

# Estimation of coil sensitivity map and correction of surface coil magnetic resonance images using wavelet decomposition

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## Introduction

Despite the signal-to-noise advantage offered by arrays of local coils, surface coils are not regularly used for brain imaging due to image brightness variations resulting from their intrinsically inhomogeneous reception profile. This problem can be addressed in post-processing if the image reception profile of the surface coil array is known. Various approaches using theoretical modeling or estimations based on a spatially smoothed version of the original image have been proposed.(1-5) Here we propose a method for estimating the coil sensitivity profile using post-hoc processing of the anatomical surface coil image using a filter bank decomposition. In this method, the high contrast edges in the images are identified and their adverse effects on the estimation of the coil map are reduced. The method is demonstrated in phased array imaging of the brain and was found to provide a robust estimation of the coil map with minimal contamination from anatomical features in the original image.

## Methods

The surface coil images can be viewed as the product of the true anatomical image  $C(n)$  and a function representing the spatial modulation imposed by the surface coil reception profile  $S(n)$  producing the observed inhomogeneous image,  $Y(n)$ . Here  $n$  is the position vector in 3D space. Our goal is to get an estimate,  $S'(n)$ , of the coil sensitivity profile. The corrected image,  $C'(n)$ , is then expressed in terms of the ratio  $Y(n) / S'(n)$ . In methods that use the image information itself to infer the coil map, the high contrast anatomical features in the original image cause the principle source of artifact in the estimated coil sensitivity map. We minimize this effect by identifying the high contrast, high spatial frequency features in the image and prepare an intermediate "reduced local contrast" image designed to reduce the effect of anatomical contrast on the coil sensitivity map. Multi-Resolution Analysis (6,7) of the reduced local contrast image decomposes the image into high spatial frequency details and low spatial frequency approximations. We use maximally flat (Daubechies) filters (6,7) with order of 1 to 3 to implement the filter bank for multiple levels of coil sensitivity map estimation. The whole process is shown in fig. 1. We also utilize an index of the final image homogeneity to quantify the quality of correction and determine which level of the filter bank structure best approximates an initial guess of the coil map based on a priori knowledge of the coil scale. Images were acquired from a GE Signa 1.5 T using a 4 coil phased array comprised of 8cm dia. coils, placed bilaterally on the head. The imaging pulse sequence was a 3D spoiled gradient echo (TR/TE = 30ms/ 6ms, slice partition thickness =1.5 mm, image size 224\*256 pixels over a 190mm FOV).

## Results

The Daubechies maximally flat filter bank was found to be computationally efficient and provide a good approximation of the coil sensitivity map. The reconstructed images provide greatly improved visualization of the anatomy due to the compression of the dynamic range in the image which originated from the spatial variations reception efficiency of the surface coil array. Figure 2 shows raw image, coil sensitivity profile and corrected image obtained using a 8 level reconstruction by wavelet transform. No additional information regarding the position of the coil and anatomical information about the brain is needed for a homogenous reconstruction to reveal both superficial and deep brain structures, including temporal lobe, frontal lobe, ventricles and basal ganglia.

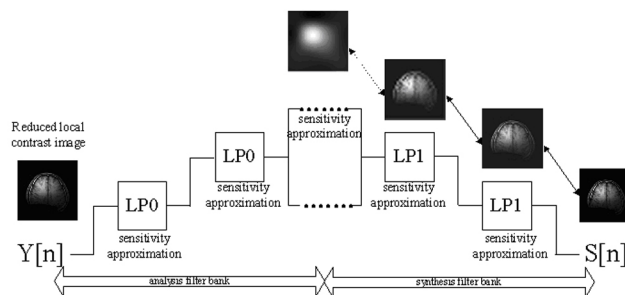


Fig. 1. The reduced local contrast image is fed into the filter bank for multiple levels of sensitivity profile estimation. LP0, LP1, HP0 and HP1 are low-pass and high pass filters in analysis and synthesis bank, including the respective up and down sample

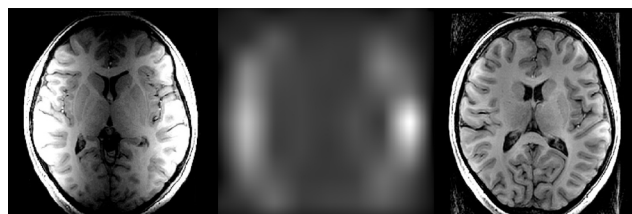


Fig. 2. The raw data, the estimated coil sensitivity map and reconstruction from Daubechies 97 filter bank.

## Discussions and Conclusions

In this paper, we propose a scheme to correct the inhomogeneity of MRI images from surface coil using wavelet transform. Daubechies maximally flat filter bank has benefits in terms of computational efficiency, and good approximation of coil sensitivity map. Reconstructed sample image shows deep structures that cannot be seen from the raw image.

## References

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