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.

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References


