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State of Art in Realistic Head Modeling for Electro-magnetic Source Imaging of the Human Brain

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Abstract: Electric currents produced by the neural activity in the brain create electric potentials on the scalp and magnetic field distribution outside the scalp. Measuring electric and magnetic fields provides a means to understand the spatio-temporal distribution of the neural activity. The representations of the intracellular electric current of active cell populations based on bimodal data are called electro-magnetic source image (EMSI). With the recent development of large arrays of magnetic sensors, and systems for measuring scalp voltages at more than 100 locations, it is now feasible to implement computational methods that employ numerical models which incorporate the correct geometry and electrical properties of the head. This paper introduces the problem of developing realistic head models for generating more accurate EMSIs. In that sense it has a major review component. Tissue classification from magnetic resonance images forms the first step for realistic head modeling. Thus existing segmentation algorithms and their performances will be discussed. Next, two numerical methods, namely the Finite Element Method (FEM) and the Boundary Element Method (BEM), will be introduced for the solution of electric potential and magnetic fields for a known source configuration. An overall measure, relative difference measure (RDM) is used to measure the performance of the numerical models implemented using isoparametric, quadratic elements. It is observed that both FEM and BEM models yield RDMs around 1%. Finally, a methodology is introduced for parallel implementation of FEM. The implemented parallelization algorithm provided a speed-up of 1.49 on two processors, for a 31769 noded mesh.

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