Iterative methods for the inversion of nonlinear magnetic and gravitational fields

Harry B. Bingham

Dept. of Civil & Mechanical Engineering

Technical University of Denmark

Abstract

Inversions of nonlinear potential field quantities such as the Normalized Source Strength (NSS) or the Total Gradient (TG) are widely used in applied and environmental geophysics. These quantities are attractive due to their non-negativity and relative insensitivity to remanent magnetization direction. Despite the fact that these quantities are derived from nonlinear transformations of potential field data, a linear inversion approach is often used in the literature without consideration of any theoretical and practical limits. We present here an approach for the nonlinear constrained inversion of these quantities and apply it to synthetic data and measurements. We show, through Generalized Singular Value Decomposition (GSVD) analysis tools, that the nonlinearity of the problem can corrupt the inversion results when using a linear approach, whereas our nonlinear iterative approach leads to more reliable reconstructions of the subsurface density/magnetization distribution.

These large-scale inversion problems are typically highly underdetermined (ill-posed) and based on noisy observational data. One classical method to treat such problems is to caste them in a Bayesian framework where the model and measurement uncertainties are treated statistically. This requires the evaluation of many thousands of plausible inputs to the forward model, which is generally a heavy computational burden. Reduced order modelling seeks to reduce this cost by approximating the forward model by a relatively small number of modes obtained through Proper Orthogonal Decomposition (POD). The talk will conclude with some thoughts on applying these ideas to improve the efficiency and accuracy of the identification of gravitational and magnetic sources from measured data.

Prof. Harry B. Bingham, Dept. of Civil & Mechanical Engineering Technical University of Denmark, 2800 Lyngby, Denmark. hbbi@dtu.dk

Prof. Bingham grew up in the San Francisco Bay Area in California, USA. He received his BSc in Applied and Engineering Physics from Cornell University in 1984, an MEng degree in Ocean Engineering from Stevens Institute of Technology in 1987 and a PhD in Ocean Engineering from MIT in 1994. He moved to Denmark in 1995 and has been at the Technical University of Denmark since 1999, first in the Dept. of Applied Mathematics and then the Dept. of Mechanical Engineering which has now become the Dept. of Civil & Mechanical Engineering.

Prof. Bingham's research is focused on accurate and efficient numerical methods for potential field problems. Applications include the modelling of linear and nonlinear wave- structure interaction in the marine environment and inversion of gravitational and magnetic fields. His work is published widely in scientific journals and conference proceedings, and he has supervised numerous PhD, MSc and BSc projects.