# Brain tissue segmentation on the 3D MDEFT image obtained at 4.7T

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## Introduction

High signal to noise ratio at high field is beneficial to classify the tissue type in the brain image. We demonstrated that MDEFT method gave high tissue contrast between grey matter (GM) and white matter (WM) in the human brain at 4.7T by optimizing the measurement [1]. However, non-uniform image intensity at high field due to increased $B_1$ inhomogeniety causes a great difficulty in the automated tissue segmentation. Therefore, the correcting process of the inhomogeneous signal intensity in the image comes to be essential at high field [2]. In the present work we compared two kinds of intensity correction techniques which are commercially available on the 3D MDEFT image obtained at 4.7T. The results were evaluated on the segmented images by SPM99. We also optimized the procedure to remove non-brain tissue to achieve more accurate tissue segmentation.

## Methods

3D MDEFT images of the brain were obtained on a 4.7T/92.5cm system (Varian, PaloAlto) with TR/TE of 10/3.7ms, FOV of 25.6x25.6x19.2cm, matrix size of 256x256x192 using a TEM coil (30cm in diameter). Obtained data matrix was zero-filled to 256x256x256 before Fourier transformation. The image data were transferred to a UNIX workstation or a Windows computer for further processing. Prior to the segmentation procedure, inhomogeneity in the signal intensity was corrected by two methods. One is based on an algorithm using Bayesian framework provided in SPM99 software [3], and the other is an algorithm using 1st to 6th order Legendre polynomials in Brain Voyager (Rainer Goebel, Brain Innovation B.V.). Tissue segmentation was performed in the standard SPM99 software, which gave three probability images (GM, WM, and CSF). Then, we removed non-brain tissue on the sum of probability images of GM, WM, and CSF using the Brain Extraction Tool (BET) in FSL software [4]. Fractional intensity threshold for the BET process was optimized at 0.15 by viewing the surface rendered image. Segmented probability images (GM, WM and CSF) were evaluated by visual inspection.

## Results and Discussion

Figure 1 shows the original and intensity corrected images of the human brain by Bayesian framework or by 6th order polynomial. Intensity profiles in Fig. 2 exhibit that either correction method gives much more uniform image compared with the original one. Figure 3 compares the tissue segmentation performed on the images corrected by Bayesian framework (upper column) or by 6th order polynomial (lower column). Basal ganglia and neighboring WM are better represented in the lower column. Boundary of cortex and subcortical WM are more clearly distinguished in the polynomial correction again. The polynomial correction also gave better representation of GM in hippocampus in other slices (not shown). From the comparison in various positions in several images we concluded that the intensity correction using 6th order polynomial is best suited to the segmentation of MDEFT images obtained at 4.7T. Since the intensity correction by 6th order polynomial enhanced the peripheral area, it tended to cause erroneous classification of non-brain tissue to CSF or GM. Thus, we tried to remove residual non-brain tissue by BET processing in FSL. Effect of BET process was almost negligible on the WM and GM segments, but CSF segment was approximately 10 to 20% reduced. We applied either intensity correction method on brain images from several subjects before the segmentation procedure. It was found that the intracranial volume, i.e. the sum of GM, WM, and CSF, obtained in the corrected images by 6th order polynomial was similar to the volume reported previously [5], while that in the correction by Bayesian framework was ~10% smaller.

## Conclusions

Intensity correction method using 6th order polynomial is suitable for obtaining uniform images from the severely inhomogeneous 3D MDEFT images of the brain obtained at 4.7T, and the standard automated segmentation software works on the corrected images.

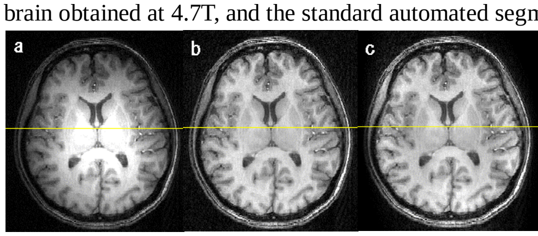


Fig.1. Original uncorrected image obtained by 3D MDEFT at 4.7T (a), and intensity corrected images by Bayesian framework (b), and by 6th order polynomial (c).

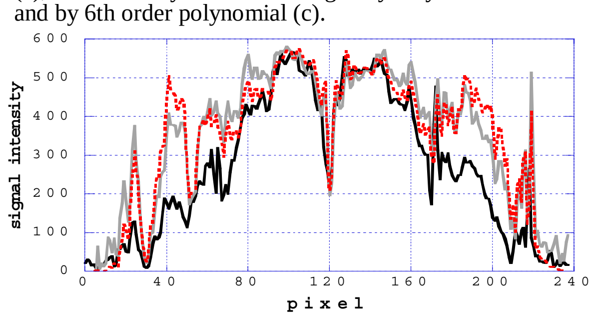


Fig.2. Intensity profiles along the line in the axial images shown in Fig.1.Black solid, red broken, and grey solid lines correspond to Fig.1(a), (b), and (c), respectively.

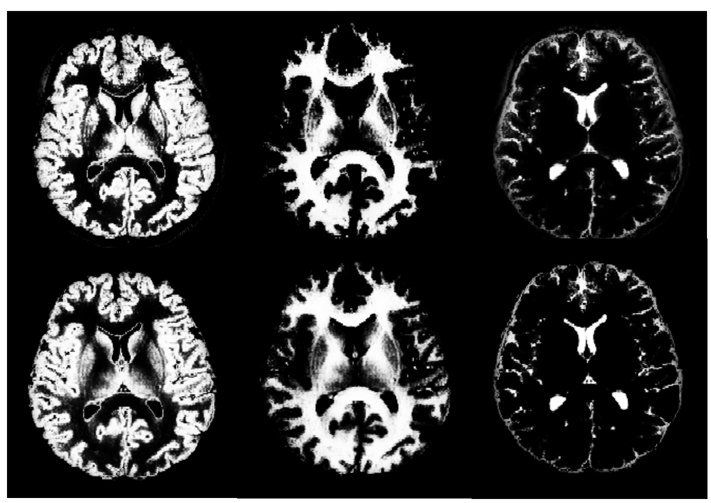

Fig.3. Probability images of GM, WM, and CSF (left to right) segmented by SPM99. Segmentation was performed on the intensity corrected image by Bayesian framework (upper column), and by 6th order polynomial (lower column).

## References

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