Method for Bias Field Correction of Brain T1-Weighted Magnetic Resonance Images Minimizing Segmentation Error

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Abstract: This work presents a new algorithm (nonuniform intensity correction; NIC) for correction of intensity inhomogeneities in T1-weighted magnetic resonance (MR) images. The bias field and a bias-free image are obtained through an iterative process that uses brain tissue segmentation. The algorithm was validated by means of realistic phantom images and a set of 24 real images. The first evaluation phase was based on a public domain phantom dataset, used previously to assess bias field correction algorithms. NIC performed similar to previously described methods in removing the bias field from phantom images, without introduction of degradation in the absence of intensity inhomogeneity. The real image dataset was used to compare the performance of this new algorithm to that of other widely used methods (N3, SPM’99, and SPM2). This dataset included both low and high bias field images from two different MR scanners of low (0.5 T) and medium (1.5 T) static fields. Using standard quality criteria for determining the goodness of the different methods, NIC achieved the best results, correcting the images of the real MR dataset, enabling its systematic use in images from both low and medium static field MR scanners. A limitation of our method is that it might fail if the bias field is so high that the initial histogram does not show bimodal distribution for white and gray matter. Hum. Brain Mapp. 22:133–144, 2004.

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Key words: nonuniform intensity correction; NIC; magnetic resonance imaging; bias field; intensity inhomogeneities; segmentation algorithms

INTRODUCTION

Segmentation of magnetic resonance (MR) images is a fundamental procedure for the quantitative study of different brain pathologies such as multiple sclerosis [Miller et al., 2002], Alzheimer’s disease [Good et al., 2002], or schizophrenia [Lawrie and Abukmeil, 1998; Weinberger and McClure, 2002]. Automatic segmentation of MR scans is very useful for these applications, although it may be hindered by several acquisition-related artifacts.

One such artifact is the lack of homogeneity of the radiofrequency (RF) or $B_1$ field, also known as “illumination artifact” or “bias field,” which consists of a smooth multiplicative variation of intensity levels across the MR image. In a standard 1.5 T MR scanner, the magnitude of this intensity variation may even exceed 30% of the signal value [Guil-