

Introduction

Electroencephalography (EEG) and Magnetoencephalography (MEG) are two non-invasive imaging modalities that measure the brain activity. Activity reconstruction is ill-posed with distributed dipole model. A unique solution is usually obtained with mathematical prior.

- ▶ Idea:
 - ▶ Reduce the size of solution space using functional regions.
 - ▶ Functional regions are assumed to have equal activation.
 - ▶ Regions are obtained using dMRI (similar fiber distributions).
 - ▶ Sparse solution (only few regions are active simultaneously).
 - ▶ BIC (Bayesian Information Criterion) [1] is used to find optimal number of active regions (K_p).

Parcellation

The connectivity profile of a source v is a vector, CP_v , that contains the number of samples that were drawn from the voxel v and diffused in the diffusion space.

- ▶ The CP is obtained using the probabilistic tractography [2].
- ▶ We use a similar approach to Bellec et al.[3] based on Mutual Nearest Neighbor (MNN) to parcellate the cortical surface using dMRI.
- ▶ The goal is to partition the set of sources on the cortical substrate into a set of non overlapping regions and similar CPs.
- ▶ The similarity measure between two regions is:

$$SM(P_i, P_j) = \frac{1}{|P_i||P_j|} \sum_{(v,w) \in (P_i \times P_j)} corr(CP_v, CP_w) \quad (1)$$

where $corr$ is the Pearson's correlation, P_i is the i^{th} region and $|P_i|$ is the size of the region i .

- ▶ In the first iteration, regions are singletons of seeds and all of them are possible candidates to merge.
- ▶ Two neighbor regions are merged if they validated the MNN condition;

$$P_i = \arg \max_{P_k \in N(P_i)} SM(P_k, P_i), P_j = \arg \max_{P_k \in N(P_j)} SM(P_k, P_j)$$

where $N(P_i)$ is the set of the neighbors of P_i .

- ▶ The region is validated if its size is more than z .
- ▶ The algorithm stops iterating when no region validates the two conditions or when $K_{iter} \leq K$.

Inverse Problem

Reducing the inverse problem from the sources to the regions space, allow us to detect extended activation or can be used as a first step to compute the activation at the source level for only active regions. We compare the results to the ones obtained by using MNE and L1 norm applied on the regions. The number of active regions is obtained using BIC.

$$BIC(K) = n \ln\left(\frac{\|M - G_K S_K\|_2^2}{n}\right) + K \ln(n) \quad n: \text{number of samples}$$

Results: False detection and Focal activation

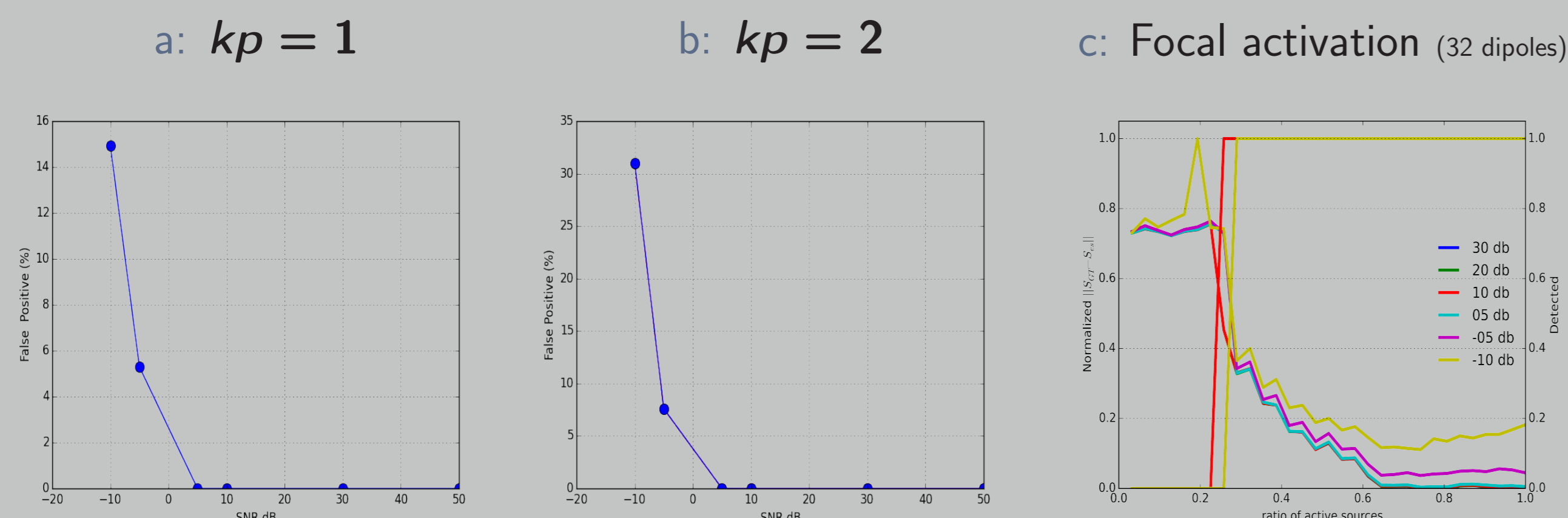
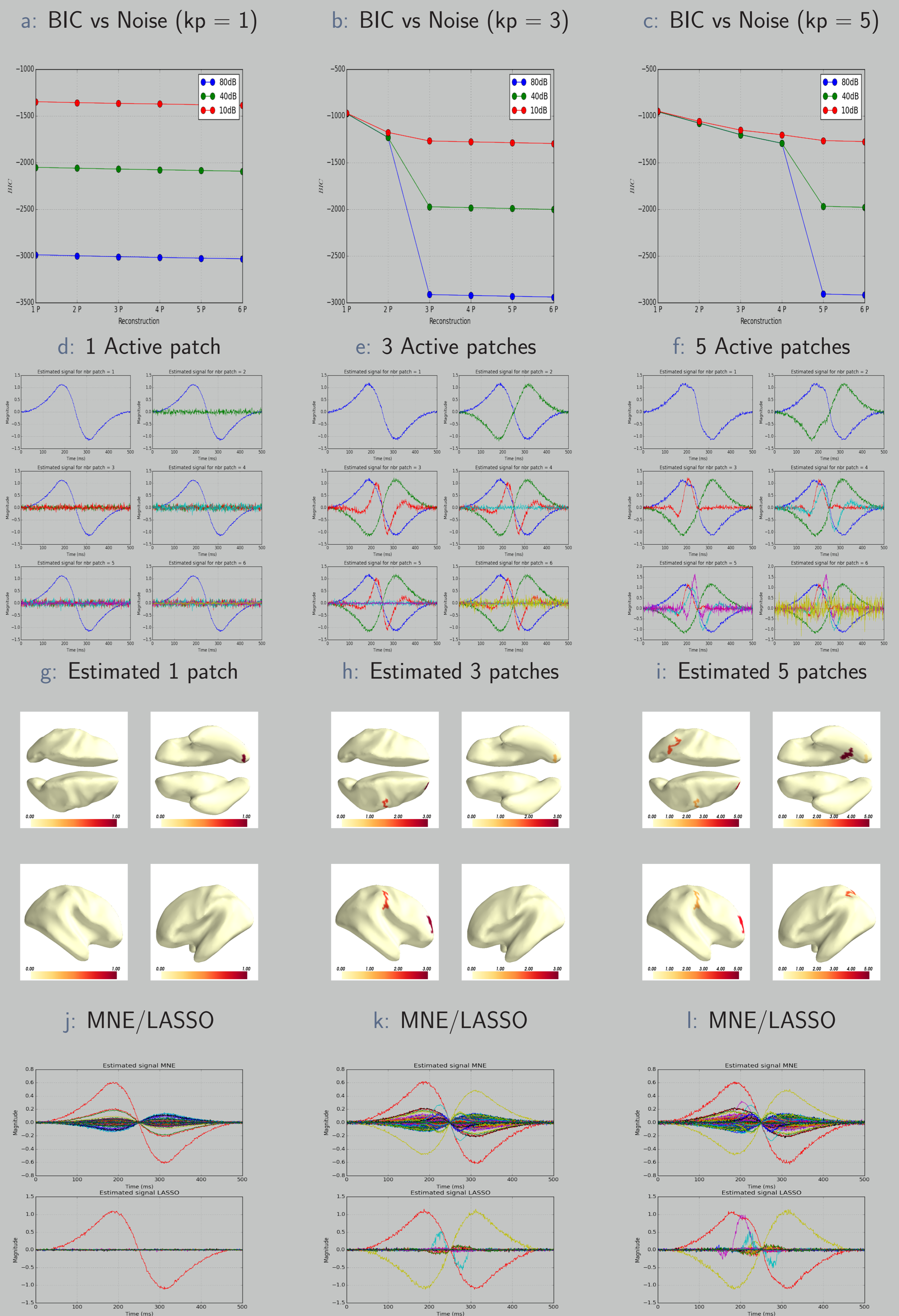


Fig. (a) and (b) show the false detected regions when activating 1 and 2 regions respectively for different noise levels. Fig. (c) shows the error in the MEG activation and the detection when activating few sources in a region for different noise levels. Total number of regions is 345.

- ▶ The correct combination of active regions are detected for $SNR > 10$ dB.
- ▶ The right region is detected when more than 20% of sources are activate.

We activated 1, 3 and 5 regions. The algorithm is compared to the source reconstruction of MNE and L1. The gain matrix is obtained using OpenMEEG (B.E.M with brain-skull conductivity ratio set to 80).

Results: Extended Sources (10 dB)



Conclusion

- ▶ The algorithm could detect the correct active regions (For $SNR \geq 10$ dB).
- ▶ Other imaging modalities (e.g. fMRI) can be used to parcellate the cortex.
- ▶ Our approach provides more accurate results than MNE and L1 norm.
- ▶ For focal activation, more than 20% of the sources inside the region must be activated for the algorithm to detect the correct region.
- ▶ K_p can be easily detected for $SNR > 10$.
- ▶ This algorithm suffers from high execution time for high K_p .

References

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- [2] T.E.J. Behrens, H. Johansen Berg, et al. Probabilistic diffusion tractography with multiple fibre orientations: What can we gain? *NeuroImage*, 34(1):144 – 155, 2007.
- [3] P. Bellec, V. Perlberg, et al. Identification of large-scale networks in the brain using fMRI. *NeuroImage*, 29(4):1231–1243, 2006.
- [4] D. G. Wakeman and R. N. Henson. A multi-subject, multi-modal human neuroimaging dataset. *Scientific Data*, 2015.

Contact Information

- ▶ Web: <http://www-sop.inria.fr/members/Brahim.Belaoucha>
- ▶ Code can be downloaded from: <https://github.com/BBELAOUCHA/Parcellation-Cortical-Surface>