Identification of Contact Conductivity of Electrodes Using EIT Total Variation Primal Dual Regularization

JARMILA DĚDKOVA, LIBOR DĚDEK
Faculty of Electrical Engineering and Communication
Brno University of Technology
Kolejní 4, 612 00 Brno
CZECH REPUBLIC
dedkova@feec.vutbr.cz http://www.feec.vutbr.cz

Abstract: - In electrical impedance tomography (EIT) currents are applied through the electrodes attached on the surface of the object and the resulting voltages are measured using the same or additional electrodes. Internal conductivity distribution is from the measured voltages and currents recalculated. If we add the electrode contact conductivity in the complete model we can estimate all parameters based on the voltage or current measurements. In this paper we propose a method to evaluate the contact conductance simultaneously with the internal electrical properties. The method is certain modification of the complete electrode model (CEM) that is used in EIT.
The aim of this paper is to formulate the problem, present the model of electrode conductivity, represent algorithm and to show some results, which have been verified experimentally. To recover the conductivity we use the widely known total variation primal dual interior point method (TV PD-IPM). We minimize the primal objective function $\Psi(\sigma)$

$$\Psi = \frac{1}{2}\sum \left\| \boldsymbol{U}_{\mathrm{FEM}}(\sigma) - \boldsymbol{U}_{\mathrm{MEAS}} \right\|^2 + \alpha \mathrm{TV}_{\beta},$$

where $\boldsymbol{U}_{\mathrm{FEM}}$ is the vector iteratively calculated using the finite elements method (FEM), $\boldsymbol{U}_{\mathrm{MEAS}}$ is the vector of measured nodal voltages, α is the regularization parameter and

$$\mathrm{TV}_{\beta} = \sum_{all\ elements} \int \left| \mathrm{grad}(\sigma) \right| d\Gamma = \sum \sqrt{\left\| \boldsymbol{R}(\sigma) \right\|^2 + \beta}.$$

Here $\boldsymbol{R}$ is a suitable regularization matrix and β is a small positive parameter, which represents an influence on the smoothing of

$\Psi(\sigma)$. To find the distribution of conductivity σ we used the PD-IPM algorithm that we write in the notation used above as

initialize primal variable σ with one step of LS algorithm, dual variable x to zero, parameter β, step of iteration k to zero,
while $k < k_{\max}$

$$\eta_{\mathrm{k}} = \sqrt{\left\| R\sigma_{\mathrm{k}} \right\|^2 + \beta}, \quad B_{\mathrm{k}} = \mathrm{diag}\left(1\text{-}\frac{x_{\mathrm{i}} R_{\mathrm{i}} \sigma_{\mathrm{k}}}{\eta_{\mathrm{i}}} \right),$$

$$D_{\mathrm{k}} = \left[\mathrm{diag}\left(\eta_{\mathrm{i}} \right) \right]^{-1},$$

$$\Delta\sigma_k = \left[J_k^{\mathrm{T}} J + \alpha R^{\mathrm{T}} B_k D_k R \right]^{-1} \left[J_k^{\mathrm{T}} \Delta U_k + \alpha R^{\mathrm{T}} B_k R \sigma_k \right],$$

$$\Delta x_k = x_k + B_k R \sigma_k + B_k D_k R \Delta\sigma_k,$$

$$\lambda_\sigma = \arg\min \Psi\left(\sigma_k + \lambda_\sigma \Delta\sigma_k \right),$$

$$\lambda_x = \max\left\{ \lambda_x : \left\| x_i + \lambda_x \Delta x_i \right\| \le 1, \; i = 1,.....,n \; \right\},$$

if reduction of Ψ has been achieved

$$\sigma_{(k+1)} = \sigma_k - \lambda_\sigma \Delta\sigma_k, \quad x_{k+1} = x_k + \min\left(1, \lambda_x \right) \Delta x_k,$$

$$\beta = \beta \cdot \beta_{red}, \qquad k = k + 1,$$

else

$$\beta = \beta / \beta_{red},$$

end

end while.

Details will be given during poster prezentation.

Acknowledgement
This work was supported by the Grant Agency of the Czech Republic (GACR) under Grant No. 102/03/1108.