# Distortion Correction for Susceptibility-Induced Artifacts in Spin Echo MR Images: Simulation Study at 1.5T and 7T

B. BELAROUSSI[1], Y. ZAIM-WADGHIRI[2], H. BENOIT-CATTIN[1], C. ODET[1], D. H. TURNBULL[2]

[1]CREATIS Laboratory - UMR CNRS 5515 - Affiliated to INSERM, Villeurbanne, France, [2]Skirball Institute of Biomolecular Medicine, New York, New York, United States

## Synopsis

In this work, we present a simple and efficient method to correct susceptibility-induced distortions in Spin Echo MR images when an arbitrary distribution of magnetic field errors is known. Using this field map, an accumulation map is built. This accumulation map reflects the errors in frequency encoding experienced by the nuclei during the imaging process. Once the accumulation map is built, it can be used for the distortion correction process. The proposed method has been tested at 1.5T and 7 T, for an air-filled sphere surrounded by tissue.

## Introduction

Susceptibility artifacts in MR imaging are caused by inhomogeneities of the static magnetic field Bo experienced by the nuclei. In Spin Echo (SE) images, static field errors give rise to geometric and intensity distortions in the slice selection and read-out direction [1]. In this paper, we describe a simple and efficient technique for correction of SE susceptibility-distorted MR images for an arbitrary distribution of error magnetic field in a direct Fourier Transform (FT) imaging method.

## Method

Let $\Delta B(x,y)$ denote the susceptibility-induced field gradients at position (x,y). These local gradients yield an image with distortions in intensity and geometry ([1], [2]). In 2DFT SE imaging, neglecting the effect along the slice-selection direction z, with phase encoding along y, and frequency encoding along x, the distortion can be modeled by [2]:

$$x' = x + \Delta B(x,y)/(Gx.\Delta x) \qquad y' = y \qquad (1)$$

Where (x,y) and (x',y') refer to the true and distorted positions in the MR image, respectively. In the illustration (Fig.1), only the in-plane distortions are considered. The 3D extension is straightforward. In the image domain, we will use the pixel position (i,j) and(i',j') instead of (x,y) and (x',y').

For the correction process, an accumulation map , noted A, is built from the distribution of error magnetic fields $\Delta B(x,y)$. This accumulation map represents the wrong encoding of the nuclei in the imaging process. Moreover, a shifted pixel is located between two integer position in the distorted image, so the accumulation coefficient at each pixel location in this distorted image, is computed according to:

$$i' = i + \Delta B(i,j)/(Gx.\Delta x) \qquad j' = j \qquad l = Floor\{i'\} \qquad r = Ceil\{i'\}$$

$$\alpha = i' - l$$

$$A(l,j') = A(l,j) + (1-\alpha) \qquad A(l,j') = A(l,j) + \alpha \qquad (2)$$

l and r are rounded down ("Floor") or up ("Ceil") to provide integer representations of i'. From this accumulation map, the corrected image, noted C, is obtained by:

$$C(i,j) = (1-\alpha).D(l,j')/A(l,j) + \alpha.D(r,j')/A(r,j') \qquad (3)$$

Here, C(i,j) is the pixel intensity of the corrected image at position (i,j) while D(l,j') is the pixel intensity at position (l,j') in the distorted image.

## Results

We present the 2D correction for an air-filled sphere surrounded by water, for different main static field strengths. The corresponding field error map is given by Fig 1a. The distorted images are computed at 1.5 T (Fig 1b) and 7 T (fig 1d) using the simulation process described in [3]. Image sizes are 128x128 and the read-out gradient values are 0.73 mT/m and 5.78 mT/m at 1.5T and 7T respectively. The field of view is 20 cm at 1.5T and 5 cm at 7T. The field map was numerically computed using the algorithm described in [4] but can also be obtained by an actual MRI acquisition [5]. Figs 1c and 1e show the corrected images of Figs 1b and 1d. Clearly, the intensity and geometric distortions are well corrected at both 1.5 T and 7 T by the proposed algorithm.

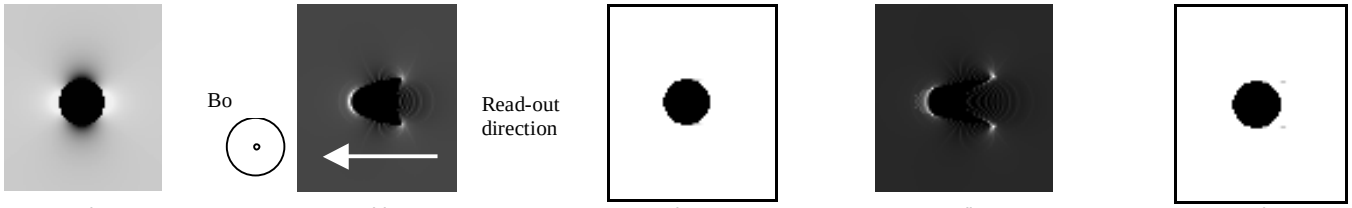


Figure 1: a) field error map, b) distorted image at 1.5 T, c) corresponding corrected image, d) distorted image at 7T, e) corresponding corrected image.

## References

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