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The 3-D magnetic imaging using the L-1 norm regularization, Part II.

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Recently some new methods for 3-D magnetic imaging were proposed (Li and Oldenburg,1996, Portniaguine and Zhdanov,2001, Pilkington,2013). Some of them have a goal to obtain the “sparse” model i.e. the simplest model that reproduce the observed data. This is because, most of the traditional way of inversion for the potential data provides distorted or unfocused images of real magnetic structures. In this study, we propose a new method introducing an L-1 norm penalized least square procedure and tried to obtain a simple, high-resolution and focused model.

Lasso (Tibshirani, 1996) is a linear regression and variable selection procedure based on the L1 penalized least square. L1 penalty has an effect of shrinkage the value of model parameters which have weak contributions to be zero. So, the Lasso does both continuous shrinkage and automatic variable selection simultaneously. On the other hand, Lasso has some drawbacks. One of them is, at most Lasso algorithm can select nonzero variables of same number of observed data. So, in the case of $p << n$ problem, i.e. when the number of unknown parameters (n) is larger than the number of observations (p), this algorithm cannot be adopted or overly shrinkage model will be obtained.

To overcome this limitation, Zou and Hastie (2005) proposed a new L-1 penalized method named ’elastic net’, and Hebiri and van de Geer (2011) proposed ’S-Lasso’. These methods are the compromise of the L-1 and L-2 or some quadratic regularization method. Using these methods, we can treat $p << n$ problems in the framework of L-1 penalized method.

In This study, we propose a new 3-D magnetic inversion method based on the Lasso-type regularization (i.e. generalized elastic net) and show the results of applying our method to the synthesized and real magnetic data.

Keywords: L1 regularization, magnetc inversion, aeromagnetic survey