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Model-free Analysis of MR Image Time-Series: How Many Clusters Should be Used?

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PURPOSE

Model-free clustering methods for MR image time-series analysis are increasingly used as an alternative to classical model-based methods, such as cross-correlation or statistical regression. But how many clusters should be used? The aim was to analyze this so-called Cluster Validity (CV) problem for MRI time-series analysis.

METHOD AND MATERIALS

Image time-series were aquired from a functional MR experiment performed in 6 healthy volunteers on a 1.5 T system (GE-EPI, TR/TE=4000/66 ms) in a 64 scan visual stimulation setting. The time-series vectors were clustered by minimal free energy vector quantization (MFE-VQ) (Wismueller et al, Int J Comp Vision 46(2)). Three CV indices known from the pattern recognition literature were computed on the results obtained by 20 runs of MFE-VQ on each data set, namely Kim's index (KI), Calinski & Harabsz index (CHI), and the intraclass index (ICI). For quantitative evaluation, the maximal correlation c of the consistently task-related component with the reference function was computed for different cluster numbers. In addition, interactive visual human expert assessment of cluster assignment quality was performed by two experienced radiologists, which served as a 'gold standard' in order to identify the optimal number of clusters.

RESULTS

The data set-specific optimal cluster number determined by human experts ranged between 3 and 7. The disagreement D between both experts was 0.17±0.05 clusters, c=0.85±0.02. KI performed best w.r.t. this gold standard, with D=0.31±0.12 only, c=0.84±0.02. CHI substantially overestimated (D=3.5±2.1, c=0.85±0.05), whereas ICI (D=0.83 ± 0.42, c=0.80 ± 0.06) systematically underestimated the optimal cluster number, which resulted in low-quality cluster assignment maps.

CONCLUSION

Choosing an appropriate CV index in order to determine the optimal number of clusters is crucial for model-free MR image time-series analysis. Besides fMRI, this observation applies to other MRI time-series as well, such as MR mammography or brain perfusion.

CLINICAL RELEVANCE/APPLICATION

To determine the optimal number of clusters is a frequently neglected, yet important step to appropriate model-free MR image time-series analysis.