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LETTER

Automated MR Segmentation Method Clarified

As pointed out by Harris et al (1), segmentation of gray matter and white matter on magnetic resonance imaging is problematic. These authors present a segmentation approach that purportedly "has the advantage over that of Lim and Pfefferbaum (1989) of avoiding ringing around both the ventricles and the outer brain edge" (p 226). This depiction of our work is unfortunately inaccurate (2). The purpose of this letter is simply to clarify our published method.

Our method for correcting the radio-frequency inhomogeneity artifact, the presence of which precludes tissue segmentation, is fully automated and involves four steps. First, we create a composite image derived by adding the early and late echo images; on the resulting image, the cerebrospinal fluid signal is isointense with tissue. Second, we remove the skull with an algorithm that identifies the edge of the internal table of the skull. Third, we remove the sharp brain-skull transition by filling the square image matrix with radial extensions of the most peripheral brain signal (a process called *feathering*). Fourth, we apply a two-dimensional, low-pass, convolution kernel (33-point) to the feathered image and then multiply the original image by the inverse of the low-pass version.

Thus, filtering of the feathered composite image serves to remove radio-frequency inhomogeneity without introducing ring artifact on brain edges, ventricles, or other cerebrospinal fluid–filled spaces. The entire procedure is automated, thereby eliminating the need for rater judgment in any step of the process.

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References

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2. Lim KO, Pfefferbaum A. Segmentation of MR brain images into cerebrospinal fluid spaces, white and gray matter. *J Comput Assist Tomogr* 1989;13:588–593

Reply

I have the utmost respect for Drs Lim and Pfefferbaum and for their work. They have contributed greatly to the field of neuroimaging in mental health research. After reading their letter to the editor, I reread their manuscript and found that their concerns were well founded. I did misinterpret their work in my recent *AJNR* article. Both their method and ours account for radio-frequency inhomogeneity correction edge effects at ventricular and skull boundaries.

I would also like to note that there have been several published articles describing advanced image-processing algorithms for automated segmentation that were not included in my literature review: for example, those published by the groups of Drs Worth and Kennedy (1) and Drs Jolesz and Kikinis (2) among others. These are interesting and promising techniques.

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References

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2. Cline HE, Lorensen WE, Kikinis R, Jolesz F. Three-dimensional segmentation of MR images of the head using probability and connectivity. *J Comput Assist Tomogr* 1990;14:1037–1045