Synthetic vs. directly-acquired MRI of identical-slice brain images: large scale and multi-contrast (PD, T1, and T2-weighted) image quality comparison

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Purpose: Synthetic MR imaging refers to an image processing technique (**Ref.** 1, 2) that uses quantitative MR images as input to generate images of any arbitrary T1 and/or T2 contrast weightings. Synthetic MRI can be performed in patient's absentia with a computer equipped with a program for image synthesis that simulates the process of image acquisition with a virtual MRI scanner (**Ref.** 2). The purpose of this work was to determine if neuroradiologists could distinguish synthetic-MR brain images generated with mixed turbo spin-echo (mixed-TSE) pulse sequence and model-conforming Q-MRI algorithms from identical-slice (self-coregistered) PD-, T1-, and T2-weighted images that were directly-acquired with the same scan. In this way, any observed visual difference can be attributed solely and unambiguously to the image processing algorithms involved in Synthetic-MR and eliminating potential positioning differences of scans performed at different points in time.

Methods: Brain MRI was performed in 23 subjects using the mixed-TSE sequence (transverse plane, 80 contiguous slices, 0.9x0.9x3 mm^3 voxel, **Ref.** 3). Mixed-TSE directly-acquired images were used to generate self-coregistered PD, T1, and T2 Q-MRI maps. These were input to the Synthetic-MRI generating algorithm to produce identical-slice replicas of the directly acquired parent images. The directly acquired images (see **Fig.** 1) were processed with model conforming Q-MRI algorithms programmed in Mathcad 2000i (Mathsoft, Cambridge MA) to generate self-coregistered maps of PD, T1, T2, correlation time diffusion coefficient, and the longitudinal to transverse relaxation time ratio T1/T2.

Two neuroradiologists were presented with 207 image pairs positioned: synthetic and directly-acquired unlabelled images were positioned randomly left-to-right. The constructed image data bank had three subsets of 69 pairs each: PD, T1, and T2-weighted. For each image pair, the neuroradiologist was asked to identify the directly-acquired image (left or right) and to specify which had superior image quality.

Results: Representative PD-, T1-, and T2-weighted images used for expert comparison by neuroradiologists are shown in **Fig.** 2. Clearly these are visually very similar. The two neuroradiologists correctly identified directly-acquired from synthetic-MR images 70% and 21% of the time respectively. Synthetic-MR image quality was assessed superior relative to the directly-acquired image 53.6% T1w, 66.7% T2w and 84.1% PDw of the time and 83.6% T1w, 72.5% T2w, and 80.6% PDw, by each neuroradiologist respectively.

Conclusion: Advances in Quantitative-MRI technologies, including Q-MRI pulse sequences as well as image processing algorithms (model conforming PD, T1, and T2 Q-MRI algorithms and contrast weighting synthesis algorithms) lead to the generation of synthetic MR brain images of that can be indistinguishable from, and sometimes preferable to their identical-slice directly-acquired counterparts, as judged blindly by neuroradiologists. To our knowledge, this is the first study comparing synthetic *vs.* directly acquired MR images of identically positioned slices. Synthetic MRI of the brain with the mixed-TSE pulse sequence and model conforming algorithms is maturing into a technique with clinical viability.

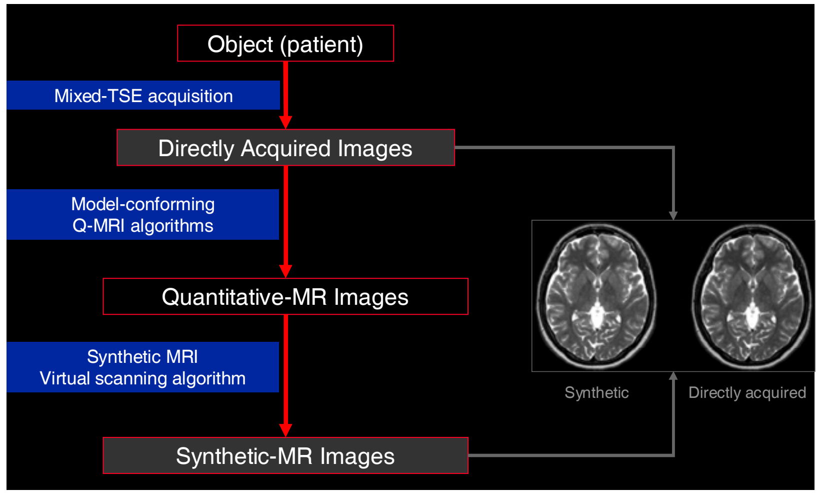

Fig. 1: **Image processing methodology**. Note that the neuroradiologists were presented with unlabeled images and that the left or right placement of the synthetic and directly acquired was random.

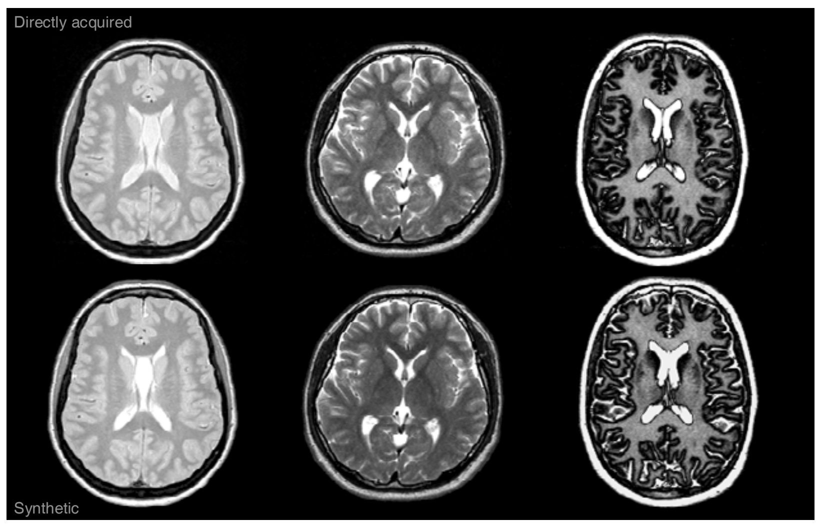

Fig 2: **Representative images used in blinded comparison**. Directly acquired (to row, from left to right) PD-weighted (TE=7ms), T1-weighted by inversion recovery (TI=700ms), and T2-weighted (TE=100ms). Identical-slice synthetic MR images

References

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