3D EIT Forward and Inverse modeling

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Electrical Impedance Tomography (EIT) is a technique to reconstruct the internal electrical conductivity distribution of the medium by measuring the low-frequency electrical potentials and currents on the boundary. The forward solver is normally based on the conventional Finite Element Method (FEM) with the completed electrode model (CEM). One of the problems of 3D EIT is its high demand in computing power and memory. This is because in order to accurately simulate the forward solution for a very small secondary field (i.e., the difference in the potential between the medium with and without the anomaly) typically obtained in EIT systems, the conventional FEM requires a mesh with large number of nodes and elements.

In this work, Spectral Element Method (SEM) instead of FEM has been used to solve the EIT forward problem. The electrode contact impedances are accounted for by the complete electrode model. Numerical results show that the SEM is capable of achieving better accuracy than the FEM with the same degree of freedom. Furthermore, the SEM is able to achieve "Spectral Accuracy" in which the error decreases exponentially with the increasing order of basis functions.

The EIT image reconstruction algorithm developed is the Distorted Born Iterative Method (DBIM), or often known as the regularized Gauss-Newton method. The inversion algorithm is first tested with synthetic data from the SEM forward solver. The simulated data is obtained from different mesh so as to avoid committing the "inverse crime". A 3D EIT system have been built in our laboratory. The system has a cone shape applicator with 128 electrodes. The results of the SEM forward solver are validated with the measured data for the 3D system. Excellent reconstruction images have been successfully obtained from the measured data. The DBIM algorithm is able to invert both conductive and resistive objects from the measured data.