MR-based Field-of-View Extension: Gradient and B0 Correction Post-Processing

J. O. Blumhagen[1,2], R. Ladebeck[1], M. Fenchel[1], J. Kampmeier[1], and K. Scheffler[2]
[1]Magnetic Resonance, Siemens Healthcare, Erlangen, Bavaria, Germany, [2]Division of Radiological Physics, University of Basel Hospital, Basel, Switzerland

Introduction. Several studies demonstrated rectification of static-field inhomogeneities inside a field-of-view (FoV) of less than 500mm using phantom-based or patient-based post-processing methods [1-3]. However, in whole-body MR/PET a distortion-free MR image using an axial FoV up to 600mm would improve the human attenuation correction [4]. Furthermore, an extended FoV can be useful in image-guided radio-surgery and biopsy. In this work we will show exemplarily for 2D spin-echo (SE) that significant distortion reduction using post-processed B0 correction can be achieved for an axial FoV up to 600mm.

Materials and Method. Slightly distorted images can be corrected with post-processing knowing the actual field errors, B0 inhomogeneities and gradient nonlinearities, and the corresponding pixel allocation. Field plots of the main magnetic field and the gradient field were acquired using a half moon probe array containing 24 probes and rotating around the magnetic field axis with 24 angular positions per turn. The measured field errors of the B0- and gradient-fields stored as Legendre coefficients were implemented in a bicubic distortion correction algorithm as an input file.
A structure phantom (diameter: 130mm, length: 650mm, homogenous in z-direction, filled with 1.25g $NiSO_4$ X $6H_2O$ + 5g NaCl per 1000g H_2O) was built with 43 tubes of 13mm in diameter to model a patient's arm (Fig. 1). An experiment was performed on a 3T whole-body system. The phantom was placed outside the normal specified FoV at x=-310mm to analyze the distortion and validate the improvements of our post-processed correction method. The distortion correction was performed exemplarily for a 2D SE transversal slice at position z=0.

FIG 1: Structure phantom consisting of 43 tubes of 13mm in diameter.

Results. An uncorrected measurement of a 2D SE transversal MR image slice of the structure phantom showed in-plane distortions in the readout direction (Fig 2A). The standard gradient distortion correction is limited to a FoV of 500mm and truncated the image (Fig 2B). Applying gradient distortion correction to a FoV of 700mm using measured gradient field coefficients caused a residual distortion in the opposite direction (Fig 2C). Figure 2D shows the rectified image after correction of both B0 inhomogeneity and gradient nonlinearity. The distortions were nearly completely removed.

Discussion. In an extended FoV, image distortions due to B0 inhomogeneities and gradient nonlinearites can be reduced using measured field coefficients as an input for post-processed correction. Consideration of gradient nonlinearities only may result in an insufficient correction. Inhomogeneity of the main magnetic field outside the normal specified FoV may necessitate B0 correction. Combined correction of both gradient nonlinearities and B0 inhomogeneities may improve the distortion reduction. Analysis of maximum distortion magnitude that can be corrected successfully is subject for further research.

Conclusion. MR image distortion due to B0 inhomogeneity and gradient nonlinearity can be corrected also at positions outside the normal specified field of view and therefore appears promising with the potential to improve the MR-based PET attenuation correction.

References. (1) Baldwin L N et al. Med Phys 36 (2009). (2) Reinsberg S A et al. Phys Med Biol 50 (2005). (3) Schmitt F. CAR Berlin (1985). (4) Delso G et al. Med Phys 37 (2010).

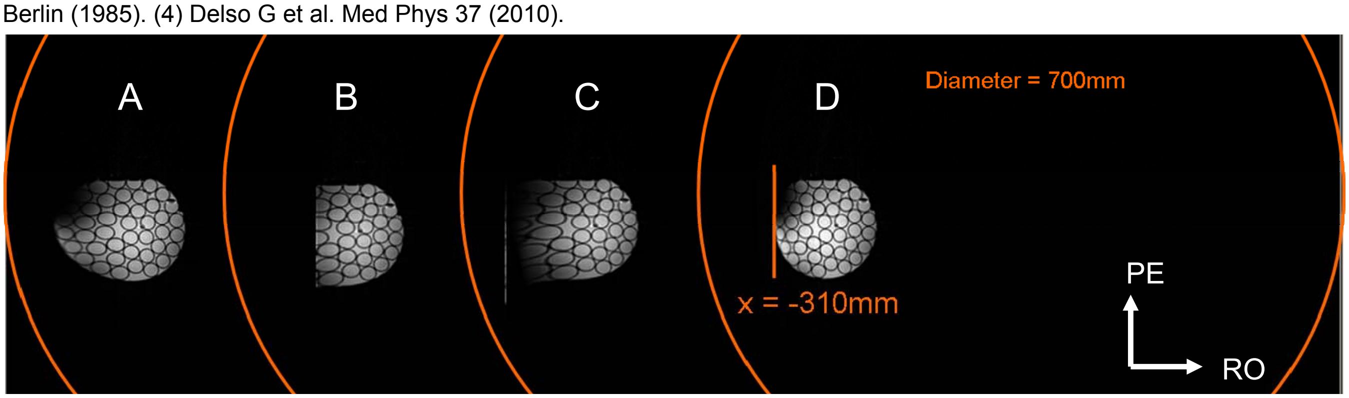

FIG 2: Axial slices at z=0 and FoV = 700mm. Structure phantom is placed at x = -310mm. A) Uncorrected, B) Standard gradient distortion correction (limited to FoV of 500mm) C) Corrected gradient nonlinearities (FoV: 700mm), D) Corrected both B0 inhomogeneities and gradient nonlinearities (FoV: 700mm).