GEOMETRICAL DISTORTION RECTIFICATION USING IMAGE STITCHING IN OPEN MRI

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Introduction: The primary advantage of magnetic resonance imaging (MRI) in radiotherapy is its excellent soft tissue contrast. The accuracy of the tumor volume delineation can be improved using MRI in combination with CT during treatment planning. Recently, open-type MR systems have become attractive for image-guided radiotherapy due to their easy patient access configuration [1-3]. However, geometric image distortion by imaging gradient nonlinearity hinders the practical applications of MRI in radiotherapy [4, 5]. In this study, we propose an image stitching algorithm to merge non-distorted images obtained at the isocenter of the magnet and demonstrate an extended field of view using the proposed geometric distortion correction technique.

Methods:

This study was performed on an open 0.32 T MRI permanent systems (Magfinder2, Genpia Co., Korea) with an H-shaped vertical magnet and a quadrature body coil. The system has a patient aperture of 1370 mm and effective field of view of 400 mm. The patient table can be moved laterally up to 120 mm relative to distance from isocenter. MR imaging was carried out on an ACR MRI Phantom and one human volunteer underwent CT and MRI scans. The grid section of the phantom was acquired with a 2D T1 spin echo (TR = 400 ms, TE = 15 ms, matrix = 256×256, FOV = 250 mm, slice thickness = 5 mm). Pelvic images within the axial plane were acquired with a 2D T2 fast spin echo using the following parameters: TR = 3800 ms, TE = 120 ms, matrix = 256×256, FOV = 500 mm, slice thickness = 5 mm, number of signal average = 2. The geometrical distortion in-plane was determined as the difference between the coordinates of each corresponding acquired intersection points of the grid sheet and the idealized points of ACR phantom. To calculate the geometric distortion at each point in the reference frame, the distortion value was measured as a function of distance from isocenter in-plane. This value was used to determine acceptable distortion range. The acceptable distortion range value in this experiment defined < 2% along the orthogonal direction and adequate image, called image tiles, has a size 220 mm and 170 mm in the horizontal and vertical directions respectively. The right and left isocenter images of axial plane of pelvis were acquired using table shift. A distortion free image of isocenter was chosen as the tile. The image stitching method in this study consisted of tile configurations using optimized global registration and seamless blending of aligned tiles.

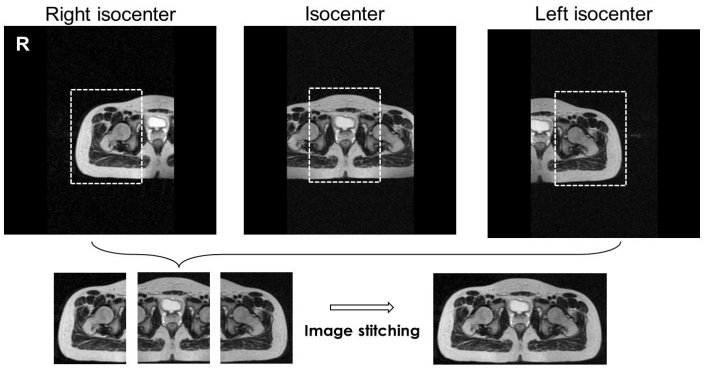

Figure 1. The overall image stitching procedure proposed in this experiment. The distortion corrected image was generated via a globally optimized configuration and nonlinear blending of differently acquired isocenter images.

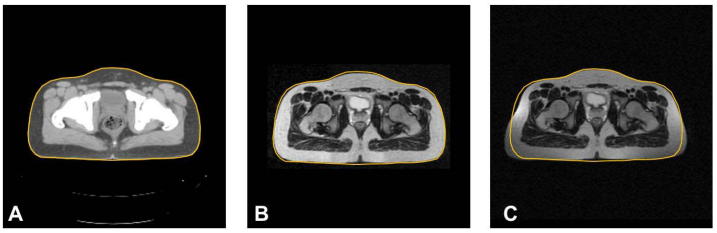

Figure 2. CT and MR images of a prostate region. (A) CT image, (B) the same subject imaged on the MR scanner with image stitching, (C) without any distortion correction.

Results and Discussion: Fig. 1 shows 3 divided isocenter axial images and the stitching procedure. Severe geometric image distortions are shown out of the region-of-interest (ROI) on the images. The straightforward stitching technique generates the composite image through the sequential generation of different views of the same object. The nonlinear blending method reduces image intensity variation and mismatching regions on the composite image. Fig. 2 shows the CT image (A) with an external body contour and two MR images with image stitching (B) and conventional scheme (C). Using the body contour from the CT image, the geometric distortion on MR images can be examined. The body contours of the CT and two MR images were 1009, 1003 and 1049 mm long, respectively. The body contour of the conventional MR image was overestimated about 4% relative to the contour of the CT image, while the stitched image shows in good agreement with the reference contour, indicating a significant geometric distortion correction was obtained. The conventional image shows a large degree of mismatch, indicating the severe geometric distortion regions off-center. Because geometric distortion caused by imaging gradient nonlinearity is not object-related but system-induced, stitching of segmented isocenter images with defined distortion free area efficiently corrects hardware imperfection.

Conclusion: Geometrical distortion was removed from a pelvic MRI using the proposed stitching technique. These methods are beneficial for contouring during radiotherapy treatment planning could improve the accuracy of the dose calculation.

Acknowledgement: This study was supported by SMBA grant funded by the Korea government (MKE) (No. SM121915).

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