

The Optimised Projection Image method for targeted tissue contrast enhancement.

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INTRODUCTION In recent years there has been an increased interest in combining phase and magnitude MRI data. Susceptibility-Weighted Imaging (SWI) identifies the relative phase (negative or positive) of a target tissue and attenuates pixels based on the phase value [1]. The method of Abduljalil et al involves direct multiplication of the phase and magnitude images [2]. We propose an Optimised Projection Image (OPI) technique which removes heuristics involved in combining phase and magnitude data to enhance contrast in MRI for a target tissue class. The OPI method fits a mixture model to the magnitude and phase data of bivariate Gaussian distributions for each tissue class, and projects the data onto an optimal image intensity axis. The Optimised Projection Image is shown to combine without loss the structure found in both the magnitude and phase images, with image intensities scaled according to tissue class posterior probabilities.

METHODS Phase and magnitude images were acquired using a Siemens TIM Trio 3T system with a Siemens 12 channel Head Matrix Coil using the following imaging parameters: axial 2D Gradient Recall Echo, T_2^* weighted imaging with TE = 45 ms, TR = 1000 ms, FA = 45°, slice thickness = 2.5mm, FOV = 240mm x 180mm, image matrix size = 384 x 448. The magnitude image was reconstructed using SENSE. The phase image was reconstructed using an in-house phase optimised SENSE method and unwrapped using the method of Haacke et al [1].

The OPI method masks out the background pixels and rescales the magnitude and phase values to between 0 and 1. Foreground pixels are plotted magnitude versus phase and a mixture model of three bivariate Gaussian distributions is fitted (Fig. 1A), representing the tissue classes: grey matter (GM), white matter (WM) and cerebro-spinal fluid (CSF). The mean of the three major axes of each class is defined as the new intensity axis (Fig A, B). The projection of the standard deviation ellipse of each class onto the intensity axis is calculated. A shift is defined for the WM and CSF classes such that the minimum intensity value of their projections align with the maximum intensity of the GM projection (Fig. 1B). Given that pixels in GM near the GM/WM border have low intensity, relocation of the WM cluster to the positive side of the GM is chosen to enhance the edge definition. The shift for the GM class is defined as zero. The intensity of each pixel is determined by calculating its projection onto the intensity axis, then shifting it by the sum of the shifts of each class weighted by the Gaussian mixture model posterior probability of the pixel belonging to that class.

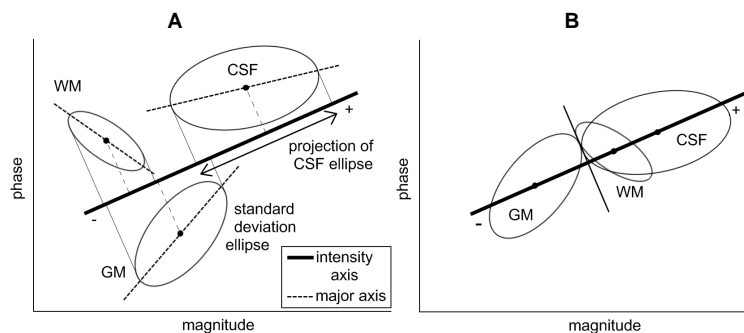


Figure 1. Optimised Projection Image (OPI) method. A schematic showing a bivariate Gaussian distribution projected onto the intensity axis (A) before and (B) after the OPI method is applied.

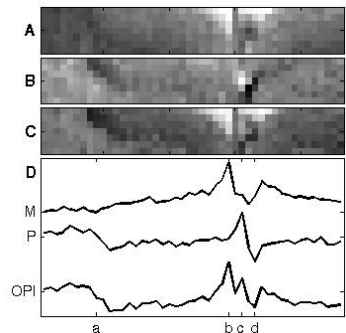


Figure 2. The (A) magnitude, (B) phase image and (C) OPI for the ROI in Figure 3. (D) Line profiles.

RESULTS The OPI optimally combines edge information from both magnitude and phase images (Fig. 3). The line profiles in Figure 2 demonstrate the combination of detail from both the phase and magnitude images that appear in the OPI. At (a), the structural detail in the phase is maintained in the OPI. At (b), (c) and (d), the OPI successfully combines the information from both magnitude and phase without loss of detail from either.

CONCLUSION The Optimised Projection Image method is a post-processing algorithm that combines both the magnitude and phase information in MRI data into a single image. We have shown that this method maintains the detail in the magnitude and phase images to create an image with enhanced edge definition and structural detail in comparison to the original magnitude and phase images.

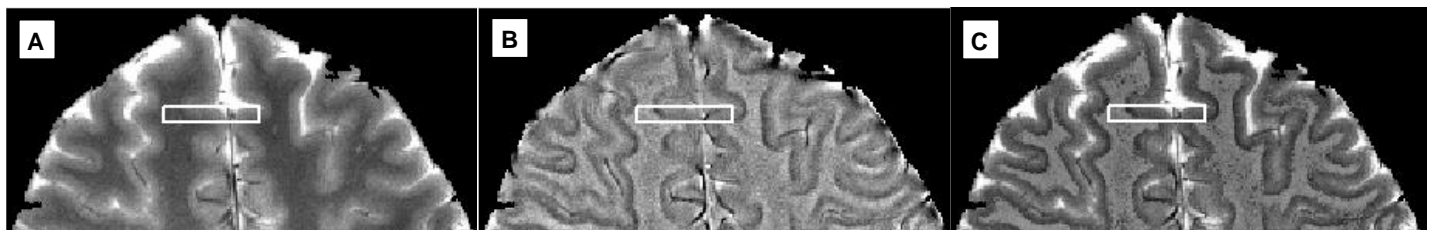


Figure 3. The (A) magnitude, (B) phase and (C) Optimised Projection Image for a frontal brain region (white boxes indicate the zoomed area in Figure 2).

References [1] E.M. Haacke et al, Magn. Res. Med. 2004, 52:612-618. [2] A.M. Abduljalil et al, J. Mag. Res. Imag. 2003, 18:284-290.