

# VOLUMETRIC MEASUREMENT OF MULTISPECTRAL BRAIN MRI : BASED ON INDEPENDENT COMPONENT ANALYSIS AND SUPPORT VECTOR MACHINE

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## ABSTRACT

Independent component analysis (ICA) implemented with support vector machine (SVM) has the advantages of using an unsupervised technique to separate the distinct objects and then followed by a supervised classification technique to perform target substance discrimination. The method could potentially be effective in image analysis of the major components of normal and diseased brain in multispectral MRI. However, there was a lack of comprehensive assessment of the proposed method for brain segmentation in the clinical applications. In this study, we tried to carry out an experiment to test the accuracy and reproducibility of the proposed method in assessing the brain volume quantification of the synthetic and clinical MRI data.

## INTRODUCTION

Recently, a new application of independent component analysis (ICA) has been investigated to perform in multispectral MR image analysis for separating tissues with different relaxation characteristics without a priori knowledge about the images [1-2]. ICA has the advantages of enhancing the image contrast of gray matter (GM) white matter (WM) and Cerebrospinal fluid (CSF), as a preprocessing method to classify and segment the brain structure, and also potentially giving additional information of other tissues in the brain for pathological analysis [1]. However, due to the nature of the ICA, only a limited number of independent components (ICs) are available to be used for signal source separation. When the number of signal sources is greater than the number of ICs, some of ICs are forced to accommodate more than one signal source in which case there is no way to use a particular IC to characterize signal sources. ICA implemented with support vector machine (SVM) has the advantages of using an unsupervised technique to separate the distinct objects into ICs in the sense of statistical independency, and then followed by a supervised classification technique in the second stage to perform target substance discrimination [2]. The method might be effective in image analysis of the major components of brain MRI, and could mitigate the limitation of more than one signal source accommodated in a single IC. However, there was a lack of comprehensive assessment of the proposed method in the clinical applications.

In this study, we tried to use a supervised segmentation method by coupling ICA with SVM for quantitative volumetric analysis of multispectral human brain MRI. The accuracy and reproducibility of the proposed method were carried out in this study by assessing the brain volume quantification of the synthetic and clinical MRI data.

## MATERIALS AND METHODS

Multispectral synthetic and clinical data of axial T1WI, T2WI and PDI were analyzed slice-by-slice with ICA to generate three new sets of IC images. For the synthetic data and clinical brain data of normal volunteers, SVM with active learning from four small sets of GM, WM, CSF and background (BG) training data selected manually was used for classification of GM, WM and CSF from three IC images. For the synthetic multiple sclerosis (MS) data and clinical brain data of patients with white matter hyperintensities, SVM with active learning from five small sets of GM, WM, CSF, BG and lesion training data selected manually was used for classification of GM, WM, CSF and lesion from three IC images. Subsequently, GM, WM and lesion volumes of cerebrum were measured after removal of the extrameningeal structures in the classified images manually. Another clinical data set of high spatial-resolution brain images was acquired with a 3-dimensional magnetization preparation rapid acquisition gradient-echo sequence (3D-MP-RAGE) and processed by the segmentation algorithms of statistical parametric mapping (SPM5) software [3] to quantify GM and WM volume of cerebrum.

### Performance Evaluation

The Tanimoto index was measured to statistically evaluate the results of the GM, WM and lesion volumes with the ground truth data of the synthetic brain images. To test intraoperator variability, four small sets training data were selected manually ten times by an experienced radiologist to segment brain components from the synthetic data. The results of GM and WM volume quantification in healthy volunteers measured by ICA with SVM were tested by comparing with those from high-spatial resolution images acquired with 3D-MP-RAGE sequence and analyzed with SPM 5. Linear correlation was used to test the measurements between two methods. To test interoperator variability, four small sets training data were selected manually by three experienced radiologists to segment GM, WM and CSF from clinical brain data of normal volunteers.

## RESULTS

The averaged *Tanimoto* index of GM and WM segmentation of synthetic normal data with 3% noise level was 0.79 by using the ICA with SVM method, which was higher than those of other reported in the literatures. The results also revealed very low intra-operator variability of ten measurements, coefficient of variation 2.1%. In the clinical normal data experiment, the results showed no significantly statistical difference of the mean GM and WM volume measurements of cerebrum between the ICA with SVM method and the SPM5 algorithm, as well as low interoperator variability. Linear correlations of GM and WM volume measurements between two methods were 0.9196 and 0.9287.

For synthetic MS data set, the accuracy of MS lesion measurements were 0.9937 in the images with 0% of noise level and intensity non-uniformity and coefficient of variation was 3.5% in ten measurements. In the clinical diseased data experiment, no lesion was classified by the SPM5 algorithm. The ICA with SVM method could clearly extract the MS lesions from the synthetic images as shown in Figure 1 and 2.

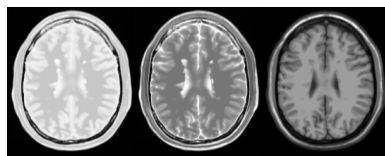


Figure 1 Three MR synthetic images with MS lesions.



Figure 2 SVM-classified ICs. Left to right are WM, GM, CSF, and MS lesions respectively.

## CONCLUSION

Our experimental results revealed significantly high accuracy and reproducibility of the ICA with SVA method in segmentation of synthetic and clinical brain data. The proposed method could effectively classify three major brain components, as well as enhance the detection and segmentation of brain lesions.

## REFERENCES

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