Region-of-Interest-Constrained Discriminant Analysis for MEG Decoding


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Brain state decoding based on whole-head MEG has been extensively studied over the past decade. However, a number of new MEG applications have recently emerged and suggested a need to decode different brain states by the signals generated from specific cortical regions only. For instance, applying MEG decoding to neurorehabilitation has attracted significant interests. This emerging technique of neurorehabilitation focuses on a target cortical region with dysfunction. The goal is to provide feedback of neural activity within this region so that the patient can learn how to produce activation patterns to facilitate the function recovery of the impaired cortical region. In this case, it is important to decode MEG signals from the target cortical region only. Otherwise, even if the decoding accuracy is high, the rehabilitation process cannot effectively train the target cortical region and induce the desired function recovery.

Towards this goal, we propose a novel region-of-interest-constrained discriminant analysis algorithm (RDA). RDA closely integrates linear classification and beamspace transformation into a unified framework by formulating a constrained non-convex optimization problem. A numerical solver is developed to solve the non-convex optimization problem posed by RDA with guaranteed global convergence. Our experimental results based on human subjects demonstrate that RDA can efficiently extract the discriminant information from a target cortical region to accurately distinguish different brain states. As shown in Fig. 1, without constraining a target region, the traditional LDA-W algorithm picks up the discriminant information from widely distributed cortical regions. However, the proposed RDA successfully selects the MEG signals generated by the target region only. On the other hand, the decoding accuracies of LDA-W and RAD are close.

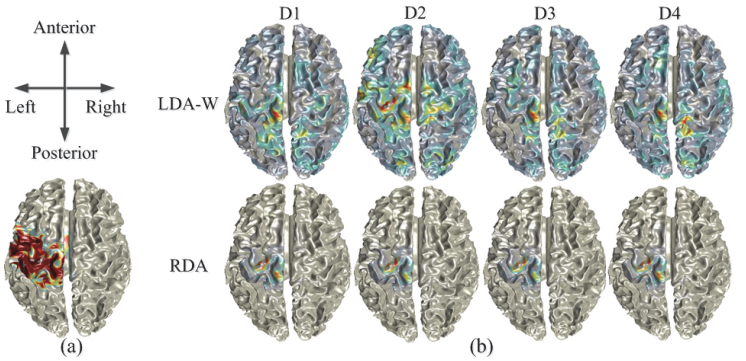

Fig. 1: (a) Red color indicates the spatial location of the target cortical region. (b) These maps show the spatial locations of the discriminant neural sources captured by LDA-W and RDA for decoding. Red color indicates the locations of the sources generating significant discriminant signals.