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Data-driven cortical clustering to provide a family of plausible solutions to the M/EEG inverse problem

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1 MOTIVATION

- Sources are represented as a connected cortical region, rather than a dipole
- Several separated cortical regions can fit the data with similar accuracy. While convex optimization based methods give a single solution, we explore a family of plausible solutions
- Estimate not only the position, but also extension range of the regions

2 ASSUMPTIONS

- Data model: $y = Lx + N$ ($L$ is a lead field)
- Source space: cortical mesh
- Brain activity $x$: single region with a constant amplitude over this region; one time sample

3 METHOD

Adapting hierarchical clustering algorithm [1] to fit M/EEG data:
- Mesh vertices represent initial clusters
- Mesh edges define the cluster neighborhood
- Among all inter neighbors clusters, find clusters $C_i^*$, $C_j^*$ which minimize:
  $$E(i,j) = \min_a \|y - a \cdot (L(c_i^*) + L(c_j^*))\|_2 + R(i,j)$$
- Merge these clusters: $c_k = c_i^* \cup c_j^*$, $L(c_k) = L(c_i^*) + L(c_j^*)$
- Repeat until the whole cortex is one cluster
- Cut the tree to obtain separated "growing" regions
- Select best regions by thresholding data fitting error

4 RESULTS

- Simulated MEG signal of one active region (in blue) with additive noise
- Reconstructed with and without regularization. (we regularized region shapes but other alternatives are possible)
- Obtained 3 spatially separated regions which explain the data with high accuracy (with regul.)
- Estimated the extension range of each region

5 CONCLUSIONS

New approach for the M/EEG inverse problem which:
- Deals with a "growing region" object, which allows to explore space of solutions
- Gives several candidates for solution and their extension ranges
- Future work:
  - Regularization term to be investigated
  - Error thresholding to be investigated
  - Multiple source case by adapting the MUSIC method [2]

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References:
[1] F. Murtagh and P. Contreras. Methods of Hierarchical Clustering. Computing Research Repository - CORR, 2011.
[2] N. Mäkelä, M. Stenroos, J. Sarvas and RJ Ilmoniemi. Truncated RAP-MUSIC (TRAP-MUSIC) for MEG and EEG source localization. NeuroImage, Volume 167, 15 February 2018, Pages 73-83.