An algorithm for orthogonal correction of phase-encoding derived artifacts in Magnetic Resonance

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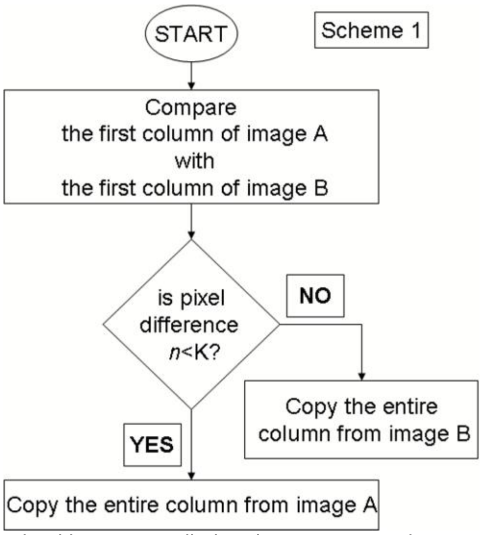
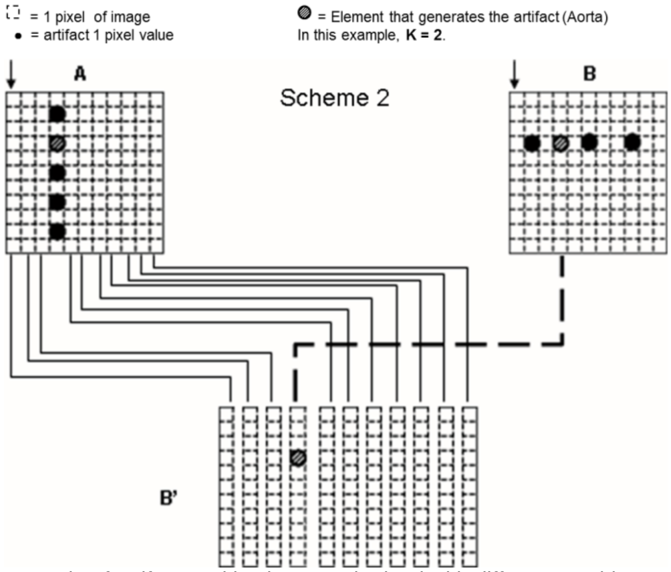
Target audience-Radiology technicians, Radiologists

PURPOSE- In Magnetic Resonance (MR) motion artifacts are common and usually manifest along the phase encoding direction, often disturbing the interpretation of the image. In the present work, we propose an alternative system ideally aimed at obtaining an artifact-free image through a new and relatively simple post-processing algorithm.

METHODS -The algorithm is based on the key concept that signal intensity alterations are always randomly distributed, whereas the spatial distribution of body anatomy is always non-random according to the well-known orthogonal correlation principle. In more detail, when acquiring twice the same MRI sequence on a given anatomical region by using identical parameters, possible artifacts will be located along the vertical direction of the image when the phase encoding is directed on columns, and along a horizontal directions of the image when the phase encoding is directed on rows. In the algorithm process, image A is acquired with phase encoding for columns and image B is acquired with phase encoding for rows, in the post process stage the software compares the different intensity values of the same image portions (pixels). Pixels with small / imperceptible different intensities are considered to be equal. The small gap in the numeric intensity of colour was calculated during the algorithm development. For each pair of images, the software calculates a number of different pixels (K). In the first step, the algorithm considers image A as the true image, and then compares A with B. Each column with a number of different pixels < K is directly copied from A in the new image B'. Each column having the value of different pixels bigger than K is copied from B (see scheme 1). A simplified example may be of help to better understanding the basic principle behind the algorithm (see scheme 2). Compare two images of the same anatomical section. At the end of this operation the algorithm considers B as the true image, and compares B with A for rows. The mechanism is similar to the previous one. In order to avoid the prolongation of exam time, the Number of Signal Averages (NSA), (or similar) can be exploited by making an even NSA, with half of them being distributed along one phase encoding direction and the remainder half being distributed along the opposite one. Then the procedure averages the resulting images in order to improve the signal-noise ratio.





The algorithm was applied at the post-processing stage to n=547 couple of artifact-positive images obtained with different machines, at different magnetic field intensities: (3.0 T, n=40; 1.5 T, n=118; 0.35 T, n=17; 0.22 T, n=372.), and including different body anatomical sites (brain, n=100; cervical spine, n=90; shoulder, n=64; wrist n=68; lumbar spine, n=70; knee, n=104; leg, n=51) with different sequences: (T1, n=192; T2, n=191; IR, n=95; Flair, n=40; Gfe T2, n=29). In all acquisitions, specific measures were applied to reduce artifacts as recommended by manufacturers. The presence of artifacts in the images was independently evaluated by two medical radiologists with more than 10 years' specific experience in MRI interpretation and who were unaware of the use of the algorithm. Inter-rater agreement between observers(weighted Kappa) was 0.949 (standard error: 0.036, 95% Confidence interval: 0.880-1).Differences in the occurrence of artifacts before-after algorithm application were tested by chi-square statistics, and a two-sided p value of <0.05 was considered to be statistically significant. The MedCalc ver. 12.0 statistical software package (MedCalc. Software, Mariakerke, Belgium) was used.

RESULTS-A complete elimination of phase encoding artifacts was obtained in 91.41% (500/547) of the images (chi-square 880.977, df=2, p<0.0001), whereas a partial correction of the image in all kinds of sequences and weightings was obtained for the coronal orientation of the shoulder (8.59% of cases, 47/547). In this special case, the presence of artifacts in the same position in both images led the algorithm to sum up the false signal intensity rather than removing it, as no images at that point possess correct data.

DISCUSSION- Introduction of our algorithm led to a significant reduction of artifacts, without prolonging the exam time. Despite some obvious similarities, a comparison between the present algorithm and prior ones indicates the existence of key differences, which could be summarized as four main distinctive features: 1) lack of action on the K-space, with the possibility to act on the final image in the post-processing phase; 2) no need for major changes of acquisition and recording signal; 3) possibility of eliminating the phase encode direction parameter; and 4) no need for increasing exam time.

CONCLUSION- Given the basic features of the proposed post-processing algorithm, requiring minor changes in the reconstruction software, we suggest that the proposed system would be potentially applicable to the existing MRI machines, independently from Tesla power or other technical characteristics.