Geophysical Research Abstracts
Vol. 13, EGU2011-4927, 2011
EGU General Assembly 2011

Tunnel detection based on data fusion with radio frequency and electrical resistive tomography

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Future non-destructive monitoring systems based on ICT and sensor technologies will provide emergency and disasters stakeholders with high situation awareness by means of real time and detailed information and images of the infrastructure status [1]. Useful technologies include Electrical Resistive Tomography (ERT) as well as Ground Penetrating Radar (GPR), which have become widely applied to obtain images of the subsurface in areas of complex geology [2, 3, 4]. However, the development and implementation of complex ICT based monitoring systems will also rely on new technologies, techniques and algorithms including the integration and correlation of the electromagnetic properties corresponding to imaging modalities such as ERT and GPR [1].

It is natural to adopt a statistical or Bayesian approach towards multi-sensor data fusion [5, 6, 7]. In this paper, the general approach to information fusion is hence to perform a multi-sensor, multimodal or multi-physics data fusion based on the statistically optimum Maximum Likelihood (ML) principle, and in particular to exploit the principles of Fisher information analysis that has been developed in [8, 9, 10].

As a generic example concerning a multi-physics inverse problem based on geophysical sensing, this paper addresses the problem of tunnel detection [4] based on data fusion with radio frequency and electrical resistive tomography. A two-dimensional problem is considered with radio frequency as well as electrical sensors places horizontally above a void in the ground. The example is concerned with information fusion for a linearized inverse problem similar to the Born approximation [3], and a truncated Singular Value Decomposition (SVD) based algorithm which combines the two imaging modalities in a way that is optimal in the sense of maximum likelihood. A Green's function approach is used to obtain the gradients for the Fisher information analysis [10] as well as for the related SVD based algorithm. The examples demonstrate that proper data fusion can be of crucial importance for ill-posed inverse problems in geophysical applications.

Acknowledgement

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under Grant Agreement no 225663.

References

[1] M. Proto, M. Bavusi, R. Bernini, L. Bigagli, M. Bost, F. Bourquin, L.M. Cottineau, V. Cuomo, P. Della Vecchia, M. Dolce, J. Dumoulin, L. Eppelbaum, G. Fornaro, M. Gustafsson, J. Hugenschmidt, J. Kaspersen, H. Kim, V. Lapenna, M. Leggio, A. Loperte, P. Mazzetti, C. Nativi, S. Moroni, S. Nordebo, F. Pacini, A. Palombo, S. Pascucci, A. Perrone, S. Pignatti, F.C. Ponzo, E. Rizzo, F. Soldovieri, and F. Taillade. Transport infrastructure surveillance and monitoring by electromagnetic sensing: the ISTIMES project. *Sensors*, 10:10620–10639, 2010.

[2] A. Perrone, A. Iannuzzi, V. Lapenna, P. Lorenzo, S. Piscitelli, E. Rizzo, and F. Sdao. High-resoultion electrical imaging of the Varco d'Izzo earthflow (southern Italy). *Journal of Applied Geophysics*, 56(1):17–29, 2004.

[3] G. Leone and F. Soldovieri. Analysis of the distorted Born approximation for subsurface reconstruction: truncation and uncertainties effect. *IEEE Trans. Geoscience and Remote Sensing*, 41(1):66–74, 2003.

[4] L. L. Monte, D. Erricolo, F. Soldovieri, and M. C. Wicks. Radio frequency tomography for tunnel detection. *IEEE Trans. Geoscience and Remote Sensing*, 48(3):1128–1137, 2010.

[5] Albert Tarantola. *Inverse problem theory and methods for model parameter estimation*. Society for Industrial and Applied Mathematics, Philadelphia, 2005.

[6] J. Kaipio and E. Somersalo. *Statistical and computational inverse problems*. Springer-Verlag, New York, 2005.

[7] H. B. Mitchell. *Multi–sensor data fusion: An introduction*. Springer-Verlag, Berlin, Heidelberg, 2007.

[8] S. Nordebo, M. Gustafsson, and F. Soldovieri. Data fusion for reconstruction algorithms via different sensors in geophysical sensing. In *European Geosciences Union General Assembly*, 2010. Vienna, Austria, 2–7 may, 2010.

[9] S. Nordebo, R. Bayford, B. Bengtsson, A. Fhager, M. Gustafsson, P. Hashemzadeh, B. Nilsson, T. Rylander, and T. Sjöden. An adjoint field approach to Fisher information-based sensitivity analysis in electrical impedance tomography. *Inverse Problems*, 26, 2010. 125008.

[10] S. Nordebo, A. Fhager, M. Gustafsson, and B. Nilsson. A Green's function approach to Fisher information analysis and preconditioning in microwave tomography. *Inverse Problems in Science and Engineering*, 18(8):1043–1063, 2010.