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P022. Leakage Effect in Hexagonal FEM Meshes of the EEG Forward Problem

H. Sonntag[1], J. Vorwerk[2], C.H. Wolters[2], L. Grasedyck[3], J. Haueisen[4], and B. Maeß[1]
[1]Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany
[2]Institute for Biomagnetism and Biosignalanalysis, University of Münster, Münster, Germany
[3]Institut für Geometrie und Praktische Mathematik, RWTH Aachen, Aachen, Germany
[4]Institute of Biomedical Engineering and Informatics, Ilmenau University of Technology, Ilmenau, Germany

When solving the EEG forward problem with high spatial resolution it is recommended to model spongy and compact bone of the skull as separate tissues.[1] Both are very thin layers and have different conductivities. Consequently, it may occur that during the finite element method (FEM) some holes in these layers are meshed and cause a current leakage. Our main goal is to introduce an algorithm for finding and fixing such holes causing leakage. We use a model with a 6-compartment structure (gray matter, cerebrospinal fluid [CSF], inner compacta, spongiosa, outer compacta, and skin) for a spherical head model digitized via regular hexagonal elements (cubes) of 1 mm^3. We use the same settings for thickness and conductivity as reported by Rampersad et al,[2] which are based on Akhtari et al[3] and consistent with the findings of Tang et al.[4] Rampersad et al[2] assumed the following values for the thickness: 1.2, 2.3, and 1.5 mm, respectively, for outer compacta, spongiosa, and inner compacta, resulting in a total skull thickness of 5 mm. The size of the finite elements (FEs) is in the order of the thickness of the compacta. Hence, we found that current leakage occurs in 6% of FE nodes of the compacta structure (in 1% of all FE nodes). We can show that the forward solution from this leaky mesh results in higher errors against the analytical solution (overall relative difference measure: RDM* > 0.07 and magnification: MAG > 1.15) compared to the findings of Wolters et al.[5] In a second setup, the leaks are closed by relabeling leaky spongiosa into compacta. With this repair mechanism, we achieve significantly smaller errors in the RDM* and MAG. In a third setup, we use the so-called node-shift approach, described by Wolters et al,[6] to reshape the hexagonal elements which are involved in the leakage effect and relabeled spongiosa and CSF or skin to compacta in the respective elements. Results are further improved as demonstrated by smaller errors (RDM* and MAG) compared to the analytical solution.

We conclude that the leakage effect in hexagonal FEM meshes needs to be corrected by closing the leaks via the suggested relabeling and node shifting at the relevant elements.

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