Synthesized b0 for diffusion distortion correction (Synb0-DisCo)

Kurt G. Schilling, Justin Blaber, Yuankai Huo, Allen Newton, Colin Hansen, Vishwesh Nath, Andrea T. Shafer, Owen Williams, Susan M. Resnick, Baxter Rogers, Adam W. Anderson, Bennett A. Landman

Magnetic Resonance Imaging
2019

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- **Goal of the paper:**

Enabling TOPUP processing with limited diffusion imaging data

Proposing to synthesize an undistorted EPI image from the structural image and use the non-distorted synthetic image as an anatomical target

✓ Using a database of pairs of structural images and multi-shot EPI images

T1-weighted images

diffusion b0 EPI

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- **Acquisition of dataset:**

  - ✓ 586 pairs of T1-weighted and diffusion b0 EPI brain images from healthy controls
  - ✓ Acquiring T1-weighted images using an MPRAGE sequence
  - ✓ Acquiring diffusion acquisition using a single shot EPI sequence
  - ✓ To obtain a non-distorted image with b0 contrast

Acquiring a high resolution, multi-shot EPI image

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- **Methodology:**
  - ➢ Acquiring b0 synthesis:

✓ Registering the multi-shot EPI b0 scans to the paired T1-weighted MPRAGE scan

⇒ Transforming the paired multi-shot EPI scans to MNI space

✓ Registering the MPRAGE scans for each subject to the MNI-152 1mm isotropic T1-weighted atlas

⇓

Reducing the variation in the data

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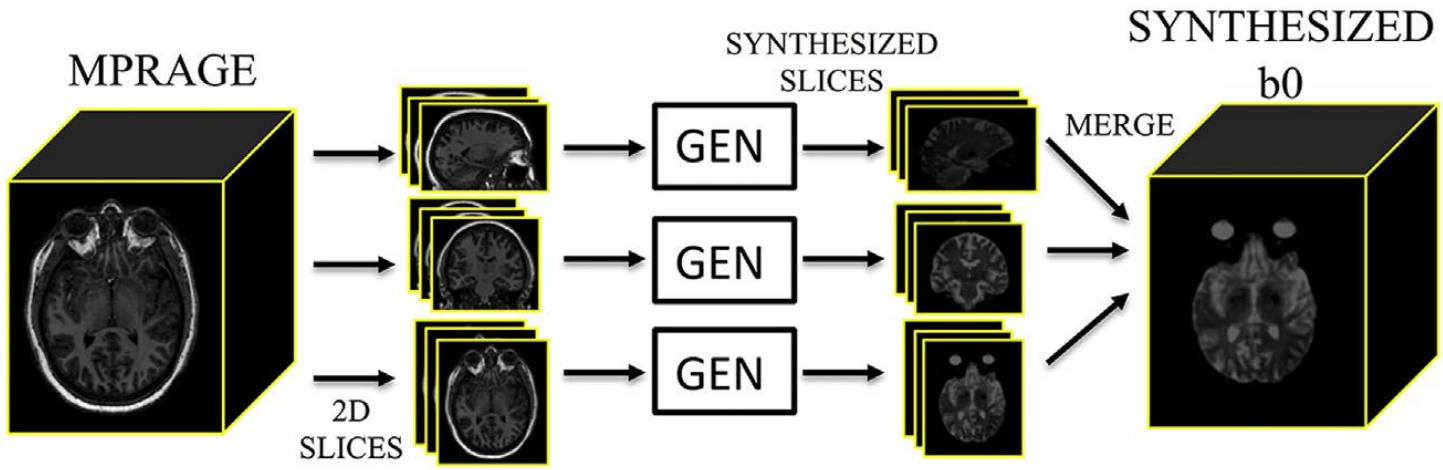
- **Training:**

Three separate GANs ⇒ One network learning mapping of sagittal 2D slices

The second learning mapping of coronal 2D slices

The third learning mapping of axial 2D slices



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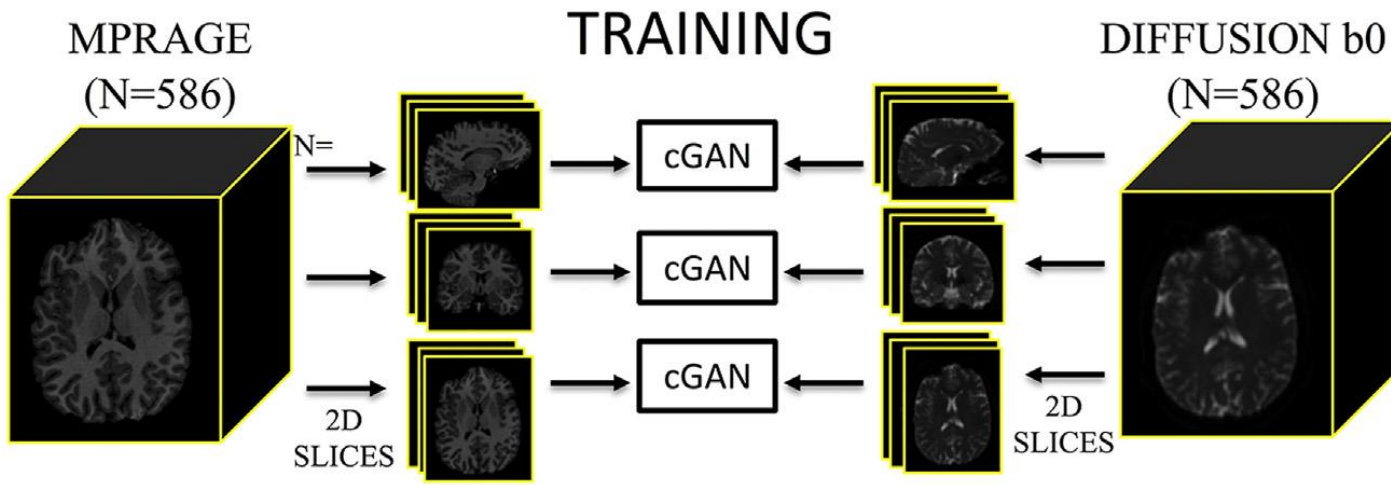
- **Pre-Training:**

✓ Pre-training three separate orthogonal pix2pix networks

✓ Using all subjects' datasets to create sets of three consecutive slices in a paired manner



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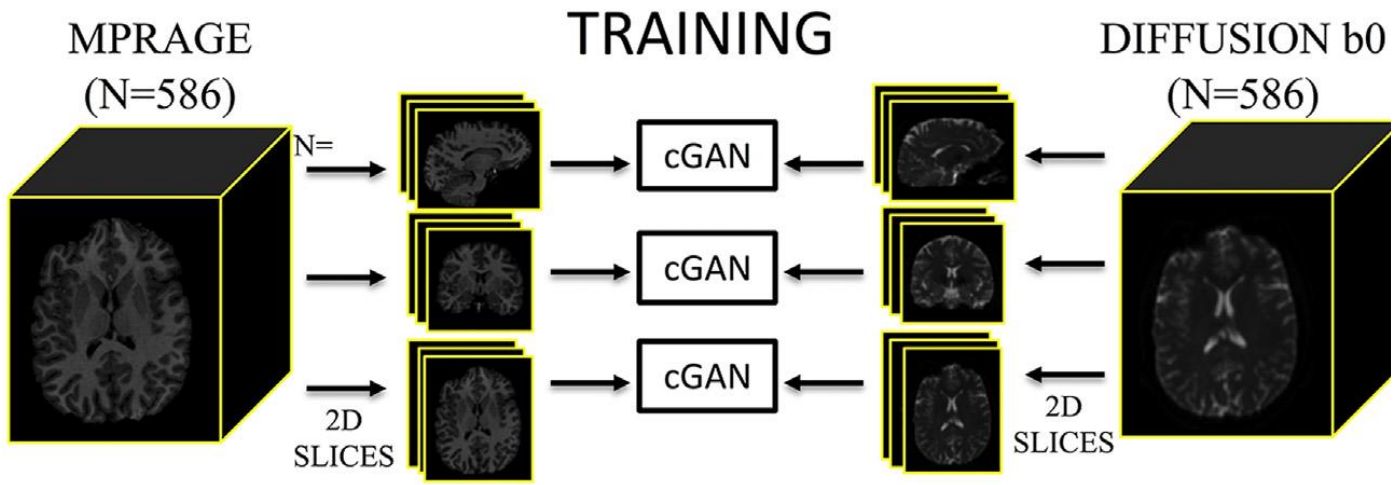
- **Pre-Training:**

Training pairs
- 113,098 for the axial
- 134,194 for the coronal
- 113,098 for the sagittal

→ Splitting 80/20% for training and validation



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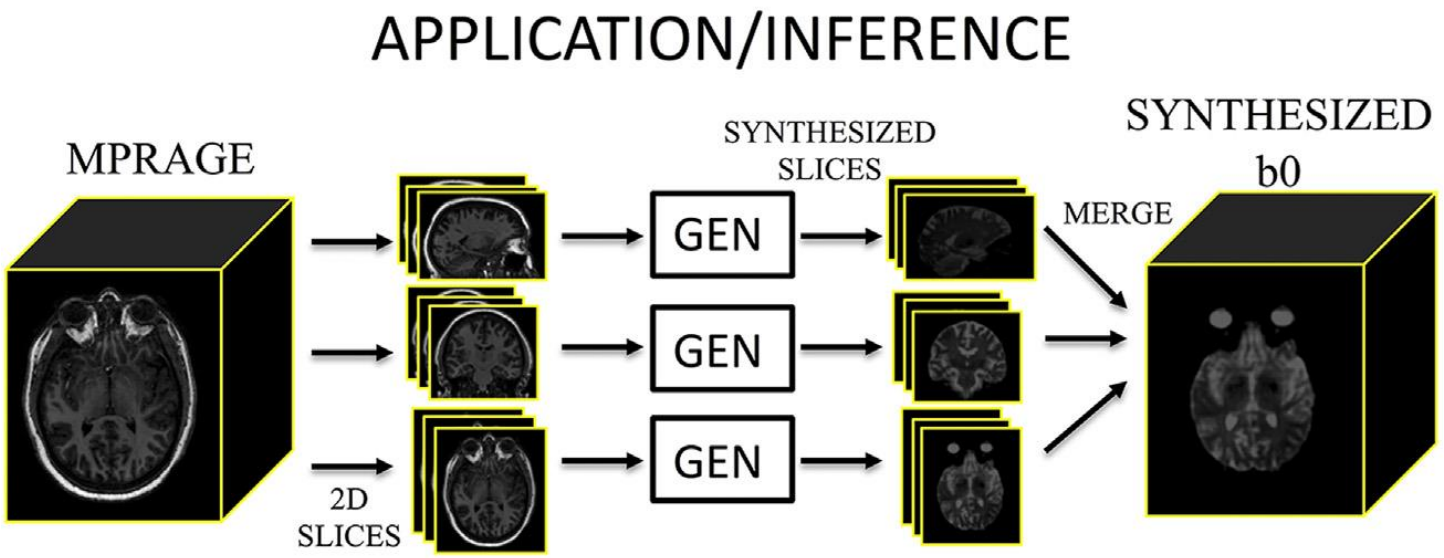
- **Application of the network:**
  - ✓ Registering MPRAGE scans to align with the MNI space
  - ✓ Processing MPRAGE to creating overlapping sets of three contiguous slices
  - ✓ Applying the corresponding generative models to each stack independently



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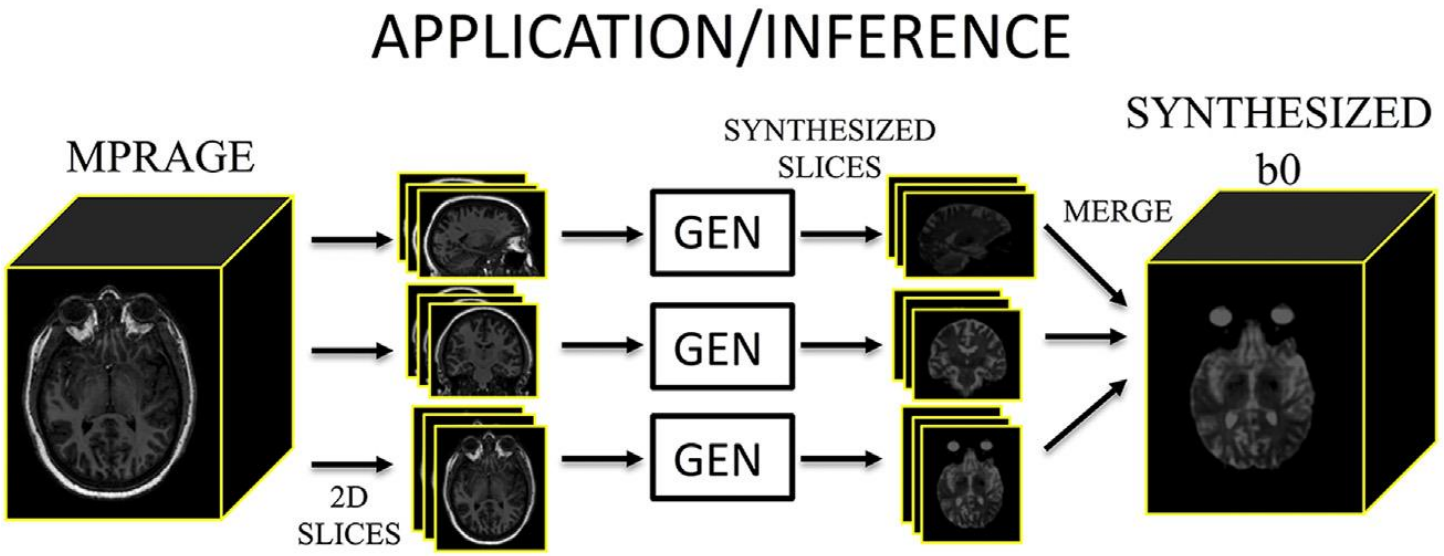
- **Application of the network:**

  - ✓ Producing three output channels for each stack of images by the generative model
  - ✓ Averaging the channels for each reconstruction to reconstruct an estimated b0 volume
  - ✓ Combining the reconstructions from the three orientations by applying median filtering

Resulting in the synthesis of a b0 image for the subject



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▪ Distortion correction:

✓ Registering the synthesized b0 image to the real (actual) b0 image

Aligning the synthetic and real b0 images

✓ Concatenating the registered synthesized b0 image and the real b0 image

Using combined dataset as input for TOPUP

✓ Further processing steps

TOPUP: estimating and correcting for susceptibility-induced distortions in the MRI data

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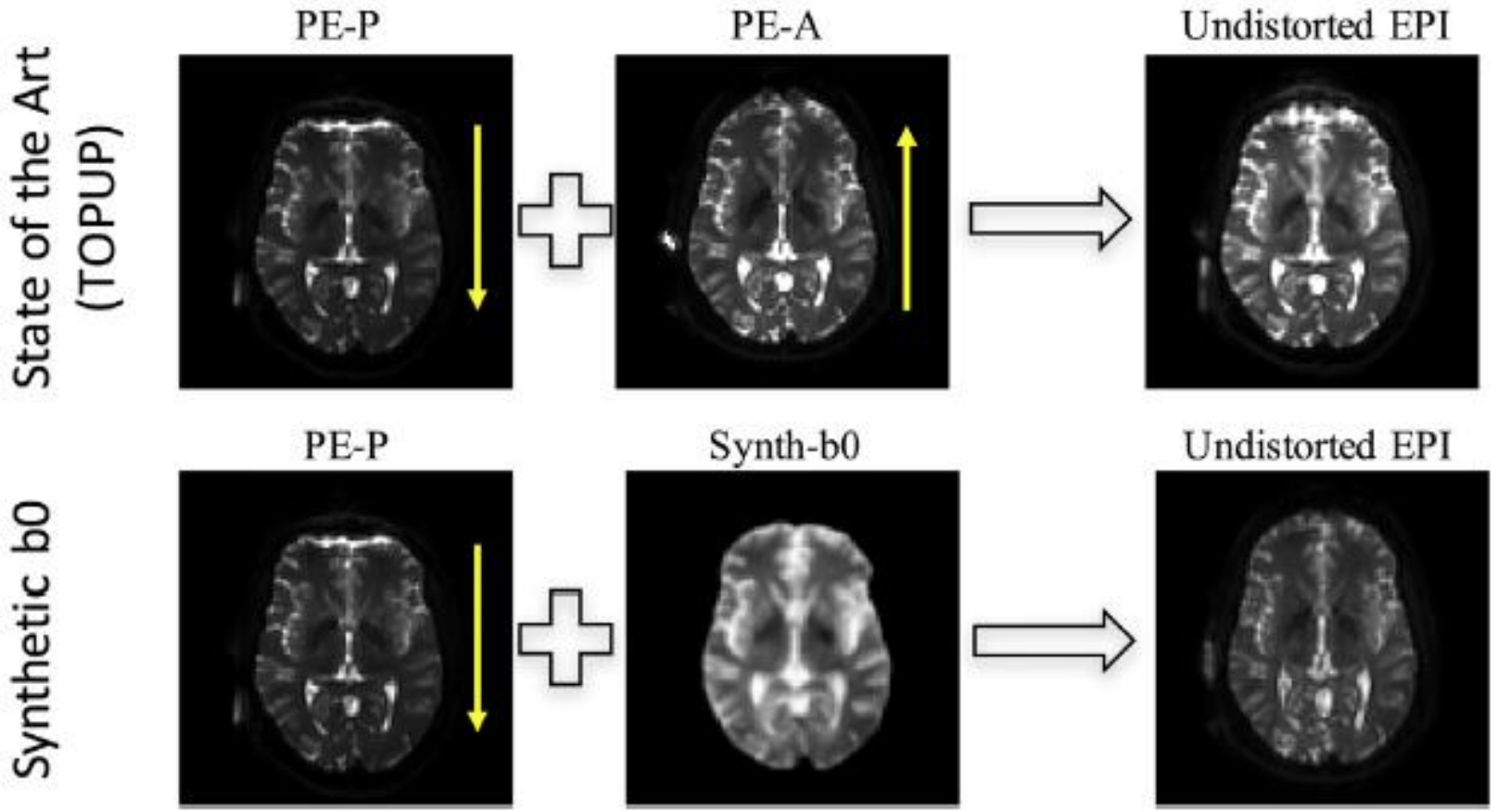
- **Results:** Test on healthy subject scanned at Vanderbilt University



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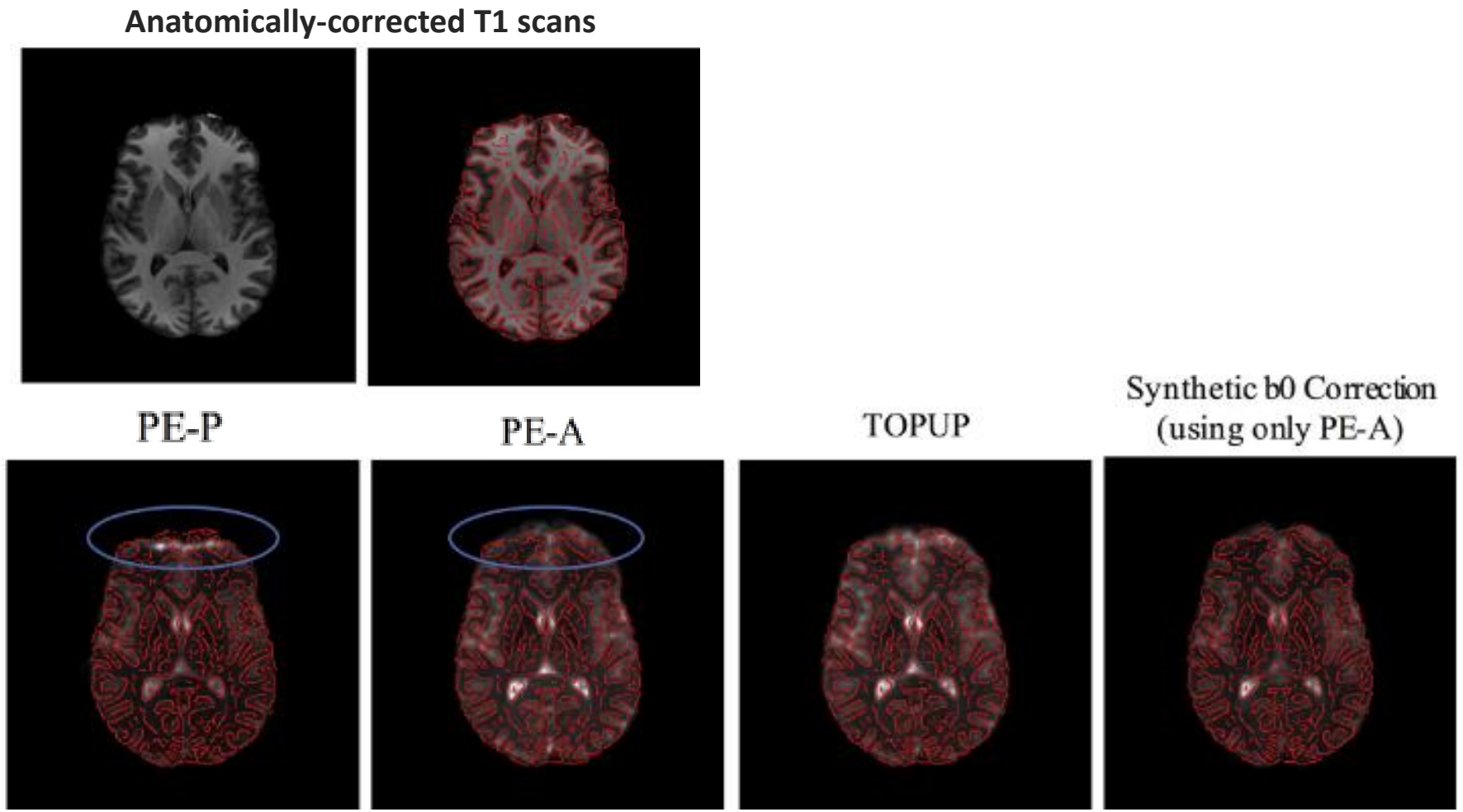

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▪ Conclusion:

✓ Utilizing the proposed network in the absence of additional reverse PE acquisitions, and only requiring a standard T1-weighted acquisition

✓ Reasonable distortion corrections similar to state-of-the art methods that require blip-up blip-down acquisitions

✕ Creating a slight blurring of fine details and structures by median filtering of sagittal, axial, and coronal slices

✕ Incapability to predict the appropriate b0 contrast in certain regions of non-healthy populations (for example, tumors)

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Thank you

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