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Development of a model of the electric field distribution inside the human brain

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This study focuses on optimizing the computational efficiency of simulating electric field distribution in the human brain using the finite element method (FEM). Due to the brain's complex and heterogeneous structure, accurate modeling requires high-resolution segmentation and realistic electrical property assignments, leading to large-scale numerical problems. To address these challenges, this research explores advanced numerical solvers, parallel computing strategies, and memory-efficient algorithms to enhance performance without compromising accuracy. Special attention is given to optimizing matrix assembly, preconditioning techniques, and load balancing in parallel computations, enabling faster convergence and reduced memory consumption. This study also investigates the performance of algebraic multigrid solvers, including the Ruge-Stuben AMG and Smoothed Aggregation AMG methods, to efficiently handle the large, sparse linear systems arising from FEM simulations. Additionally, we implement parallelized matrix assembly in Julia using distributed computing and shared memory techniques to optimize workload distribution and reduce communication overhead in large-scale simulations.

Authors: Dr CHABER, Bartosz (Warsaw University of Technology); Mr TRUSIEWICZ, Konrad (Warsaw University of Technology); Mr GURYN, Mikołaj (Warsaw University of Technology); Ms GAIK, Zuzanna (Warsaw University of Technology)

Presenters: Mr TRUSIEWICZ, Konrad (Warsaw University of Technology); Mr GURYN, Mikołaj (Warsaw University of Technology); Ms GAIK, Zuzanna (Warsaw University of Technology)

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