxel models for Japanese adult males and females of average height and weight have been developed [1]. Moreover, the authors have developed a large-scale finite element analysis (FEA) software package for the high-frequency electromagnetic field [2] and succeeded in analyses of human body models [3]. Especially, as a large-scale analysis, a 30 billion degrees of freedom model, which is generated by a parallel mesh refinement [4] of the voxel models, has been successfully performed [5]. However, a voxel-based model that has stepped surfaces causes unnatural and wrong distribution of electromagnetic waves around organ boundaries in the FEA [6].

In this study, to improvement of electromagnetic wave distribution around organ boundaries in the FEA, a human body model with smooth organ boundaries is constructed. Moreover, a high-frequency electromagnetic field analysis of a human body model is demonstrated. The complex symmetric system of the linear equation derived from the formulation of the E method is solved by the conjugate orthogonal conjugate gradient method. Besides, the domain decomposition method is utilized for parallel computing.

Keywords: Electromagnetic field analysis, edge finite element method, complex symmetric linear systems, domain decomposition method, parallel computing

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