Anisotropic hidden Markov random field modeling for unsupervised MRI brain tissue segmentation and brain tumor detection

M. Wels[a], G. Staatz[b], A. Rossi[c], M. Huber[d], and J. Hornegger[a]

[a] *Institute of Pattern Recognition, University Erlangen-Nuremberg, Germany,*
[b] *Institute of Radiology, University Medical Center Erlangen, Germany,*
[c] *Department of Pediatric Neuroradiology, G. Gaslini Children's Research Hospital, Genoa, Italy,*
[d] *Siemens AG, CT SE SCR 2, Erlangen, Germany.*

Keywords: Brain tissue classification, Expectation-Maximization, MR imaging

1. Introduction

Our work addresses the problem of brain tissue classification within multi-spectral MR volume sequences. Current Expectation Maximization (EM) segmentation approaches using Hidden Markov Random Field (HMRF) modeling techniques suffer from over smoothing the final segmentation result. To overcome this problem, we propose two multi-spectral anisotropic HMRF models that extent an existing isotropic HMRF-EM segmentation framework. These models are capable to regularize the smoothing effect of the HMRF component on the final segmentation by local image characteristics allowing for coherent segmentation results on homogeneous tissue regions whilst edges between different tissue components are better preserved.

2. Methods

Anisotropy is incorporated into our unsupervised statistical segmentation framework by either considering image gradients or intensity distances within predefined voxel neighborhoods similar to anisotropic diffusion filtering. An initial segmentation of the brain soft tissue into different tissue classes is obtained by K-Means clustering and skull stripping on one of the 3D input sequences. Subsequently, the initial segmentation is refined using anisotropic versions of an HMRF-EM segmentation framework that operates on multi-spectral input data. Finally one of the detected compartments can be chosen semi-automatically by the operator for further processing. For evaluation purposes the performance of both the newly proposed anisotropic methods is compared to standard approaches on physiologic phantom MRI data as well as on pathologic clinical MRI data using the Dice metric and expert annotated ground-truth.

3. Results

Experiments show that both the anisotropic approaches perform better in classification of cerebral gray and white matter on multi-spectral simulated MRI data in terms of the Dice metric under typical MR imaging conditions. Segmentation results on clinical MR data show that the proposed methods are more sensitive to small structures within the images.

4. Conclusion

The two methods discussed in our contribution try to overcome the problem of over smoothing small anatomical structures in the context of HMRF-EM brain tissue segmentation by means of anisotropic HMRF models. Future work will involve further assessment and refinement of the proposed methods and investigation of more sophisticated approaches to incorporate anisotropy into HMRF modeling.