Susceptibility artifact correction in GE images

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Introduction

In Gradient Echo (GE) images, susceptibility artifact induces both intravoxel dephasing and pixel shifting (Fig. 2-a) leading to intensity and geometric distortions [1] that may disturb image analysis. In previous works, correction of GE images is assessed by modifying acquisition parameters or by using specific sequences [2]. All the proposed techniques always constrain the acquisition process and a trade-off has to be found with the initial imaging goal. So far, there is no image processing existing method. In this work, we propose an original image-processing based correction method for susceptibility artifact in GE MR Images when a field map of the imaged object is known. Susceptibility artifact impact is modeled by means of a pixel shifting map and an intensity distortion map. The intensity distortion map which takes into account different complex phenomena is obtained through MRI simulation.

Method

The effect of susceptibility artifact can be decomposed into pixel shifting and intensity distortions and treated separately (Fig. 1). The main input of the proposed method is a field map of the imaged object. The field map is obtained through a double GE phase images acquisition followed by phase unwrapping. Acquisition parameters used to obtain the distorted image (DI) are also necessary. From these two entries, the Maps Building Bloc produces two maps: a pixel shifting map (PSM) and intensity distortions map (IDM). The corrected image (CI) is the output of the correction bloc which entries are the PSM, the IDM and DI.

To build the pixel shifting map, we use the relation between the true (i, j) and real positions (i', j') (eq. 1) where Gx and Δx are the readout gradient value and pixel size, respectively.

$$PSM(i, j) = i' - i = \Delta B(i, j) / (\Delta x . Gx) \; ; \quad j' = j \quad \textbf{(1)}$$

$$DI(i', j') = G(i', j') . CI(i, j) \quad \textbf{(2)}$$

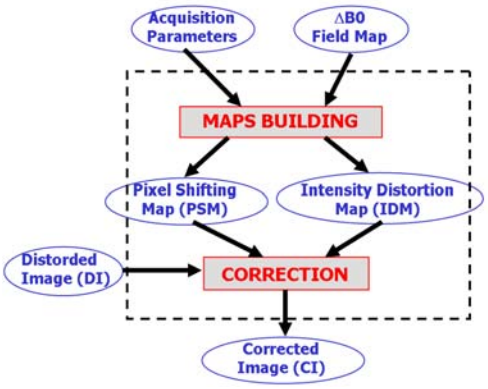
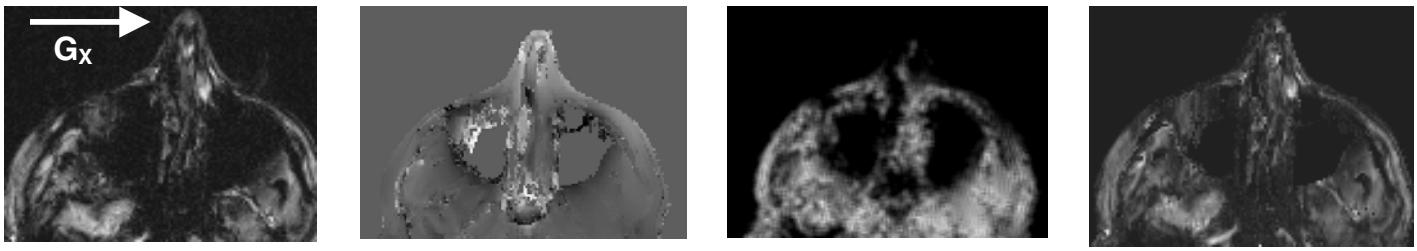


Figure 1: Correction scheme overview

From MR signal analysis in presence and absence of susceptibility artifact, intensity distortions have been modeled by means of an intensity gain G at the real positions (i', j') (eq. 2). On the GE MR image, there is no analytical expression for the gain G. However, such an intensity distortions map can be obtained by an alternative way: MRI simulation which takes into account T2* effect simulation [3]. From a field map of the image object used as input of the MRI simulator, a simulated MR image which contrast only depends on the imaged object field map (i.e. susceptibility artifact) can be obtained, and gives the intensity distortion map. Correction process consists in modifying erroneous pixel intensity using IDM and then in correctly relocating it using PSM.

Results

The proposed method has been tested on simulated and real data. As example, we have illustrated the proposed method on head images (Fig. 2-a) acquired at 1.5T (TR/TE = 500/20 ms, BW=50 kHz). We focused on tissue around nasal cavities where susceptibility artifact impact is more pronounced. Pixel shifting Map and Intensity Distortion Map are given by Figure 2-b and Figure 2-c, respectively. After correction (Fig. 2-d), both intensity and geometry have been recovered. After correction (Fig. 2-d), tissue intensity around nasal cavities has been recovered allowing a better analysis of these GE images.



a) Distorted GE image b) Pixel Shifting Map c) Intensity Distortions Map d) Corrected GE image

Figure 2: Correction of 256x256 GE brain images (Bo=1.5T- TR/TE=500/20ms, BW=50 kHz).

With the general evolution of MRI towards high field imaging, the proposed correction method will be useful.

References

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