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Estimation of R_2* using extended rosette acquisition

Sangwoo Lee*§, Scott Peltier†§, Jeffrey Fessler*, Douglas Noll‡§

**Electrical Engineering and Computer Science*
†Applied Physics
‡Biomedical Engineering
§FMRI Lab, University of Michigan

Subject: Imaging Techniques

Abstract

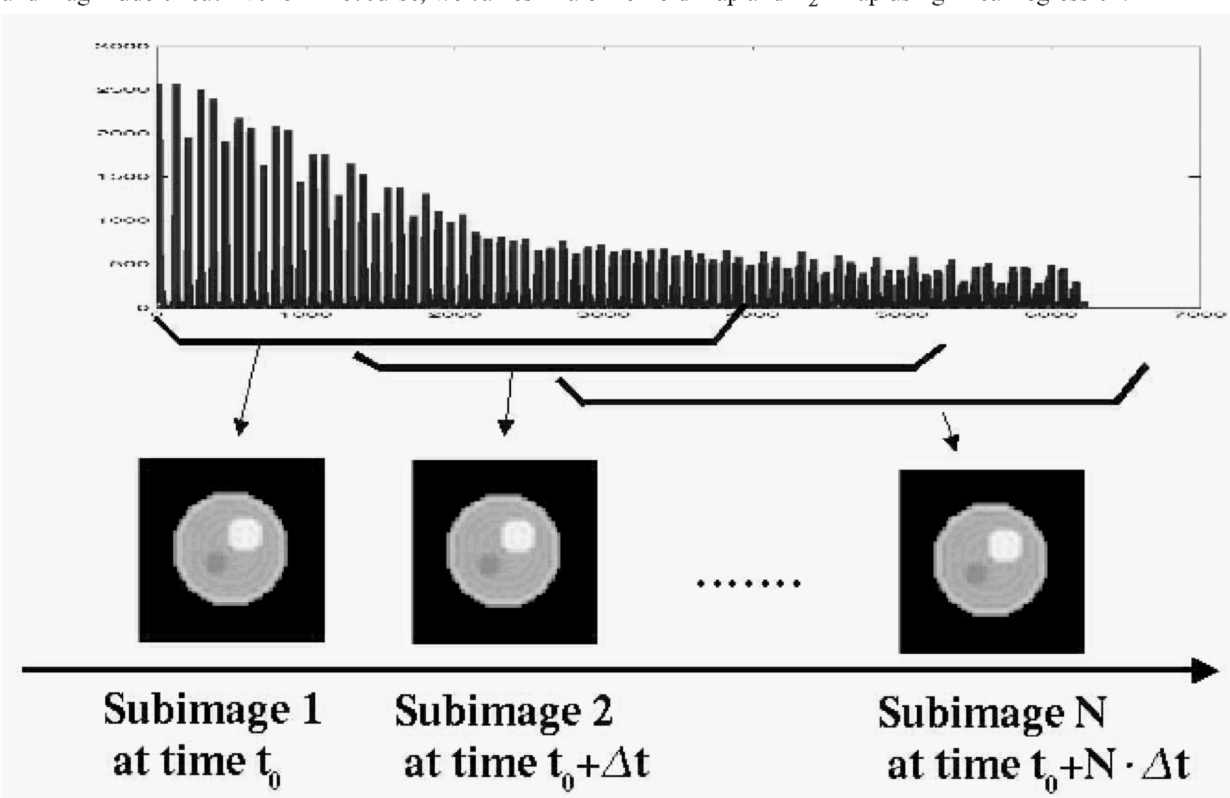
Introduction

In BOLD studies, the R_2* map, (or T2* map) is used to quantitate physiological changes in brain, or to optimize functional contrast [1]. Also R2* fMRI may be more robust to head movement and other sources of artifact. Several studies used multi-echo imaging method to estimate time series of R_2* map [2-3]. However, the multi-echo method requires extra echos (5~12), demanding significant amount of scan time.

In this work, we suggest a novel way to simultaneously estimate field map and R_2* map using an extended rosette acquisition with less scan time to increase the time resolution of R_2* map. A simulation study was done to compare the accuracy of the method, and results from a functional study are shown.

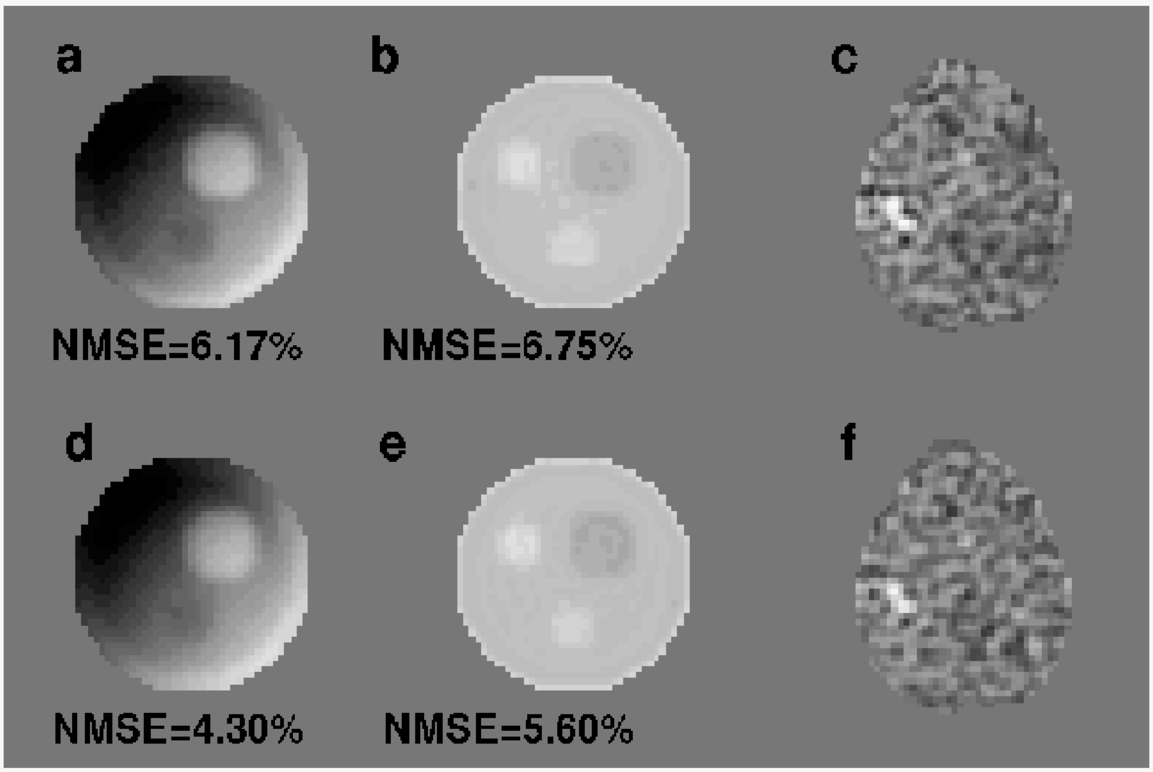
Methods

The rosette trajectory has an oscillatory behavior, therefore it is easy to extend the acquisition time to revisit the earlier k-space locations. With an extended rosette acquisition, we can form a set of images at different TE's by sliding the location of the data window (Figure 1). Although each sub-image shares certain amount of data with its neighbors, they represent the object at a certain TE uniquely. From the phase and magnitude of each voxel timecourse, we can estimate the field map and R_2* map using linear regression.



However, the data redundancy in sub-images results in noisy field map estimates. To reduce this error, an iterative method was used as follows: the current estimate of the field map was used to correct susceptibility artifact for each sub-image, then the remaining field map component is estimated from the corrected sub-images. The current estimate of field map was updated by adding it to the previous estimate. After several iterations, we estimate the R2* map from the log of the field map-corrected sub-images. Two pairs of non-overlapping sub-images were chosen, and R_2* maps were calculated from each pair, then averaged.

A simulation study was conducted on a synthesized object (64x64) with a reference field map (min:-14Hz, max:9.94Hz) and a reference R_2* map (min:20 s^{-1}, max:29.8 s^{-1}). The sub-images were reconstructed using quadratic penalized least square method [3]. A functional study was conducted using a 3.0T GE Signa-LX scanner. The rosette trajectory had the following parameters: w1=1024.6Hz, w2=204.9Hz, max slew=167.47mT/m/ms, max gradient=1.89G/cm, FOV=20cm, resolution=5mm with two interleaves. Scan parameters were: TE=6.0 ms, TR=1000 ms, total data acquisition time=43.9ms/interleave, flip angle=90 and slice thickness=3mm. A finger tapping paradigm (15s off/15s on/4 repeats) was presented to one subject.



Results
Figure 2 shows the simulation and functional study results. The simulation shows that the suggested method can provide enhanced accuracy in the estimates of field map and R_2* map. The functional study shows the R_2* correlation map has the same activation extent as the typical BOLD correlation method, but the values allow quantitation.

Discussion
The suggested method provided enhanced accuracy in the estimates of field map and R2* map from an acquisition substantially shorter (50%) than a true multi-echo acquisition.

References
1) MRM 42:87 (1999)
2) JMRI 9:531 (1999)
3) IEEE Tran. Med. Imag. 13(2):290 (1994)