MRI tissue classification is an important problem with many applications in biomedicine. State-of-the-art methods rely on parametric model fitting via the Expectation-Maximization algorithm combined with Markov random field models on local arrangements of tissue class labels for spatial smoothness. In contrast, the proposed method models images as random fields and relies on minimizing an entropy-based metric defined on neighborhoods of intensities. Furthermore, we use nonparametric density estimation which offers advantages over parametric model fitting for this problem. Combined with co-registered brain atlas information, the approach is fully automatic.

Tissue classification methods that rely only on single-pixel intensity statistics of magnetic resonance images perform poorly on noisy data. Single-pixel intensity distributions of different tissue classes overlap to very large extents in the presence of imaging noise. To solve this problem, traditional approaches manipulate single-pixel tissue probabilities with a Gibbs prior. This prior results from a Markov random field model on local neighborhoods of tissue class labels. We propose an alternative approach that directly uses intensity information (instead of labels) from local neighborhoods.

Top Row: An axial slice from simulated, T1-weighted MRI (left). Classification of CSF, gray matter and white matter using only single-pixel statistics (middle) and neighborhood intensity statistics (right). Note that the noise in the image is translated to noise in tissue labels in the single-pixel method. Taking neighborhood intensities into account removes the effects of image noise in the classification to a large extent without significantly distorting the geometrically subtle structures of the boundary between gray and white matter.

Middle Row: A coronal slice from simulated, T1-weighted MRI and tissue classification results.

Bottom Row: A coronal slice from a T1-weighted, 1mm isotropic real MRI (left). Tissue classification with neighborhood intensity statistics (right) gives a spatially smooth segmentation.

Comparison of proposed method with state-of-the-art on simulated data*. Overlap metric between segmentation and ground truth plotted against image noise level. Proposed algorithm performs better at all noise levels. No drop off in performance at low noise levels. Also scales better at extreme noise levels due to the use of intensity information from neighboring pixels.

Experiments on MRI with intensity inhomogeneity (bias field). Bias field correction is necessary for successful tissue classification. The proposed algorithm is compatible with previous correction algorithms such as least-squares polynomial fitting to discrepancies between observed data and model predictions. The results with the correction are within 0.5% of the previous results on MRI with no bias field.

* BrainWeb MRI simulator: http://www.bic.mni.mcgill.ca/brainweb/

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