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Analysis of correlated activity in fMRI data via Hopfield neural networks

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Certain aspects of spatio-temporal information processing in the brain are reflected by the task-dependent interaction of activated areas as provided by the analysis of fMRI data. Studying cross-correlation between pixels time courses of the fMRI signal, this information can be revealed by extracting clusters of strongly correlated pixels. Considering only relevant information by introducing a minimal correlation level θ a graph-theoretical approach [1] can be applied to the network defined by pixel pairs with correlations above θ.

Activated areas can now be determined by typical graph structures such as cliques or connectivity components. Clique, i.e.fully connected sets of vertices, and connectivity components, which have at least one path between any two vertices, are extreme cases with respect to the degree of connectivity. Since cliques may be corrupted by noise and be not fully connected in the observed graph and, on the other hand, in connectivity components not directly connected pixels may have low pairwise correlation, it appears natural to study clusters of intermediate connectivity.

In the present approach a variant of Hopfield's neural network model [2] is used, which allows to extract clusters of various degree of connectivity, ranging between the two extreme cases of cliques and connectivity components [3]. Moreover we also consider a measure of a connectivity degree which combines graphical connectivity and the correlation threshold θ. Further a criterion is proposed which allows to evaluate the relevance of such structures based on the robustness with respect to parameter variations. Exploiting the intracluster correlations, we can show that regions of substantial correlation with an external stimulus can be unambiguously separated from other activity.

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