Non-uniformity normalization using 3D Canny edges and Legendre polynomial approximation of the bias field: validation on 7T T1W brain images

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MR signal intensity, especially at high field strength, is affected by inhomogeneity, or shading artefacts, manifested as a smooth spatially varying signal intensity distortions. Nonuniformity is attributed to inhomogeneous RF fields, inhomogeneous reception sensitivity and electromagnetic interaction with the object being scanned [1]. Correction of this effect is the key to successful implementation of all MR image analyses, including segmentation, registration and functional modeling of dynamic data. We have developed a new method BiCal (Bias Calculation) for non-uniformity correction that uses two very general assumptions: a) bias field is multiplicative (algorithm can be trivially modified for the additive field) - b) local signal intensity variation within a homogeneous tissue are caused by the bias field.

Methods
We begin by detecting 3D edge surfaces (3D Canny in this implementation). Voxels identified as edges and adjacent voxels are marked. Also marked are background (air) voxels which are identified by signal < 2 times the level of estimated overall image noise. Unmarked voxels constitute a single binary mask H that represents all the regions of homogeneous tissue. We next search for a slowly varying analytic scalar field L(x,y,z) = ln(Bias) represented as the linear combination of 3D Legendre polynomials up to degree N. The value of N is defined by the user and controls the maximal spatial frequency of the resulting field. Useful results were achieved for N in the range [3-20] for our 7T brain data. Next the logarithm volume P(x,y,z)=ln(SI)

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