# Quantitative comparison of the informational content of $T_2^*$-weighted magnitude, phase and SWI 7T MR data by means of texture analysis of the cortical ribbon in elderly subjects

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## INTRODUCTION

Susceptibility weighted imaging (SWI), a combination of $T_2^*$-weighted magnitude and phase imaging, has garnered much interest due to its contrast-enhancing properties with respect to iron levels [1]. Additionally, $T_2^*$-weighted phase images at ultra-high field strength appear to be promising to study the cortical changes based on iron deposition in neurodegenerative diseases [2],[3]. It is, however, not clear whether SWI provides additional information compared to separate $T_2^*$-weighted magnitude and especially phase imaging. Texture analysis, which captures image-based patterns that can be imperceptible to the human eye [4], could potentially be applied to study disease-specific iron patterns. It also provides a means to objectively measure and compare the information content of image data. The aim of this work is to investigate and compare the information content of magnitude, phase and SWI data by means of classification based on textural features of the cerebral cortex.

## MATERIALS AND METHODS

*Data:* The dataset included 18 elderly subjects. These subjects were categorized into two groups based on their Mini–Mental State Examination (MMSE) scores: low-MMSE group (7 subjects with MMSE scores between 19 and 24, mean age=78.7±3.6 yrs) and high-MMSE group (11 subjects with MMSE scores between 25 and 30, mean age=61.7±8.5 yrs). Subjects with MMSE scores ≥ 25 are considered cognitively normal.

*MR imaging:* All subjects were scanned using a flow-compensated transverse 2D $T_2^*$-weighted gradient-echo scan including the frontal and parietal regions with a scan duration of 10 minutes (TR/TE/flip angle=794/25ms/45°, voxel size=0.24x0.24x1mm$^3$, FOV=240x180mm$^2$), acquiring 20 slices. A navigator echo correction technique (TE=9.5ms) was used to correct for resonance frequency fluctuations.

*Data analysis:* The cerebral cortex was automatically segmented using a combination of both $T_2^*$-weighted magnitude and phase images [5]. SWI images were constructed by multiplying magnitude images by phase masks with a multiplication factor of 4 [1].

Textural features were extracted from magnitude, phase and SWI images based on Gray Level Co-occurrence Matrix (GLCM). The intensity of all images was scaled using a quantization level of 64. Two-dimensional GLCM was computed for each slice in the axial plane. The computed GLCMs were then summed up over all slices to obtain a single matrix for the 3D volume. GLCMs were computed considering 4 offset angles ($\theta$=0$^0$, 45$^0$, 90$^0$, 135$^0$) and 14 distances ($d$=1, 2,…, 14). Thirteen Haralick features were derived from each GLCM [6]. For each distance, the mean and range over the four offset angles were computed. All computed values together formed a set of 364 features.

Principal Component Analysis (PCA) was applied for the reduction of feature dimension. Classification with Fisher linear discriminant classifier [7] was carried out using magnitude-based, phase-based and SWI-based features respectively. A leave-one-out cross-validation approach was applied to assess the classification performance.

## RESULTS

Figure 1 shows examples of $T_2^*$-weighted magnitude, phase and SWI images. Figure 2 presents the classification accuracy with respect to the number of features retained after PCA for the three different approaches.

Classification using phase-based features resulted in the best overall accuracy compared to using magnitude-based or SWI-based features (average = 74.7±10.9% *vs.* 53.1±6.4% *vs.* 65.1±13%). The highest classification accuracy is 89%, 83% and 67% for the phase-based, SWI-based and magnitude-based approaches, respectively. Maximum classification accuracy for phase data was obtained with fewer features than for magnitude and SWI data. It can also be noted that classification based on magnitude data performs poorly, which may account for the decreased accuracy of classification based on SWI data compared to the phase-based approach.

The results suggest that, from a texture information perspective, phase images have higher information content than either magnitude or SWI images.

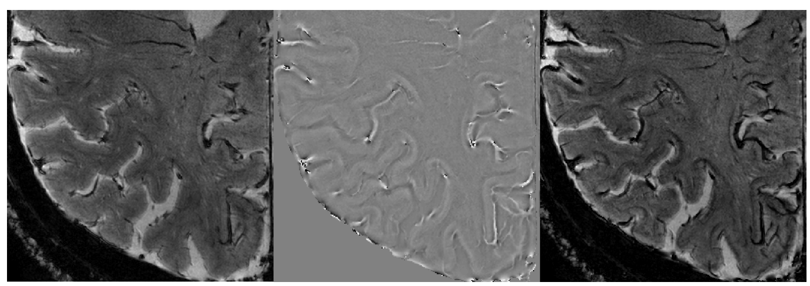

Figure 1: Example of $T_2^*$-weighted magnitude (left), phase (middle), and SWI images (right) of a male elderly subject (74 years).

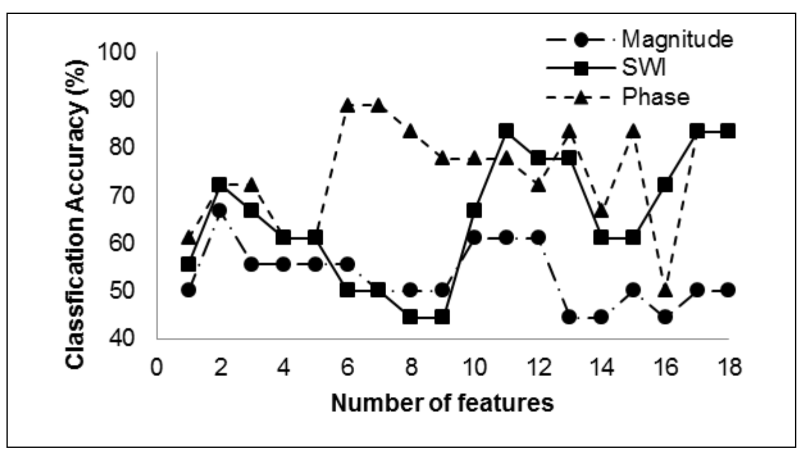


Figure 2: Accuracy of classification using features derived from magnitude, phase or SWI images.

## REFERENCES

[1] Haacke et al, Am J Neuroradiol 30:19-30 (2009)
[2] Duyn et al, Proc Natl Acad Sci 104,11796 -11801 (2007)
[3] Yao et al, NeuroImage 44:1259-1266 (2009)
[4] Kassner et al, Am J Neuroradiol 31:809-816 (2010)
[5] Doan et al, Proc ISMRM 5111 (2010)
[6] Haralick et al, IEEE Trans Syst Man Cybern 3:610-621 (1973)
[7] Duda et al, Wiley New York (2001)

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