SCANNER CALIBRATION FOR MULTISITE GEOMETRIC ACCURACY: HOW TO DO IT

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Introduction: For longitudinal MRI studies, particularly multisite trials, it is critical to maintain accurate and identical geometry specifications at each site and each measurement time point. The goal of this study was to use published ADNI (Alzheimer's Disease Neuroimaging Initiative) [1] methods for non-ADNI studies to calibrate more than one MRI system [2], and then verify that calibration for use in volumetric brain studies. We provide step-by-step details to allow other researchers to implement the same methodology for their needs, creating a calibration pipeline which uses software that can be freely downloaded.

Methods: For this study, published ADNI calibration methods and freely available correction and analysis software are used to geometrically calibrate the 3T MRI scanners at two different institutions in two different cities. Both institutions purchased the "ADNI phantom" from Phantom Labs [3]. Each site has a GE 3T long bore scanner with CRM gradients and 8-channel brain receive coils. Site A's 3T scanner is running GE software version 14.0M4, while Site B is using 12.0M4. Both sites used product T1w IR-FSPGR sequence tailored as closely as possible to the published ADNI protocol.

Sagittal 3D phantom series are obtained using the native scanner gradient configuration. The resulting DICOM images were transferred to freeware Linux database application (Conquest DICOM) [4]. Next, the data was processed with a Matlab-based gradient non-linearity distortion correction program [5, 6], which uses the scanner gradient harmonic coefficient file as input. Then, Non-parametric Non-uniform Normalization (N3) program [7, 8] was used to reduce the intensity non-uniformities caused by various effects like poor RF uniformity, eddy currents, etc. After these image corrections were performed, the Matlab-based phantom data analysis software Acceptance Qualification Tool (Aqual2) was used [9]. The output of the Aqual2 provides a snapshot of the gradient non-linearity, and scale factors to adjust the peak gradient values to provide a better first-order correction, thus improving linearity. Figure 1 depicts examples of Z-gradient linearity correction after applying scale factors to the processed data. Deviations are less than 1mm. Figure 2 shows the outputs of the different steps of the implemented pipeline. Figure 3 shows the merged datasets. The left portion of the image is from Site A and the right portion is from Site B. Left side of the image was made darker and smaller in order to make the point of merge more visible.
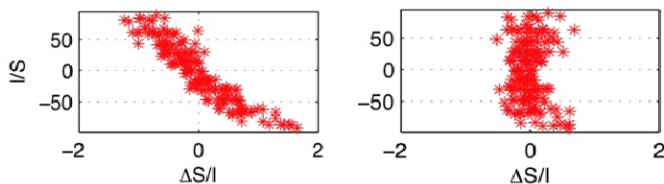

Figure 1: Site B Z-gradient linearity before and after.
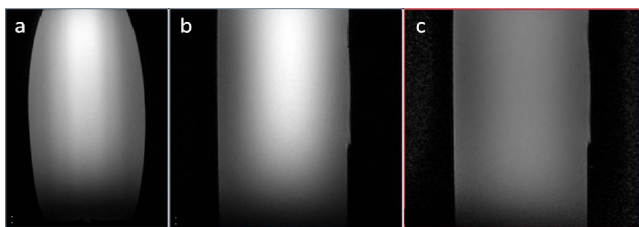

Figure 2: (a) Phantom image without any corrections, (b) after gradient nonlinearity correction, (c) after N3.
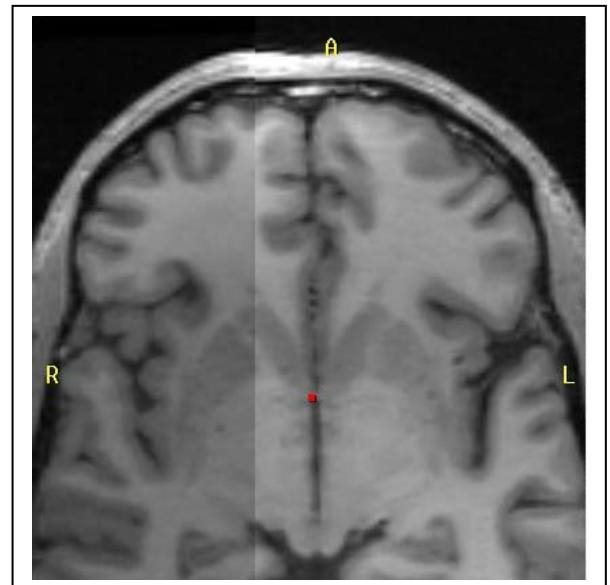

Figure 3: Sample axial slice from merged data.

Results and Discussion: Following scanner calibrations, we scanned two volunteers at both sites and compared each volunteer's image site pair using clinically available volumetric merging software (Medtronic, Inc). The software uses a semi-automated "point merge" to align (no scaling) the image volumes, and provides an estimate of the difference of the data sets at various fudicial points identified by the user. For both sets the global alignment was within 1mm or less than 0.5% over the FOV. With our small sample size, we have demonstrated that the published ADNI methods and freely available (downloadable) software tools are useful for geometrically calibrating different scanners for longitudinal studies.

References:
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