

"SPARSITY PATTERNS IN THE NUMERICAL SOLUTION OF THE INVERSE PROBLEMS OF ERT AND ECT: A STUDY ON STABILITY AND COMPUTATIONAL ASPECTS"

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Electrical resistance tomography and electrical capacitance tomography are two imaging techniques used in medical, process and geophysical exploration to image the electrical conductivity and permittivity distribution within a medium, from electrical measurements made on the surface of the medium. Both the techniques involve the solution of a specific inverse problem, which is ill-posed, and also highly non-linear.

The focus of the thesis is on the mathematical aspects of the numerical algorithms used for the solution of these inverse problems. Given the non-linearity of the problems, the most popular numerical algorithms rely on the Output Least Squares (OLS) framework. The OLS framework formulates the inverse problems in order to minimize the discrepancy between the measured and simulated data, by adjusting the unknown distribution through a sequence of local linear or quadratic approximations. Finally, the solution of the inverse problem results from the solution of a sequence of linear systems of equations with large and dense matrices. Differently from OLS, the recently appeared Residual Least Squares (RLS) framework, because of a different formulation of the inverse problem, results in the solution of a sequence of linear systems of equations with large and sparse matrices. The memory saving due to the sparsity of these matrices represents for RLS a big advantage in comparison with OLS, because RLS can tackle problems that would be very memory demanding with OLS. This thesis also shows that the sparsity in these matrices follows specific patterns, which are analyzed in order to develop a fast numerical solution method. With regard to the ill-posedness of the inverse problems, this thesis also analyzes several methods to stabilize the solution from RLS.