FD-Net: An unsupervised deep forward-distortion model for susceptibility artifact correction in EPI

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FD-Net: An unsupervised deep forward-distortion model for susceptibility artifact correction in EPI

- **Goal of the paper:**

Introducing an unsupervised deep-learning method for fast and effective correction of susceptibility artifacts in reversed phase-encode images

novel unsupervised deep Forward-Distortion Network (FD-Net) that predicts both the susceptibility-induced displacement field and the anatomically correct image.
FD-Net predicts
a single anatomically corrected image along with a dis-
placement field..

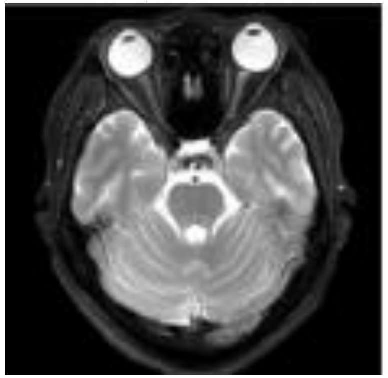
❖Distortion correction of single-shot EPI enabled by deep-learning

- **Deep neural network for EPI distortion correction:**

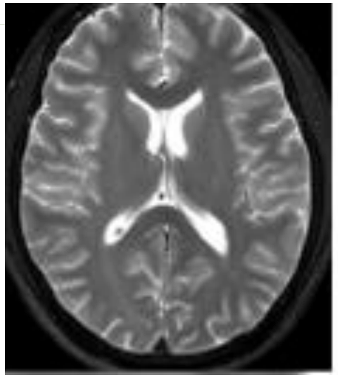
Input images { Anatomical T2W-TSE / Single Shot EPI }

T2W-TSE ⇨

- ✓ Including undistorted anatomical information
- ✓ Improving the output image quality



T2W-TSE



T2W-TSE

Zhangxuan Hu, Yishi Wang, Zhe Zhang, Jieying Zhang, Huimao Zhang, Chunjie Guo, Yuejiao Sun, Hua Guo, Distortion correction of single-shot EPI enabled by deep-learning, NeuroImage, Volume 221, 2020

❖Distortion correction of single-shot EPI enabled by deep-learning

- **Deep neural network for EPI distortion correction:**

Input images → 8 channels

- ✓ 1 b = 0
- ✓ 6 b = 1000 images with different diffusion directions acquired using SS-EPI
- ✓ 1 T2W-TSE image

Output images → 7 channels

- ✓ 1 b = 0
- ✓ 6 b = 1000 images acquired with PSF-EPI

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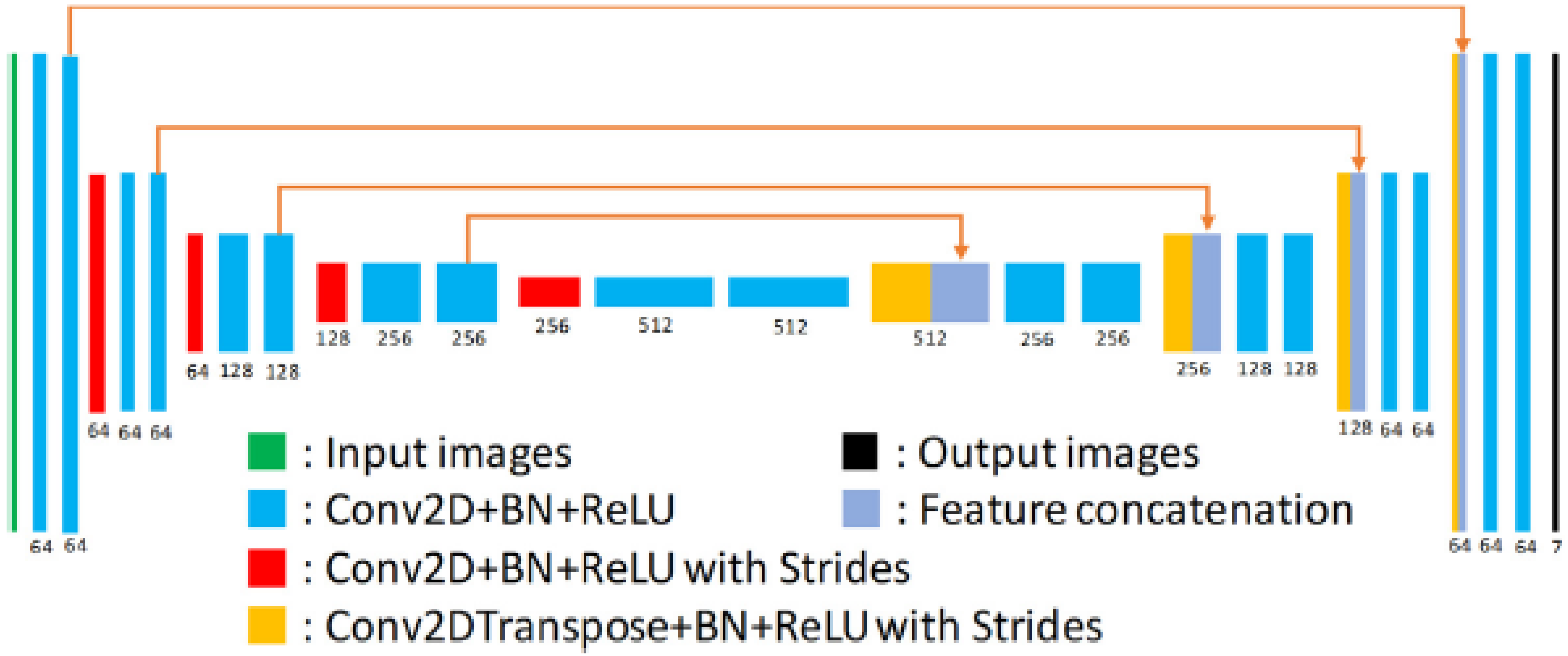
- **Deep neural network for EPI distortion correction:**



❖Distortion correction of single-shot EPI enabled by deep-learning

- **Deep neural network for EPI distortion correction:**

Loss function:

output of the neural network

✓ structural consistency (Structural Similarity Index, SSIM): = 1 – SSIM (,)

corresponding target

✓ voxel- wise differences (L1 loss): =

✓ image edge preservation (Gradient loss): = ++

Total loss *min* + (1 -) [+ (1 -)], = 0.84, = 0.9

Gaussian weights

❖Distortion correction of single-shot EPI enabled by deep-learning

- **Dataset:**

Ten healthy volunteers

- ✓ 7 volunteers for training
- ✓ 2 volunteers as a validation set
- ✓ 1 volunteer as a test set

The mismatch between input images, T2W-TSE and SS-EPI images

⇩

Errors to the final output

⇩

✓ Using the state-of-the-art registration algorithm when image mismatch exists between the two input images

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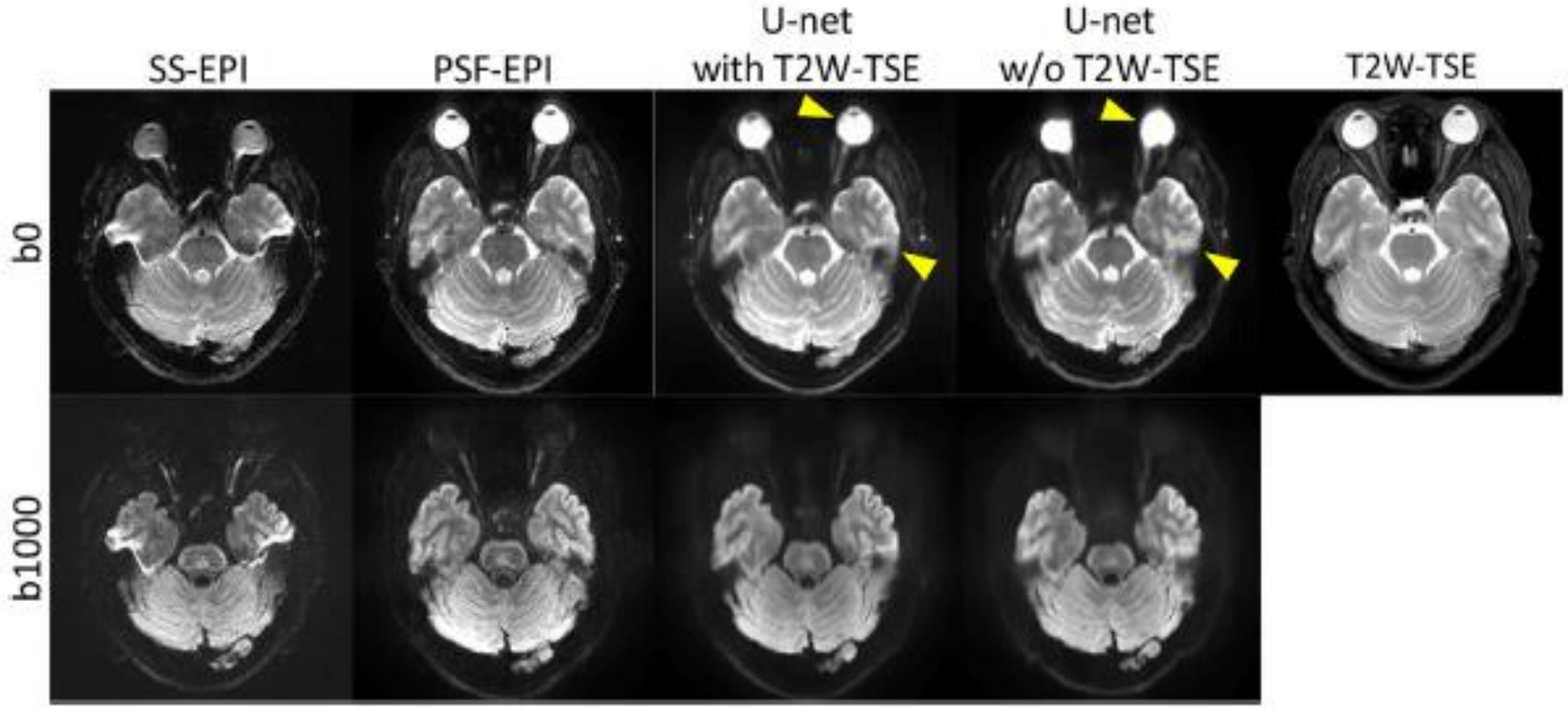
- **Results:**

Comparison of the correction results using the U-net with or without the T2W-TSE images

✓ Better restoring at structures in regions suffering from severe field inhomogeneities



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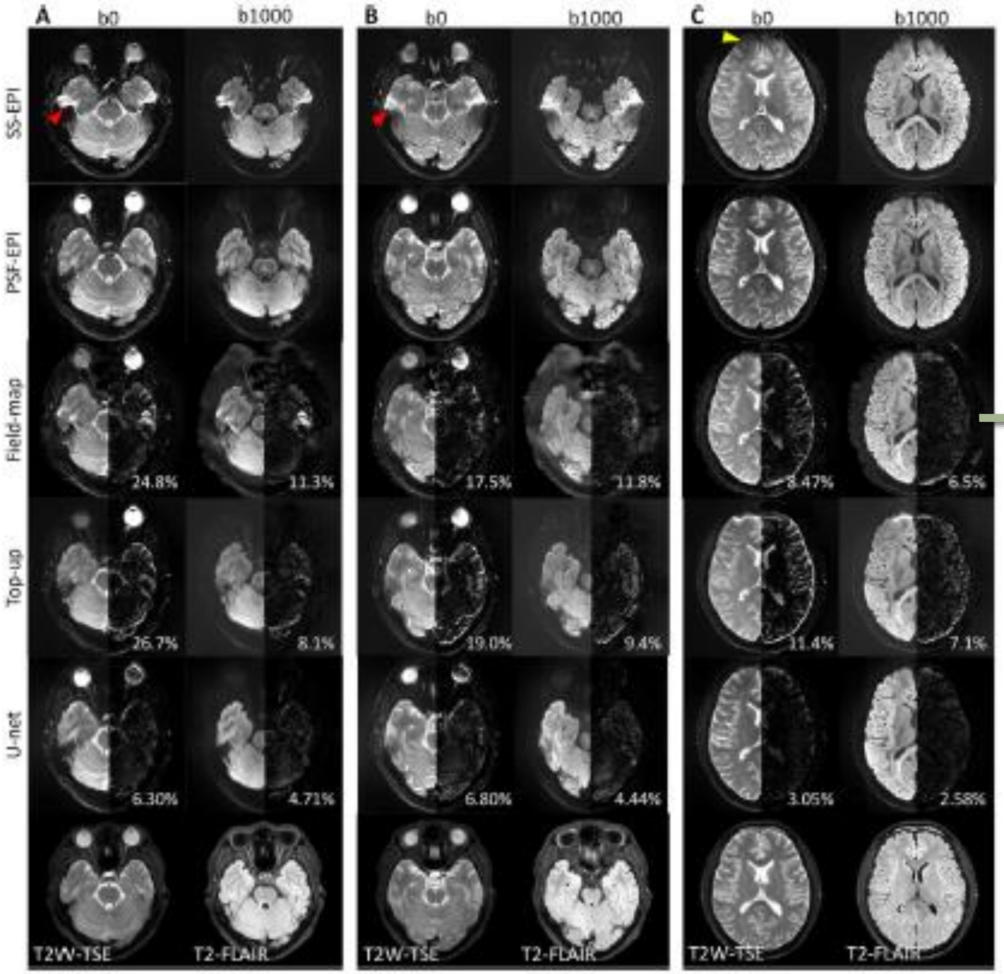
- **Results:**

Distortion correction results from three different methods along with other reference images



Red: high signal intensities due to signal pile-up
Yellow: low signal intensities due to signal compression

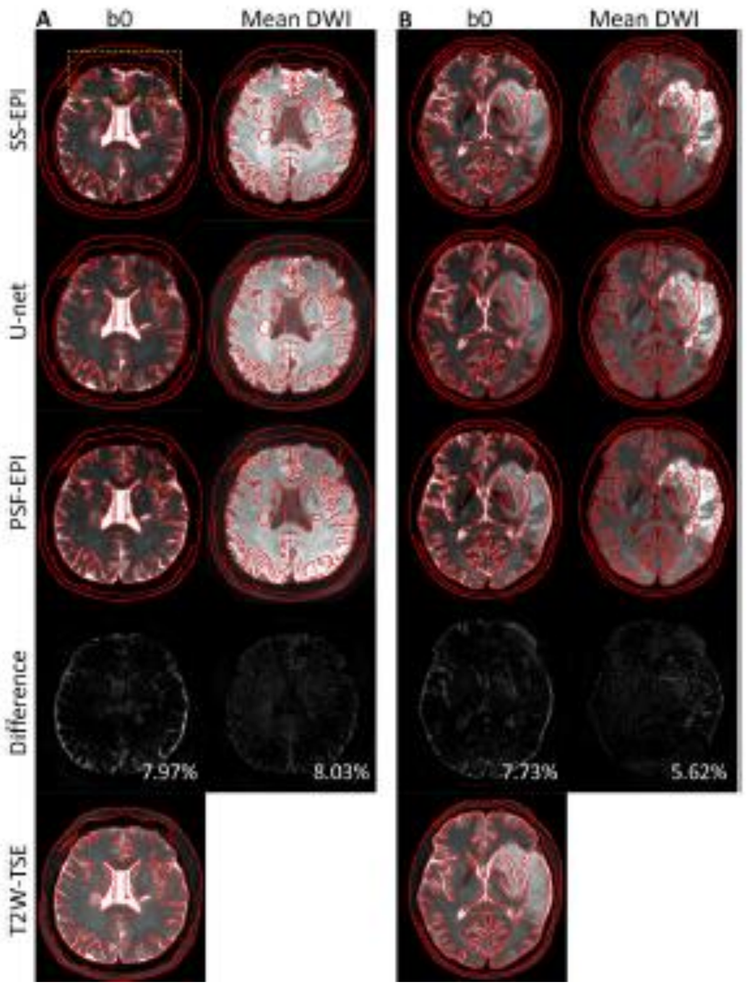
Difference maps between distortion-corrected images and PSF-EPI

✓ Showing better consistency with the PSF-EPI and T2W-TSE images

❖Distortion correction of single-shot EPI enabled by deep-learning

- **Results:**

Investigating if the network trained on healthy volunteers can handle patients' DWI images with lesions



Patient A with prior cerebral infarction
Patient B with subacute cerebral infarction

✓ The edges extracted from the corresponding T2W-TSE images are overlaid onto the b0 and mean-DWI images

❖Distortion correction of single-shot EPI enabled by deep-learning

- **Conclusion:**

✓ The neural network trained on healthy volunteers' data has the potential to generalize to patients with lesions

✓ the method is effective in correcting distortions even when there are variations in signal intensity due to different diffusion weightings

× The small number of patients included for checking the generalization feasibility of the U-net model

× Existing of observed differences in signal intensity along brain edges between the PSF-EPI and SS-EPI images, indicating the need for further optimization, especially in specific regions

× Requiring input images with the same phase-encoding direction as the training set and observing blurring artifacts and sensitivity to anatomy when testing the network on images with the opposite phase-encoding direction

Thank you