

Dual-echo Magnetic Resonance Image Segmentation Using Vector Decomposition and Probability Techniques

Yi-Hsuan Kao

Proton magnetic resonance (MR) imaging has become the primary imaging modality for evaluating normal brains, tumors, and other abnormalities such as multiple sclerosis, infarction, hemorrhage, etc., in the brain. Multiple slice, dual-echo, long-TR pulse sequences are used on over 90% of patients who have brain MR scans, because these sequences provide proton density-weighted and T2-weighted image pairs for many (20-50) slices in a reasonable scan time (5-7 min.). It is desirable to segment these dual-echo images to provide quantitative measurements of tissue volumes, geometry, and the locations of normal and abnormal tissues for diagnosis and treatment purposes.

Previous segmentation methods, such as vector decomposition methods and probability methods, do not simultaneously account for partial-volume mixing between tissues, random noise, and the appearance of multiple tissues in dual-echo MR images. The purpose of this thesis research was to provide a fractional volume calculation algorithm for segmenting dual-echo MR images in the presence of partial-volume mixing, random noise, and multiple tissues.

A general theory for calculating fractional volumes of q pure tissues from p images was developed and analyzed mathematically. Since dual-echo MR images are most commonly used in clinical MR scans, three- and two-tissue models, based on the general theory, were developed for segmenting dual-echo MR images. The three- and two-tissue models account for partial volume mixing among three and two tissues in dual-echo images, respectively. They are capable of segmenting more than one group of three or two tissues from a pair of dual-echo images by sequentially analyzing different groups of tissues. The statistical aspects of the two models were validated using phantom experiments. Clinical examples segmented using the two models showed promising results. Comparison with other segmentation methods and suggestions for future research are presented.