# The Effect of Optimal Design of Low-pass Filter with Image Type in RF Field Inhomogeneity Correction using Homomorphic Filtering-based Method

I. Cho[1], I. Song[2], J. Oh[3], T. Kim[4], K. Chang[2], D. Jeong[1]

[1]Department of Electronic Engineering, College of Engineering, Inha University, Incheon, Korea, Republic of, [2]Department of Radiology, Seoul National University Hospital, Seoul, Korea, Republic of, [3]Interdisciplinary Program of Biomedical Engineering, Seoul National University, Seoul, Korea, Republic of, [4]Department of Diagnostic Radiology, Korea University College of Medicine, Seoul, Korea, Republic of

**Introduction**

RF field inhomogeneity is the variability of tissue intensity level with respect to image location or vascular structure. The intensity variability is the major deterrent of the performance decline of automatic segmentation methods based on image pixel absolute intensity. Homomorphic filtering-based correction is used as the most common method of several proposed ones because the homomorphic filtering-based correction is very simple and powerful. Homomorphic filtering consists of the procedure of dividing illumination and reflectance parts of image, and low-pass filtering. By designing a proper low-pass filter, RF field inhomogeneity may be accurately corrected. However applying the same low-pass filter with the same cut-off frequency to any images may induce wrong segmentation results. Therefore, we proposed low-pass filter with different cut-off frequency must be used with different type MR images.

**Material and Methods**

MR images were captured with a 1.5T MR unit using the quadrature head coil. Contiguous transverse dual T2 and PD-weighted images were obtained using the FSE sequence. We used a simple homomorphic filtering-based correction as following [3]:

$$I'(x,y) = \exp\left\{\ln\left(I(x,y)\right) - lpf\left[\ln\left(I(x,y)\right)\right]\right\}$$

where $I(x,y)$ is the deskulled image and $'lpf'$ denotes a low-pass filter operation.

Low-pass filter used in homomorphic filter is implemented with finite impulse response (FIR) filter and the FIR filter has three parameters of cut-off frequency, filter size and filter power. In our simulation, filter power was fixed. After removing skulls using multi-seed points region-growing method, homomorphic filtering-based correction is applied by changing cut-off frequency and filter size of the low-pass filter. Corrected T2 and PD–weighted images were segmented to cerebrospinal fluid (CSF), gray matter (GM) and white matter (WM) using k-means clustering method. Based on segmentation results, we obtained two parameters of low-pass filter that showed the best result.

**Results**

Our simulation used T2 and PD -weighted images with RF field inhomogeneity in two normal patients. Original images (Fig. 1) with RF inhomogeneity were corrected using homomorphic filtering-based method and segmented using k-means clustering-based method. In applying the same low-pass filter to both images, through segmentation results we could know that whereas T2 was accurately corrected but PD was not in Fig 2, in Fig. 3 to the contrary. By using each different low-pass filter parameters proper for each image, however, best segmentation results could be obtained (Fig. 4). Each patient may be also corrected with different low-pass filter. Fig. 4 and Fig. 5 show that different low-pass filter should be used in different subjects to obtain best segmentation results.

**Discussion and Conclusions**

Our segmentation simulation results showed that optimal low-pass filter for homomorphic filtering-based correction must be designed according to image types and subjects. And automatic determination algorithm of optimal low-pass filter parameters for homomorphic filtering-based correction need further study.

**References**

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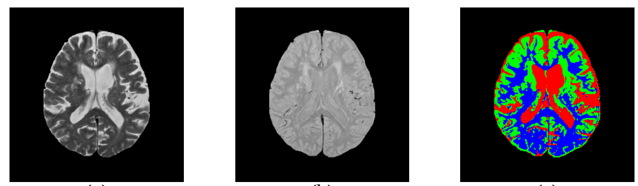
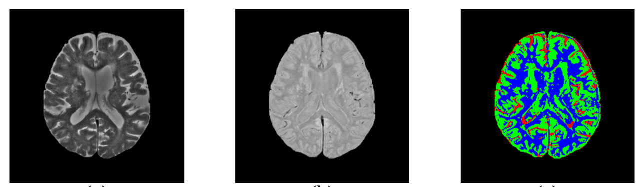
(a) (b)

Fig.1. (a) T2 and (b) PD –weighted images with RF field inhomogeneity.



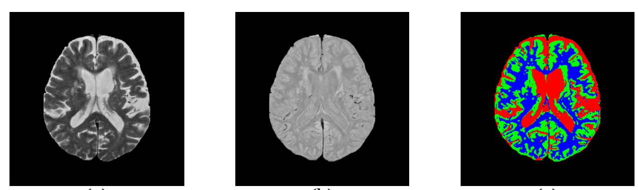
(a) (b) (c)

Fig. 2. Corrected (a) T2 and (b) PD –weighted images using the same low-pass filter parameters (cut-off frequency: 0.03, filter size: 15) and (c) segmentation results (red: CSF, green: GM, blue: WM).



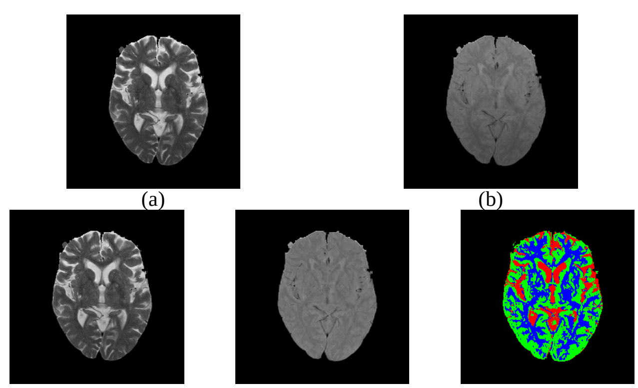
(a) (b) (c)

Fig. 3. Corrected (a) T2 and (b) PD –weighted images using the same low-pass filter parameters (cut-off frequency: 0.05, filter size: 27) and (c) segmentation results (red: CSF, green: GM, blue: WM).



(a) (b) (c)

Fig. 4. Corrected (a) T2 and (b) PD images using different low-pass filter parameters and (c) segmentation results (red: CSF, green: GM, blue: WM).



(a) (b) (c) (d) (e)

Fig. 5. Original (a) T2 and (b) PD –weighted images were corrected using homomorphic filtering-based method with different low-pass filter parameters to obtain (e) best segmentation results (red: CSF, green: GM, blue: WM). In T2, cut-off frequency is 0.03 and filter size is 15. In PD, cut-off frequency is 0.068 and filter size is 29.