Intensity Uniformity Correction by Removing Bias Field with Wavelet Smoothing

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Abstract

The purpose of this study was to improve intensity uniformity of MRI images by adapting a wavelet transform (Daubechies, D4) instead of Gaussian kernel for smoothing to find bias field when N3 method is being performed. Gaussian kernel smoothing was introduced because it helps to prevent the image from degraded boundary effects for some amount, but in this case the property of wavelet function that separates image’s high and low frequency components makes it possible to retain high frequency components of image without any changes. Higher uniformity and better SNR is observed when wavelet transform is performed.

Introduction

Hardware imperfectness in MRI, for example coil sensitivity or improperly added magnetic objects, causes various effects on image quality in MRI [1]. A bias field of image is one of the effects that should be removed by post image processing procedure to reproduce ideal uniform image. The N3 method, which calculates the bias field of image to be removed, was introduced by Sled in his paper for reproducing more uniform image [2]. During the procedure of calculating the bias field to be removed, Gaussian kernel smoothing was used and this smoothing for bias field has significant impact on the performance of whole procedure [2]. The method suggested in this study is using wavelet transform for smoothing and compared with Gaussian smoothing for how much improvement in uniformity can be achieved [3].

Materials and Methods

The homemade head coil for this study was designed to increase the effect of non-uniformity than commercially used coil. Error data between non-uniform image and ideally uniform image is acquired by N3 method and before it is defined as a bias field from the original image, it needs to be smoothed. For this smoothing, wavelet transform rearranges the coefficients of base functions and the resulting first half components of result contains high frequency component. Force those first half components to be 0 and leave rest half. Then the high frequency components of error data take no effect on inverse wavelet transform. The differences to be made in wavelet smoothing method are more iteration of smoothing process and proper scaling factor for resulting bias field intensity. This scaling factor takes a role to increase wavelet results up to the desired level. Even though more iteration is required, the required time for processing the task is shorter than Gaussian kernel smoothing since less computation is required. Following equations are applied to compare the uniformity and SNR of original, Gaussian, and wavelet images.

Results

As shown in Figure 1, each image profile of center indicates original image, Gaussian smoothing N3 method, and wavelet smoothing N3 method. Wavelet smoothing result is represented most uniform profile. Table 1 is the result of calculations for uniformity and SNR.. In table 1, uniformity percentage represents wavelet smoothing method built the most uniform image among three and SNR also rose a little while the noise standard deviation of background stayed same. Figure 2 is showing the process of improving uniformity of image. First non-uniform image is calculated to find error data and it is smoothed by wavelet transform to achieve final uniform image.

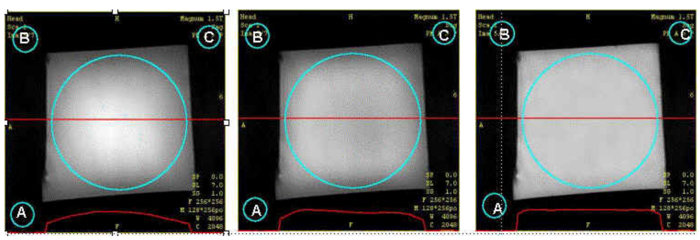

Figure 1. Comparison of Phantom images

	Non-uniformity (%)	Signal Mean	Noise Std. Dev.			SNR
			A	B	C	
Original	49.8	2692	7.41	8.08	7.96	344.9
Gaussian	40.5	2568	7.31	8.08	8.30	332.0
Wavelet	16.0	2950	7.96	7.85	7.80	367.1

Table 1 Uniformity and SNR of phantom images

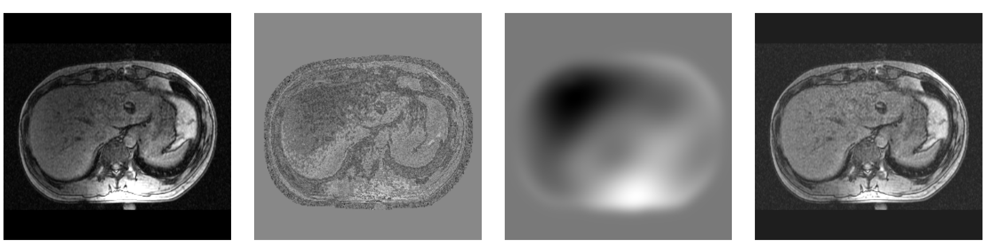

Figure 2 Original, Error, Bias field, and uniform data

Conclusions

The property of wavelet to divide image’s high frequency and low frequency components helps to remove bias field from image and to improve uniformity of image. We concluded this wavelet smoothing method needs to be tested for various clinical cases and RF coils.

References

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