A Generative Probabilistic Model and Discriminative Extensions for Brain Lesion Segmentation - With Application to Tumor and Stroke

We introduce a generative probabilistic model for segmentation of brain lesions in multi-dimensional images that generalizes the EM segmenter, a common approach for modelling brain images using Gaussian mixtures and a probabilistic tissue atlas that employs expectation-maximization (EM), to estimate the label map for a new image. Our model augments the probabilistic atlas of the healthy tissues with a latent atlas of the lesion. We derive an estimation algorithm with closed-form EM update equations. The method extracts a latent atlas prior distribution and the lesion posterior distributions jointly from the image data. It delineates lesion areas individually in each channel, allowing for differences in lesion appearance across modalities, an important feature of many brain tumor imaging sequences. We also propose discriminative model extensions to map the output of the generative model to arbitrary labels with semantic and biological meaning, such as "tumor core" or "fluid-filled structure", but without a one-to-one correspondence to the hypo- or hyper-intense lesion areas identified by the generative model. We test the approach in two image sets: the publicly available BRATS set of glioma patient scans, and multimodal brain images of patients with acute and subacute ischemic stroke. We find the generative model that has been designed for tumor lesions to generalize well to stroke images, and the extended discriminative-discriminative model to be one of the top ranking methods in the BRATS evaluation.

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