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Convolutional Neural Network for 2-D MRI Image Reconstruction in k-space

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Background

- Brain MRI is an excellent non-invasive imaging method for monitoring and diagnosing brain diseases and disorders.
- Scans can take 30-90 minutes increasing patient discomfort and medical cost and making it difficult to use in time-sensitive cases.
- MRI data is collected in k-space, where each pixel corresponds to a spatial frequency. The Fourier transform of k-space generates the MRI images we commonly see.
- Undersampling in k-space improves acquisition time but reduces image quality. Missing data is filled in with 0’s – a process known as zero-filling.
- Using Convolutional Neural Networks (CNNs) to “fill in” missing information from zero-filled images accelerates MRI acquisition

Project Goals

1. Reconstruct 2-D MRI brain images from zero-filled images in the image domain and in k-space using CNN
2. Investigate the performance improvement of training CNNs in k-space compared to the image domain

Data and Results

- Average PSNR and SSIM for reconstruction in the image domain: 27.50 dB and 0.7855, respectively
- Average PSNR and SSIM for reconstruction k-space: 28.59 dB and 0.7050, respectively
- 1.09 dB improvement in average PSNR for training in k-space vs. in the image domain

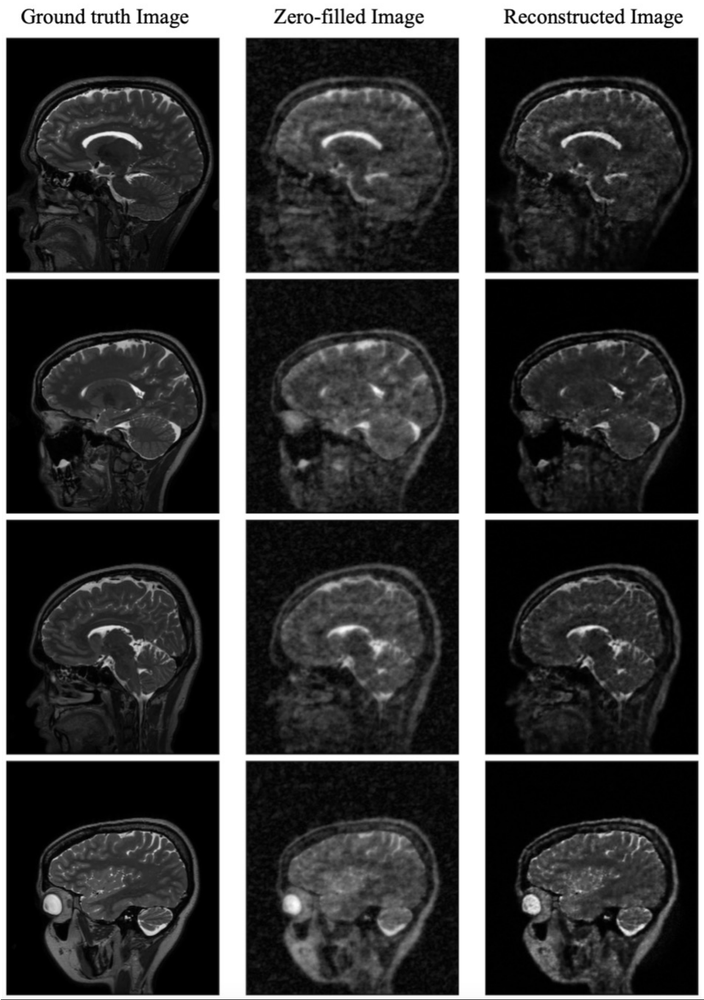

Fig 1. Side by side comparisons from the image domain reconstruction

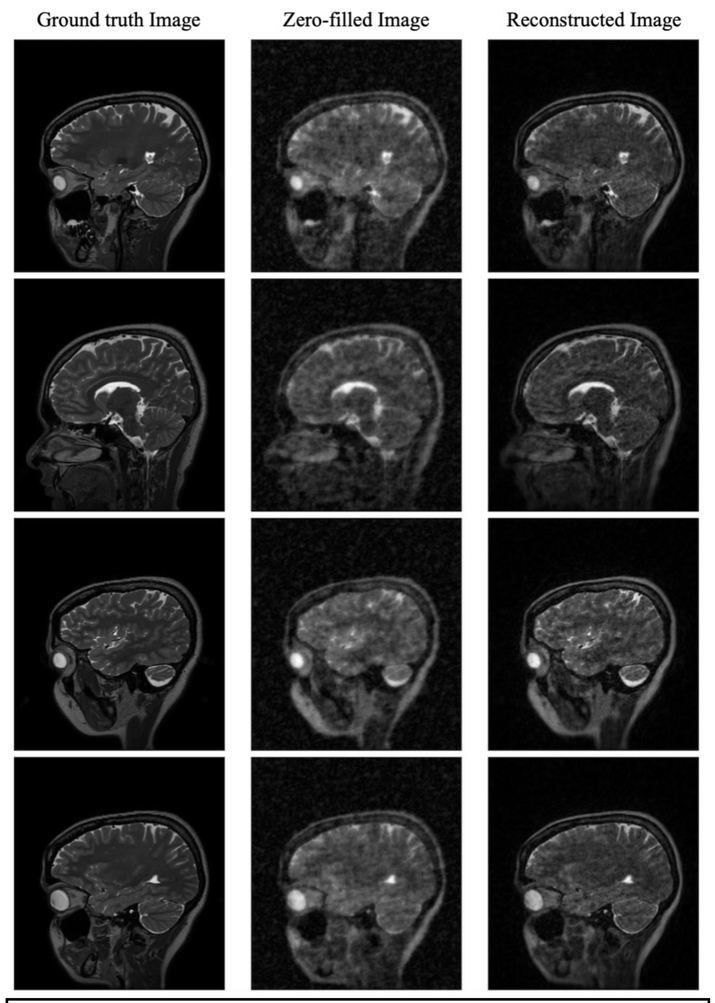

Fig 2. Side by side comparisons from the k-space resconstruction

Methods

- Wrote code in Python and the NVIDIA T4 TensorCore GPUs on Google Colab were used for training.
- Trained a PyTorch implementation of a U-net model (a CNN architecture) by mapping zero-filled images to their desired ground truths in the image domain and in k-space.
- Assessed the quality of the reconstructed images visually and with average PSNR and SSIM.

Conclusions

- Qualitative and quantitative measurements demonstrate the effectiveness of a simple U-net architecture (CNN) for 2-D brain MRI image reconstruction in both the image domain and k-space.
  - Reconstructed images from zero-filled images at 6-fold acceleration, enabling improved patient comfort and medical cost.
- Observed improved performance training in k-space vs. image domain
- Further research is needed to:
  - Improve image quality by incorporating our model into an artifact removal framework
  - Develop deep learning methods for 3-D interpolation in k-space

Contact Information

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The work presented here was done for the purposes of ESE 498 Capstone Design Project.

Scan QR Code on the right for Project Website: