A MULTI-PHASE SEGMENTATION APPROACH TO THE ELECTRICAL IMPEDANCE TOMOGRAPHY PROBLEM

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Abstract. In Electrical Impedance Tomography (EIT), different current patterns are injected to the unknown object through the electrodes attached at the boundary $\partial\Omega$ of Ω. The corresponding voltages V are measured on its boundary surface. Based on the measured voltages, image reconstruction is done by solving an inverse problem of a generalized Laplace equation

$$-\nabla \cdot (\sigma \nabla \phi) = 0 \quad \text{on } \Omega = [0,1] \times [0,1]$$

subject to homogeneous Neumann boundary conditions. Here σ is the conductivity distribution and ϕ is the electric potential over Ω. In other words, with known V and ϕ, we seek to solve for the typically piecewise values of σ, from which the geometry of internal objects may be inferred.

In this work, the forward problem is solved using the Finite Element Method (FEM). We will then solve the inverse EIT problem by using a multi-phase segmentation approach. Here σ is expressed as

$$\sigma(x) = \sum_{m=1}^{M} \sigma_m(x)\chi_m(x),$$

χ_m is the characteristic function of a subdomain Ω_m where $\Omega_m \cap \Omega_n = \emptyset$, $\Omega = \cup_{m=1}^{M} \Omega_m$ and M is the expected number of segments of Ω. A modified minimization problem is presented and an update σ_m^k is computed. χ_m is then estimated first by using the topological derivative of the cost functional to get an initial χ_m^0. Then χ_m is relaxed to allow it to assume values between 0 and 1. The cost function is expressed in terms of this function and χ_m is updated using a descent method with respect to χ_m.