Recent Advances in Medical Image Segmentation and Classification

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Abstract: The automatic detection, segmentation, and classification of brain tumors using multi-spectral MRI data is a highly researched area, gaining particular attention through the Brain Tumor Segmentation (BraTS) challenges held annually since 2012 in conjunction with MICCAI conferences. The research community has proposed up to a thousand different solutions, leveraging a wide range of artificial intelligence techniques—from classical machine learning methods to the evolution of convolutional neural networks and deep learning. The key distinction between these approaches lies in how features are handled: traditional methods rely on handcrafted features extracted for individual pixels and use classification to determine the corresponding tissue type for each, whereas deep learning approaches process entire slices or volumes, autonomously extracting the features required for decision making.

My team joined this research trend in 2015, which was the time when CNN-based solutions started to conquer the field by surpassing the methods that were built on classical classification techniques. Just like others, we also started with the well-established classical methodologies, and attempted to build an optimally working solution that can provide highly accurate segmentation while keeping the computational load at a low level. We proposed several ensemble learning based procedures, using classification methods like binary decision trees, random forest or XGBoost, and provided each with the necessary preprocessing and post-processing steps that enabled the optimized procedure to provide segmentation quality comparable to what CNN-based solutions can give. On the other hand, we developed U-net based solutions to improve the segmentation quality of brain tumors and its parts, and to distinguish normal brain tissue types from multi-spectral MRI records. Furthermore, CNN-based methods were developed to distinguish various tumor types like glioma, meningioma, and pituitary tumor.

This lecture aims to explore the common challenges and difficulties faced by automatic brain tumor segmentation methods, while comparing the requirements and capabilities of classical machine learning approaches with those of convolutional networks and deep learning solutions.

Keywords: brain tumor detection, brain tumor segmentation, brain tumor classification, magnetic resonance imaging, machine learning.