Reducing motion artifacts in brain MRI using vision transformers and self-supervised learning

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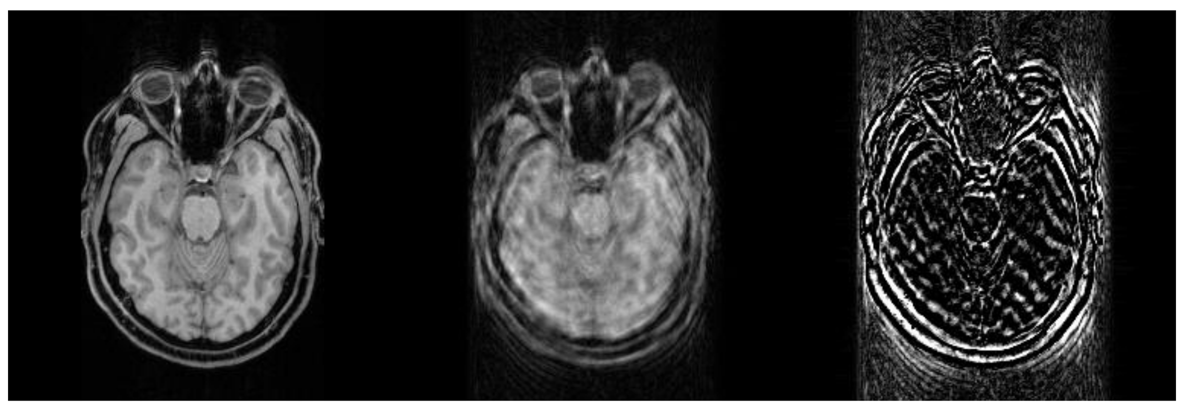
ICIP abu dhabi 2024
IEEE International Conference on Image Processing
27 - 30 October 2024 | Abu Dhabi, UAE

BACKGROUND

Motion in human subjects is inevitable and motion-induced magnetic resonance imaging (MRI) artifacts can deteriorate image quality and reduce diagnostic accuracy.



Representative clean image, corrupted image, and error map (absolute value of the difference between results and clean image multiplied 5.0).

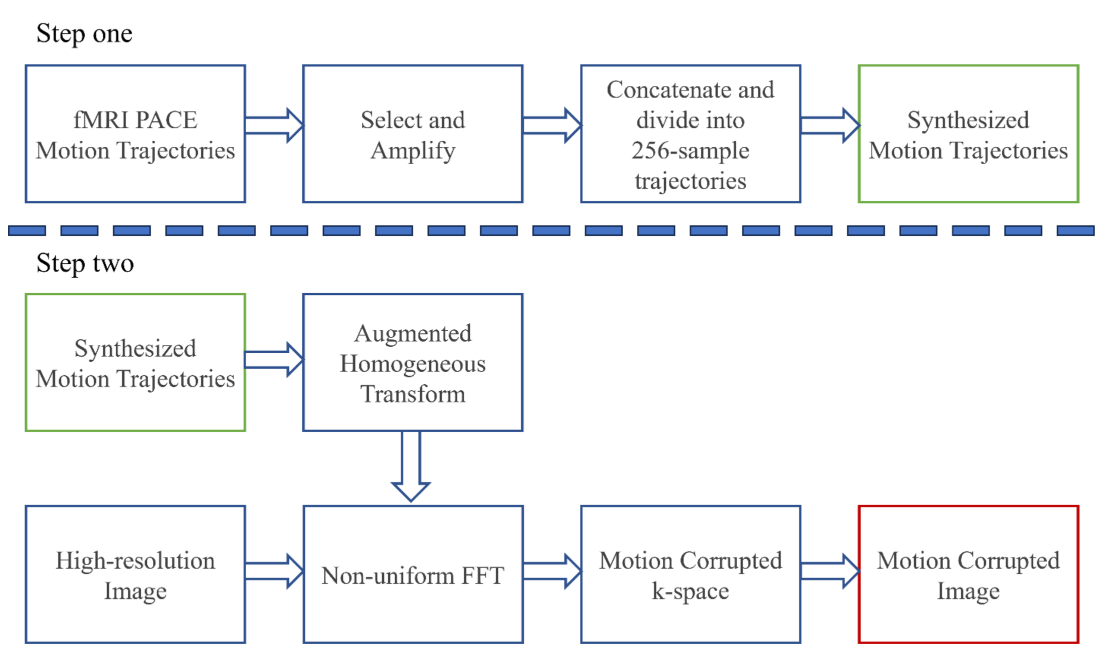
OBJECTIVE

The purpose of this work is to develop and assess a motion correction method using a self-supervised learning (SSL) and vision transformers named MC-Former.

MATERIALS AND METHODS

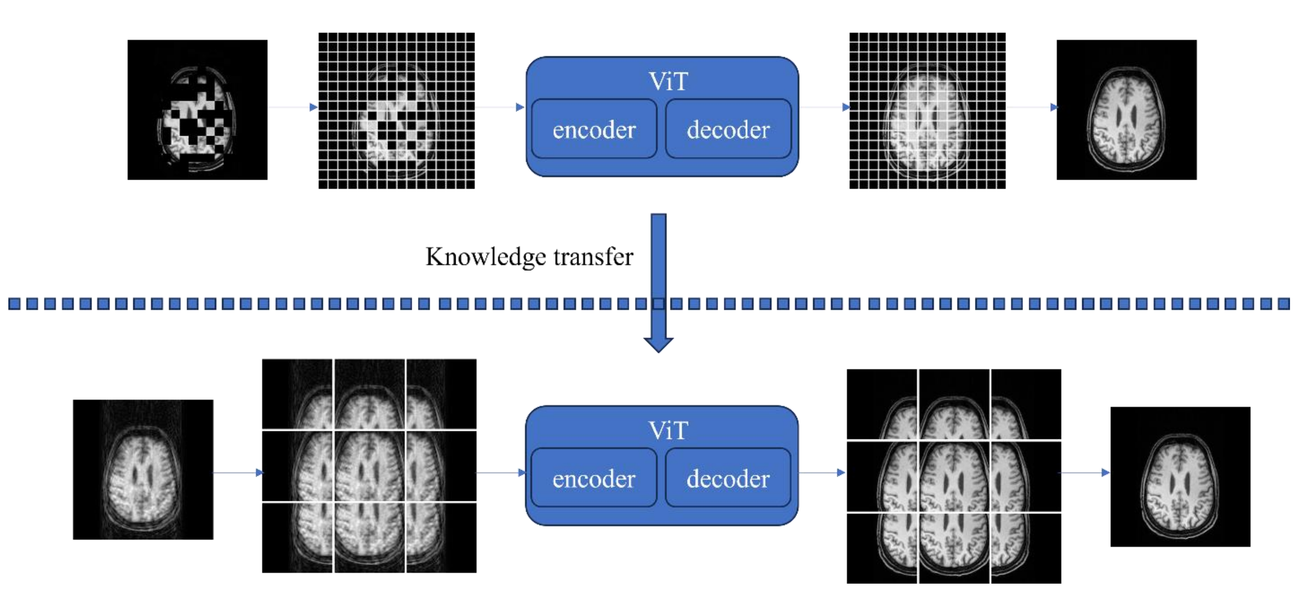
DATA

3T 3D sagittal magnetization-prepared rapid gradient-echo (MP-RAGE) scans from 52 subjects were used to generate 13,700, 1,950 and 4,680 slices as training, validation, and test sets.



METHOD

The MC-Former was derived from a vision transformers-based model with encoder-decoder structure and skip connections. We randomly masked 50% of patches from the T1-weighted axial clean image as input and reconstructed the missing patches using self-supervised pre-training. T1-weighted axial brain images contaminated with synthetic motions were then used to train the MC-Former to remove motion artifacts. Evaluation used simulated T1-weighted axial images unseen during training. The MC-Former is compared against MC-Net[1] and Restormer[2], which are state-of-the-art methods for motion correction and motion deblurring.



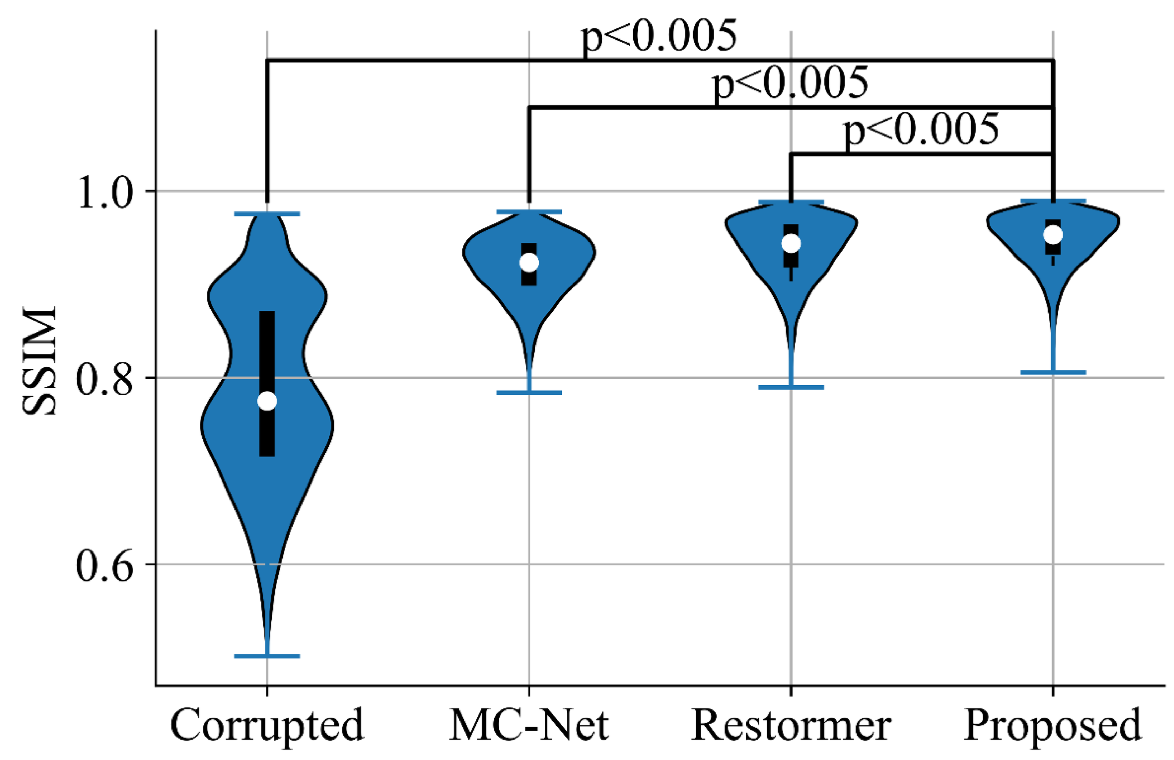
EVALUATION METRICS

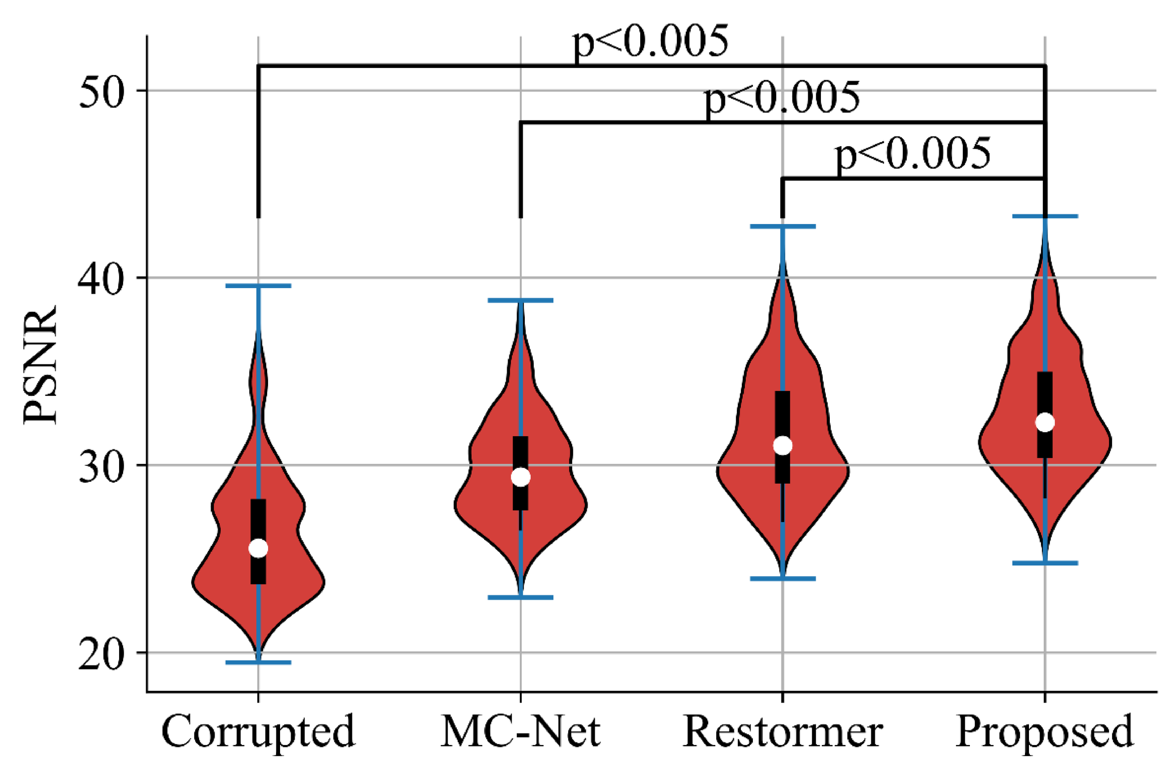
Performance indices included the peak signal to noise ratio (PSNR) and structural similarity index measure (SSIM). Paired t-tests were used for comparisons with p-value<0.05 considered significant.

RESULTS

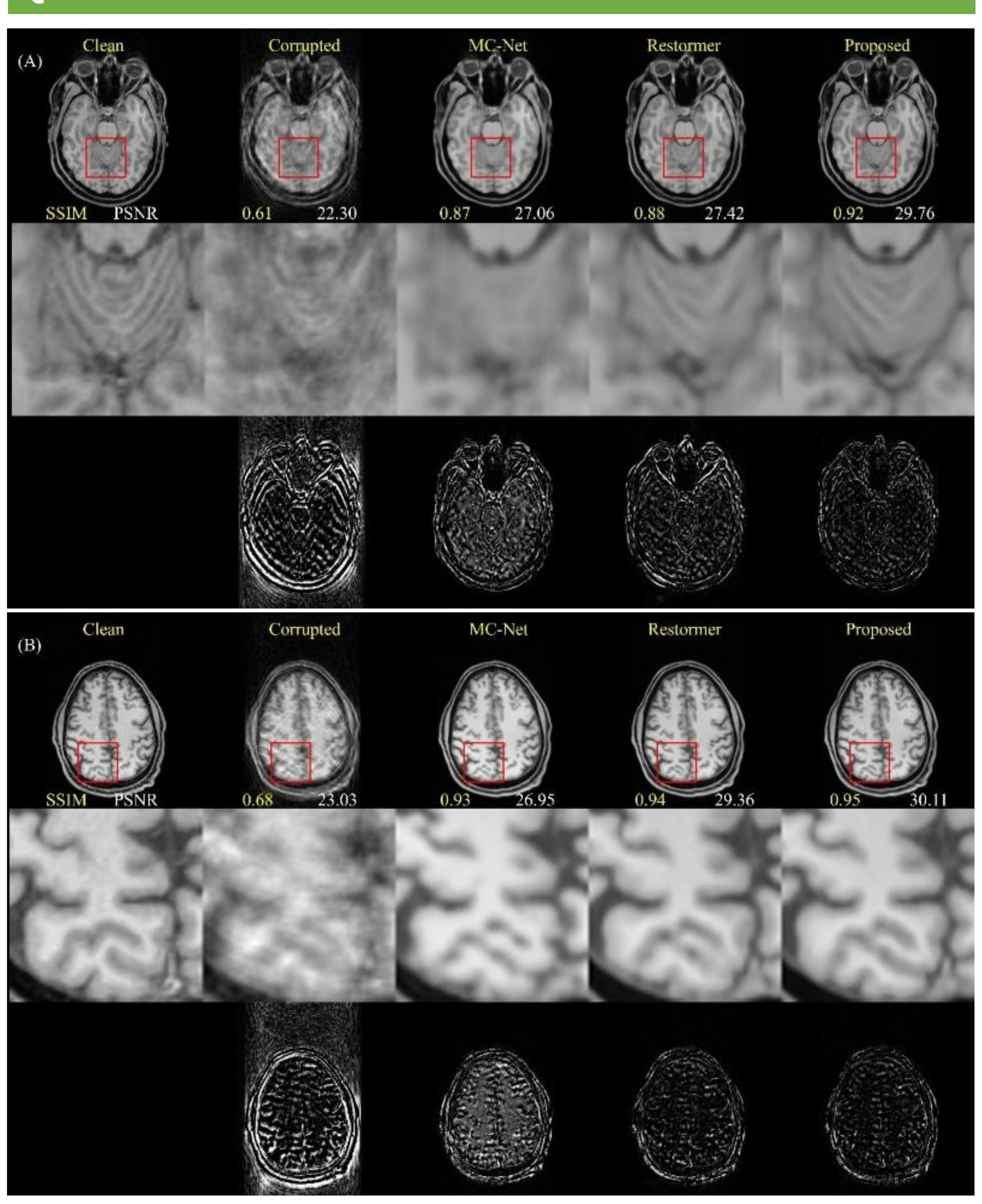
QUANTITATIVE EVALUATION

The MC-Former significantly outperformed the other two methods in terms of both PSNR and SSIM.



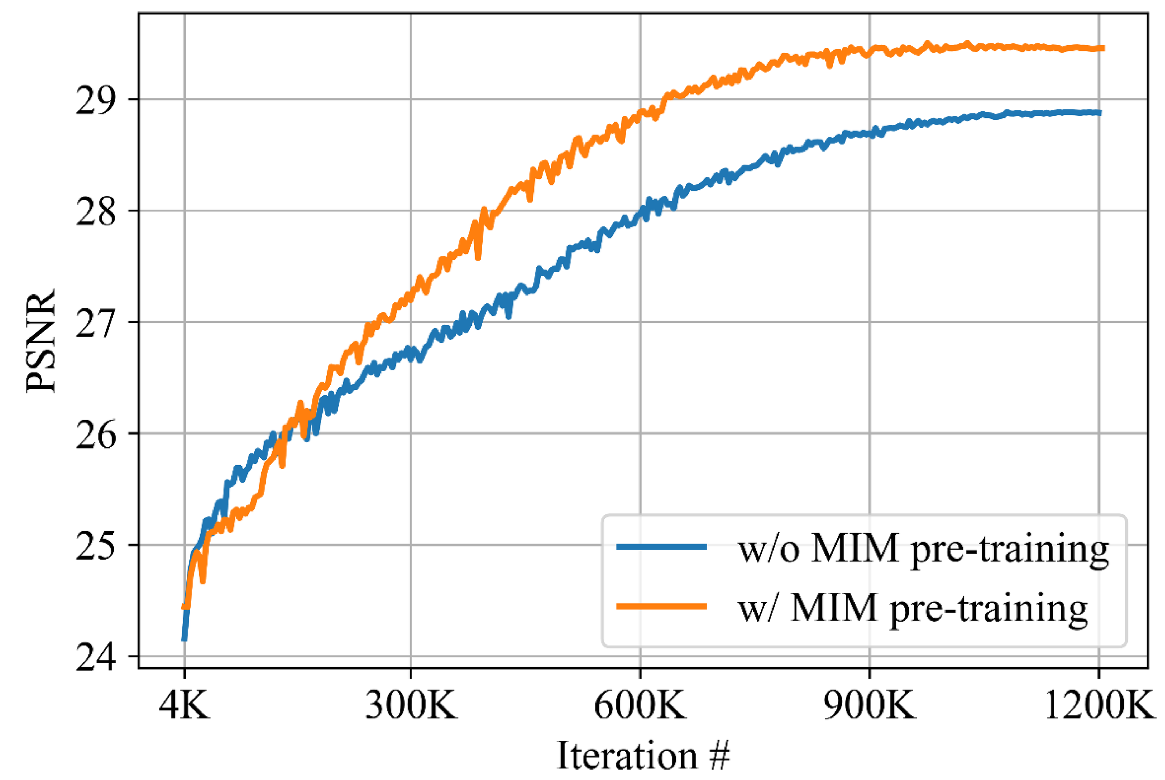


QUALITATIVE EVALUATION



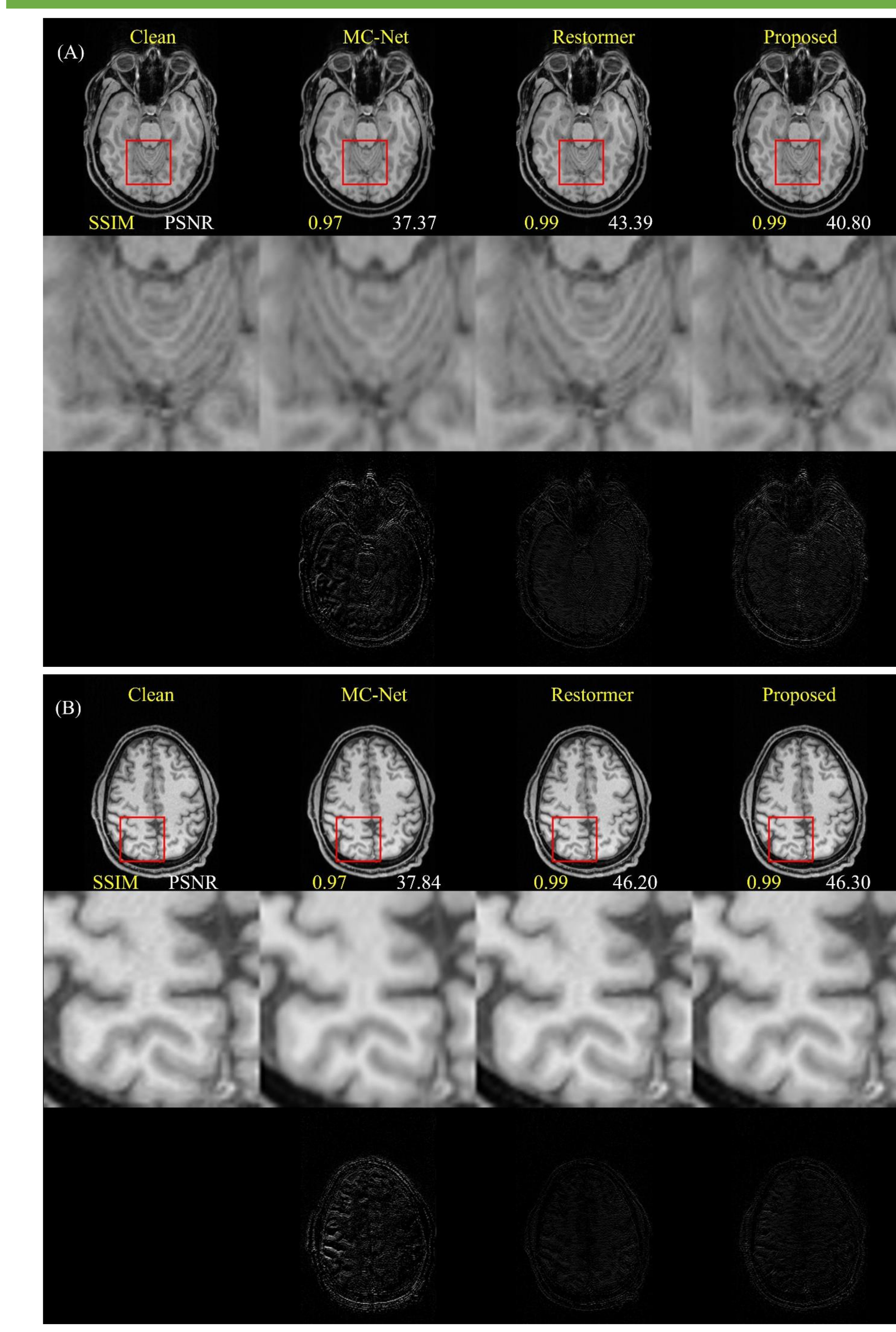
The first row of each subfigure contains the "clean" (reference) image, corrupted image, and motion correction results using the MC-Net[1], Restormer[2], and the proposed MC-Former. The second row of each subfigure zooms in on the red rectangle. The third row shows the error maps between the reference ("clean") image and corrupted and corrected images (absolute value of the difference between results and clean image multiplied by 5.0). MC-Former recovers more details than the other two approaches.

EVALUATION OF SSL



The model with SSL as pre-training has better performance and faster convergence than the model without SSL as pre-training.

EVALUATION ON CLEAN IMAGES



The ViT approaches (Restormer and the proposed) were better than the MC-Net at retaining image details when "clean" images were processed.

Conclusions

MC-Former can effectively suppress motion artifacts in brain MRI without compromising image quality. The effectiveness and efficiency of MC-former shows its potential for use in clinical settings. The code and trained model are available at https://github.com/MRIMoCo/MC-Former.

REFERENCES

1. L. Zhang et al., "Motion Correction for Brain MRI Using Deep Learning and a Novel Hybrid Loss Function," Algorithms, vol. 17, no. 5, p. 215, 2024.
2. S. W. Zamir et al., "Restormer: Efficient transformer for high-resolution image restoration," in Proceedings of the IEEE/CVF conference on computer vision and pattern recognition, 2022, pp. 5728–5739.