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Data fusion for reconstruction algorithms via different sensors in geophysical sensing

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1 Abstract

A unified approach to sensitivity analysis and data fusion for multi-physics inverse scattering problems will be presented which is based on Fisher information analysis for distributed parameter systems, cf., [4]. This approach is particularly useful when there is a diversity of measurement sensors having varying noise spectral content and signal to noise ratios, such as with information fusion with multi-physics data. Here, the Fisher information analysis yields a systematic procedure to incorporate a statistically based weighting of the measurements.

The forward operator is the mapping that takes the unknown material parameters of interest to the measurement data. It will be shown that the Fisher information analysis is equivalent to performing a Singular Value Decomposition (SVD) analysis of the linearized forward operator [1,2,5], provided that the measurement noise is Gaussian distributed and that the appropriate scalar product is chosen for the space of measurement data. Hence, the Fisher information concept provides a systematic means of choosing the scalar product for the related Hilbert space in a way that is statistically optimum.

In particular, if $\mathcal{J}$ denotes the Jacobian, or the Fréchet derivative of the forward operator, then the Fisher information integral operator is given by $\mathcal{I} = 2\mathcal{J}^*\mathcal{J}$ where $\mathcal{J}^*$ is the Hilbert adjoint operator, see e.g., [3] for the finite-dimensional case. Hence, the truncated SVD algorithm [1,2,5] corresponds here to a regularized pseudo-inverse based on the Fisher information operator.

Application examples using the truncated SVD algorithm [5] for multi-physics inverse problems in geophysical sensing will be considered.

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