International Conference on Optimization, Simulation and Control

Non Destructive Testing Method to Detect Underground Gold Using by fdEIT

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Abstract

Electrical Impedance Tomography (EIT) is an imaging technique to visualizes admittivity or impedance distribution inside an electrically conducting object both in 2D and in 3D.

In frequency difference EIT problem measured data at two different frequency subtract to produce images of changes in admittivity distribution with respect to frequency, which are acquired at the same time.

We consider admittivity distribution

$$\gamma = \sigma + i\omega\epsilon$$

as a function position r(x,y,z).

Where,

- γ - admittivity
- σ - electrical conductivity
- ω - angular frequency
- ϵ - electrical permittivity

Introduction

We attached E electrodes on the surface of interested area Ω .

Then inject current between a selected pair of electrodes $\mathcal{E}_j$ and $\mathcal{E}_{j+1}$ for j = 1,2,…, E-1 and E with $\mathcal{E}_{E+1}$ = $\mathcal{E}_1$.

The induced electrical potential denote by u^j in the domain Ω and potential u^j satisfies the following elliptic PDE with Neumann boundary condition

$$\begin{cases} -\nabla\cdot\gamma\,\nabla u^j(r) = 0 \quad in\ \Omega \\ \int_{\varepsilon_j}\gamma\frac{\partial u^j}{\partial n}\,dr = -\int_{\varepsilon_{j+1}}\gamma\frac{\partial u^j}{\partial n}\,dr \\ -\gamma\nabla u^j n = 0 \quad on\ \ \partial\Omega\backslash\varepsilon_j\cup\varepsilon_{j+1} \end{cases} \qquad (1)$$

where, n is outward normal vector on $\partial\Omega$.

Inject current through E pair of electrodes and measure induced voltage on the E voltage electrodes and we get E^2 measurements of voltages which are expressed in a matrix form F for a given γ .

F(γ)= $[V^{1,1}(\gamma),\dots,V^{1,E}(\gamma),V^{2,1}(\gamma)\dots V^{2,E}(\gamma),\dots,V^{E,1}(\gamma),\dots,V^{E,E}(\gamma)]$

Methods and Materials

We inject same currents into the imaging domain with γ and a known γ^0.

Lemma . The perturbation $\delta\gamma = \gamma - \gamma^0$ satisfies

$$\int_\Omega \delta\gamma\nabla u^j\cdot\nabla u_0^k dr = f^l(\gamma) - f^l(\gamma^0) \qquad (2)$$

where, u_0^k is the solution of (1) with γ^0 in place of γ and $f^l(\gamma)$ is lth component of F(γ).

We discretize the domain Ω into N subregions as $\Omega = \bigcup_{n=1}^{N} T_n$. We assume γ, γ^0 and $\delta\gamma$ are constants in each T_n . Then we can express (2) as

$$S_{\gamma^0}\delta\gamma = \delta F$$

or

$$\begin{pmatrix} \int_{T_1}\nabla u_0^1\nabla u_0^1 & \int_{T_2}\nabla u_0^1\nabla u_0^1 & \cdots & \int_{T_N}\nabla u_0^1\nabla u_0^1 \\ \int_{T_1}\nabla u_0^1\nabla u_0^2 & \int_{T_2}\nabla u_0^1\nabla u_0^2 & \cdots & \int_{T_N}\nabla u_0^1\nabla u_0^2 \\ \vdots & & & \vdots \\ \int_{T_1}\nabla u_0^E\nabla u_0^E & \int_{T_2}\nabla u_0^E\nabla u_0^E & \cdots & \int_{T_N}\nabla u_0^E\nabla u_0^E \end{pmatrix} \begin{pmatrix} \delta\gamma_1 \\ \delta\gamma_2 \\ \vdots \\ \vdots \\ \delta\gamma_N \end{pmatrix} = \begin{pmatrix} f^1(\gamma^0+\delta\gamma) - f^1(\gamma_0) \\ \vdots \\ f^E(\gamma^0+\delta\gamma) - f^E(\gamma_0) \\ \vdots \\ \vdots \end{pmatrix}$$

Solving the linear equation

$$\delta\gamma^0 = (S_{\gamma^0}^{\mathrm{T}}S_{\gamma^0} + \lambda\,R\,)^{-1}S_{\gamma^0}^{\mathrm{T}}\,\delta F^0$$

where, λ is the a regularization parameter and R is a regularization matrix.

Algorithm

Step 1. Let γ^0 as the initial guess and δ is tolerance.

Step 2. For γ^m solve the forward problem (1) and get $u_{\gamma^m}^j$

Step 3. Compute S_{γ^m} matrix

Step 4. Calculate $\delta\gamma^m$

Step 5. Update $\gamma^{m+1} = \gamma^m + \delta\gamma^m$

Step 6. Repeat the process until $\|\delta\gamma^m\| < \delta$.

Results

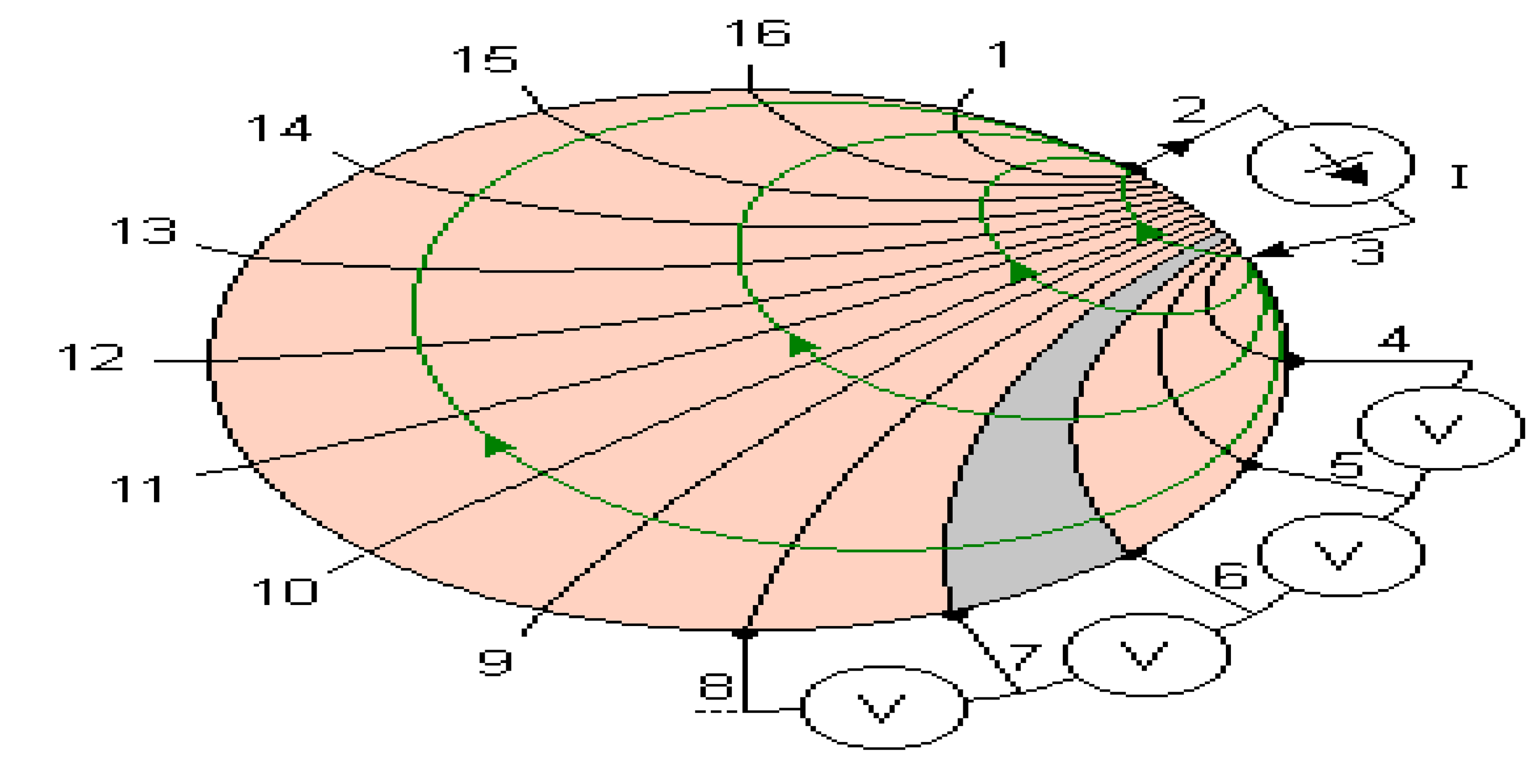

Figure 1. NtD data from 16- channel EIT system.

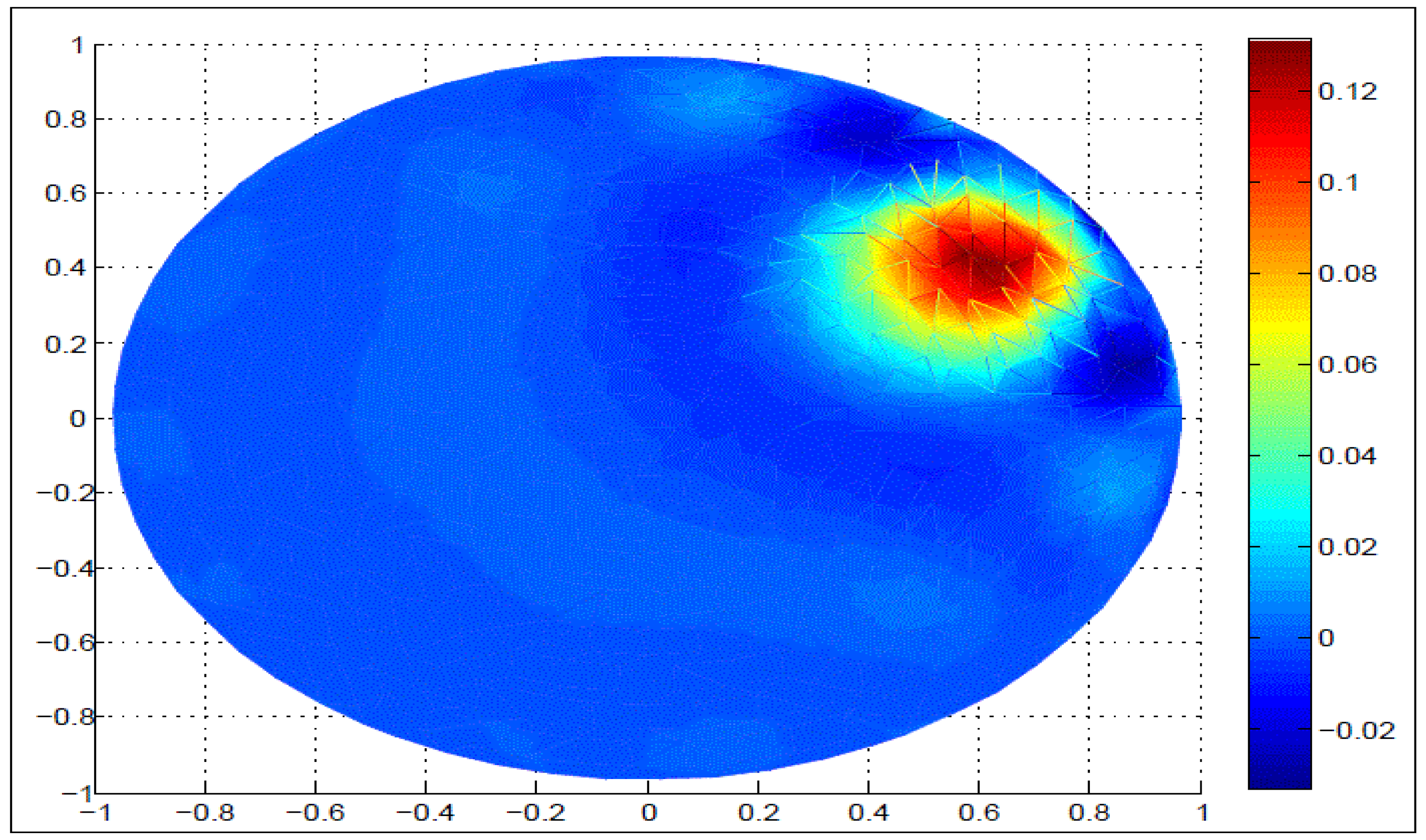

Figure 2. Reconsructed image

Conclusions

Inverse problem of EIT inherits some technical difficulties, suffering from the ill-posed problem with geometry, limited electrode measurements, and were affected by unknown boundary uncertainty in electrode position, and systematic artifacts, even though it is able to show frequency-difference imaging by non-destructive way.

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