Large scale non-linear 3D reconstruction algorithms for electrical impedance tomography of the human brain

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Abstarct

Multi - Frequency Electrical Impedance Tomography (MFEIT) is a recent non-invasive portable imaging method. Impedance changes with frequency; each tissue has a characteristic spectroscopic signature. Through an array of scalp electrodes, multiple frequencies at low currents are injected, while boundary voltages are measured. 3D impedance maps can be reconstructed from peripheral measurements. However, several difficulties stand in the way: 1) The human head comprises complex geometry shells, which produce large impedance contrasts between the various head tissues types, 2) Accurate MFEIT modelling results in computationally demanding forward models, 3) Ill-posedness of the inverse problem (boundary measurements are dependent and limited in number), and 5) Lack of scaling invariance causes saturation of the forward solution as complex perturbations are manifested non-linearly over the boundary. There is a clear need of development of non-linear reconstruction methods for this problem; however, standard efficient methods, such as Newton-type methods are not scalable for large scale problems, whereas large scale methods such as Krylov-subspace methods suffer from weak convergence. This study introduces, for the first time, the application of the Krylov-Newton method for MFEIT, with acceleration by parallelisation and incorporation of an Algebraic Multi Grid forward solver preconditioner.