Asymmetric Spin Echo Acquisition Facilitates T2 window Based Brain Segmentation and Volume Measurement for Alzheimer’s Disease

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Synopsis:
A fast, accurate, unsupervised segmentation technique using a T2 window method has been developed for brain segmentation and volume measurement to track the rate of atrophy in Alzheimer’s disease. The technique is based on multi-spectrum analysis and hence susceptible to cluster overlapping, resulting in misclassifications that affect brain volume measurements. An asymmetric spin echo acquisition clusters tissues according to T2 and T2*. Brain tissue (gray and white matter) and facial tissue (fat and muscle) are better separated with the asymmetric echo acquisition than with the standard dual spin echo acquisition.

Introduction:
An unsupervised, fully automated brain segmentation and volume measurement technique, using multi-spectral analysis method to classify tissues based on T2 (1), has been developed for tracking the rate of atrophy in the Alzheimer’s disease. This technique originally used standard dual spin echo acquisition. Cluster overlapping between brain tissue (gray and white matter) and facial tissue (fat and muscle) caused some tissue misclassification, compromising the accuracy of brain volume measurements. Improvement in image acquisition is needed to separate these tissue clusters more effectively. An asymmetric spin echo acquisition serves this purpose. In this acquisition, the second readout window is delayed from its origin to introduce T2* contrast in the second spin echo.

Materials and Methods:
The asymmetric dual spin echo sequence is a modified version of standard flow-compensated dual spin echo sequence. The second echo is shifted, and the readout gradients are adjusted to maintain flow-compensation. The pulse sequence is illustrated in Fig. 1. This sequence is implemented on a GE SIGNA 1.5T scanner (Waukesha, WI). Standard spin echo and asymmetric spin echo images are compared on a probable Alzheimer’s disease patient with IRB approval. The imaging details are: Coronal acquisition, FOV 20cm x 20cm, Matrix 256 x 128, TE118ms, TR 8000ms, Slice thickness 2mm with no gaps. Flow compensation is applied in both readout and slice direction for both echoes. For the spin echo, TE2 is set to 80ms. For the asymmetric spin echo, TE2 is set to 65ms and the readout delay (amount of echo shift as indicated in Fig 1) is 15ms.

Results and Discussion:
Figure 2 compares the spin echo and the asymmetric spin echo acquisition. Figures 2b is the 2D scatter plot, where x-axis and y-axis represent the signal intensity of the first and second echo respectively. Fig 2a is the radial histogram plot of the scatter plot, and the x-axis represents the radial angle (1). The asymmetric dual spin echo acquisition (ADSE) results in 10 degrees separation between the brain tissue cluster (cluster B) and the facial tissue cluster (cluster A), whereas the separation of these two tissues in standard dual spin echo sequence (DSE) is only 5 degrees.

Conclusion:
The asymmetric spin echo classifies tissues based on both T2 and T2*; results in better tissue clustering; and therefore provides a means to improve the accuracy in volume measurement.

References:

Figure 1. Pulse diagram of the asymmetric spin echo sequence. Dash line represents the standard spin echo acquisition. The phase encoding and slice selective gradients are unchanged and are not shown in the figure.

Figure 2. Asymmetric dual spin echo (ADSE) results in better tissue clustering than the standard dual spin echo (DSE). (a). Radial histograms. (b). Scatter plots. A, B and C represents facial tissue (fat and muscle), brain tissue (gray and white matter) and CSF respectively.