First Order Dynamic Shimming for 7 Tesla Human Imaging

S. Sengupta[1], M. J. Avison[1], D. Foxall[2], and J. Gore[1]
[1]Institute of Imaging Science, Vanderbilt University, Nashville, Tennessee, United States, [2]Philips Medical Systems, Cleveland, Ohio, United States

Introduction

Dynamic Shimming is a technique for obtaining optimal Bo field homogeneity for a multi slice region by updating the shim coil currents for every slice in real time [1]. Dynamic shimming can produce greater field homogeneity within each slice than global volume shimming methods. It can therefore reduce signal losses and geometric distortions due to variations in magnetic susceptibility within the body, and can be especially useful in fast T_2* weighted imaging sequences such as EPI. We have implemented first order dynamic shimming on a human 7T system for brain imaging studies. Initial results from the study, and an evaluation of the improvements made, are presented.

Methods

Our studies were performed on a Philips 7T human imaging system. Modifications were made in the shimming pulse program software modules to accommodate first order slice by slice dynamic shimming. To demonstrate the effects, we used a spherical phantom of 15 cm diameter and a Transmit/Receive head coil for our studies. Following a survey scan, 128 x 128 pixel resolution field maps were acquired using a shifted echo gradient echo sequence for the slices of interest. The field maps were exported to a local workstation and analyzed in Matlab 7.0 using a least squares algorithm to obtain the first order corrections for each individual slice, which were written in text files in tabular form and ported back to the scanner console computer. These shim text files are then read by the pulse program during slice selection in subsequent scanning, causing the first order shims to be updated to the slice optimized values. A second field mapping scan was then run to verify the results. A global shimming routine was also performed using the same scan geometry for comparison.

Results and Discussion

Fig 1 shows field maps of three axial slices (slice thickness 5 mm and gap thickness 1 mm) of the phantom at the same position before shimming, after the standard first order shimming and after dynamic shimming. Table 1 shows the standard deviation of a 40 x 40 pixel region around the center of the phantom. The dynamically shimmed slices show clear improvement over the globally shimmed slices in terms of the field map spread. This result may be further improved, especially for the outer slices, if more slices are used for the analysis, giving a better fit and lower error with better through plane information. Implementation of 2nd order dynamic shims will require additional investigation into eddy current effects, settling times, frequency shifts and possible integration of new hardware, but simulations suggest these will also provide improved image quality [2].

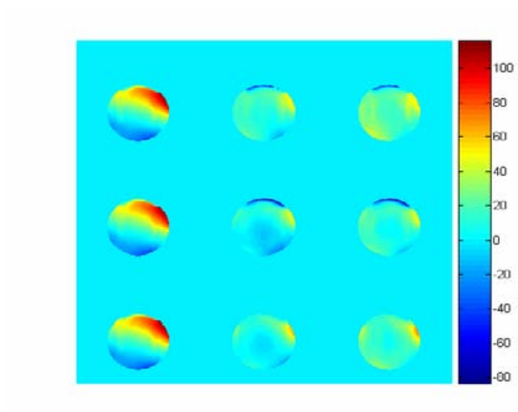

Fig 1: Axial fieldmaps in Hz of three slices before (left col), after first order global shim (center col) and after first order dynamic shimming (right col).

	Spread in 40 x 40 central region of the fieldmaps in Hz		
Slice	**Before Shimming**	**After Philips Global Shim**	**After Dynamic Shimming**
1	25.30	5.86	4.97
2	27.88	8.34	6.16
3	27.66	7.39	5.60

Table 1: Standard Deviation of a 40 x 40 central region in the three slices before shimming, after first order global shim and after first order dynamic shimming.

Conclusions

Dynamic shimming has been implemented on a human 7T scanner to the first order and work is in progress to extend it to higher orders. The first order implementation yielded good results and seems to be a promising approach for tackling the effects of inhomogeneities inherent in using high field strength magnets.

Reference

[1] Blamire AM et al, Magn Reson. Med. 36:159, 1996. [2] Zhao Y et al, J of Magn Reson, 173, 10-22, 2005