Level set versus triangulation-based regularization for the inverse EEG/MEG problem using the Symmetric Boundary Element Method

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Following recent breakthrough in the forward MEG/EEG problem, we propose and compare two methods for localizing cortex activity from EEG/MEG measurements. This is known as the inverse problem in MEG and EEG. Recent works [Abboud,Clerc,Faugeras,Keriven,Kybic] have shown that, using a new symmetric approach, the Bondary Element Method (BEM) can achieve significantly better precision for the forward problem than any other previously known BEM or Finite Elements Method (FEM). In our BEM formulation, electrical activity of the brain is assumed to be mainly concentrated on the surface of the cortex, this can be biologicaly justified for a large domain of studies of the brain. Thus, sources are modelized by dipole distribution (or dipole density) all over the surface of the cortex. The arising forward problem is then linear. The inverse problem is solved as a constrained reconstruction problem adressed by a PDE. This PDE contains two terms: a data-driven one (least square) and a regularization one. The last implies surface laplacian and can be treated in two ways: firstly in deriving numerical schemes over a triangulated surface, it allows to keep on working on the mesh, where the data-driven term is defined. Secondly, we can embed the mesh into a grid and use a well-studied level set method [Bertalmio,Sheng,Osher,Sapiro], this brings simple, flexible and well-known numerical schemes. Regularization type is a critical point in data-driven recontruction. Whereas the minimal norm constraint may deliver over-scattered source of activity, isotropic filtering force electrical activity to have low spatial gradients. Finaly, anisotropic filtering seek minimal total variation solutions, this implies well-delimited active zones on the cortex (typically piecewise constant).

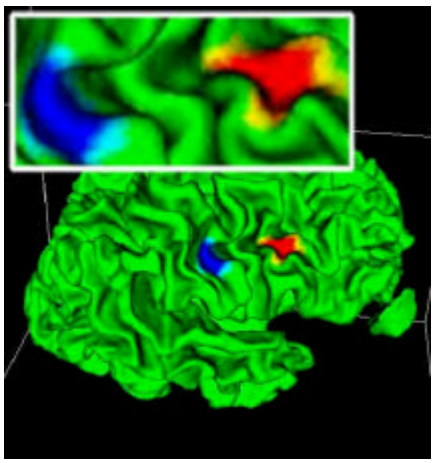

Fig.1: *Original Synthetic Sources*

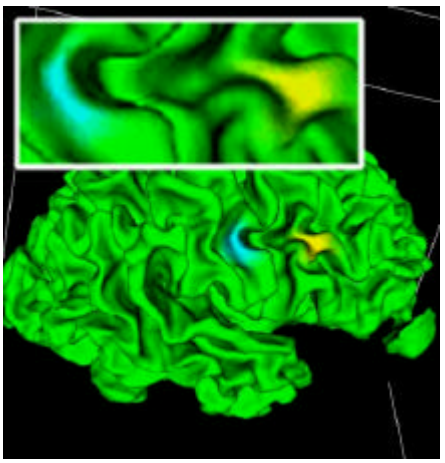

Fig.2: *Isotropic Reconstruction*

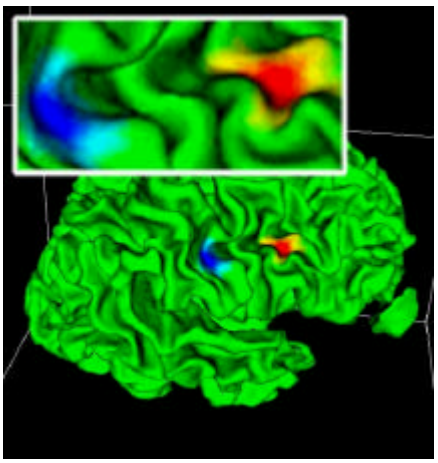

Fig.3: *Anisotropic Reconstruction*

We compare this two regularization methods in the MEG/EEG inverse problem (via symmetric BEM formulation) in terms of precision, speed and performance. We deal with several types of regularization too (isotropic, anisotropic).

Results are presented on phantom and real data and compared with other, more classical techniques.