Regional Distribution of Outliers Across a Population of Diffusion MRI in Human Brain

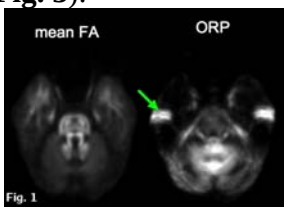
Lindsay Walker[1], Jinzhong Yang[2], Xiaoying Wu[2], Kristina Simonyan[3], Ragini Verma[2], Carlo Pierpaoli[1]

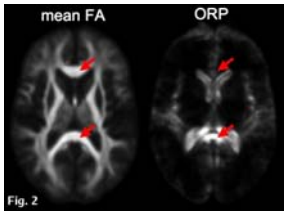
[1]NICHD, NIH, Bethesda, MD, United States/[2]Dept. of Radiology, University of Pennsylvania, Philadelphia, PA, United States/[3]NINDS, NIH, Bethesda, MD, United States

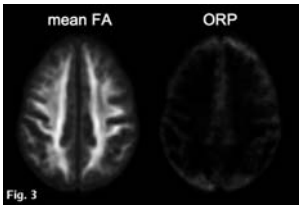
Introduction: Perturbation of the NMR signal by subject motion and pulsatile motion as a result of the cardiac cycle is known to affect diffusion tensor (DTI) derived quantities [1-3]. When cardiac gating has been neglected, robust tensor fitting can be used to account for outliers [4-5]. We present an analysis of outliers across a population of healthy volunteers using non-linear least squares and RESTORE [5] robust tensor fitting algorithms.

Methods: 20 subjects (52.7 ± 9.49 years, 8 male) were scanned on a 3.0T GE Excite scanner (GE Medical Systems). Whole-brain single-shot EPI DWI datasets were acquired with: TE/TR = 73.4/13000ms, 0.9375x0.9375mm^2 in-plane resolution, 54 slices, 2.4mm thick, b-value 1000s/mm^2, 33 non-collinear directions, 3 images at 0s/mm^2, two replicates, SENSE acceleration factor 2, with no cardiac gating. Images were corrected for motion, eddy current, and EPI distortions [6-7]. Tensor fitting was performed using both a non-linear least squares algorithm, and the RESTORE robust method to identify and reject outliers. We calculated an outlier rejection map from the RESTORE fitting, with brighter areas indicating a higher number of outliers rejected. For the population analysis, all subjects were spatially normalized to a single subject using a method that performs a fully deformable registration of the tensor datasets to the target dataset [8] including reorientation of the tensors post normalization. The deformation of each subject was applied to their FA and outlier maps. The mean, spatially normalized, outlier map was calculated from the 20 subjects to create an outlier rejection probability (ORP) map for the population.

Results: In the ORP map, white corresponds to a 15% rejection of data points as outliers. The ORP map shows a clear regional distribution of outliers in the population, with a higher percentage of outliers in the medial portions of the cerebellum, middle cerebellar peduncles, discrete regions in the temporal lobes (**Fig. 1**), ventricles, midline of the genu and splenium of the corpus callosum (**Fig. 2**), at air-tissue interfaces and csf-tissue interfaces (**Fig. 3**).







Conclusions: Outliers are caused by several factors including intravoxel distortion due to shear of tissue during cardiac pulsation, magnetic susceptibility artifacts, flow in the ventricles, poor SNR at air-tissue interfaces, and local fluctuations in signals due to time varying partial voluming in the csf-tissue interfaces. What is most striking is that the regions of high percentage outlier rejection are well defined on the ORP, indicating consistent areas affected by these distortions within the population. This consistency implies a regionally varying statistical power which should be considered when performing DTI analysis.

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Category: *Modeling and Analysis*
Sub-Category: *Exploratory methods, artifact removal*