

# Multi-Contrast High-Field Quality Image Synthesis for Portable Low-Field MRI Using Generative Adversarial Networks and Paired Data

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## Introduction

Portable low-field strength (64mT) MRI scanners promise to increase access to neuroimaging for clinical and research purposes, however these devices produce lower quality images compared to high-field scanners. In this study, we developed and evaluated a deep learning architecture to generate high-field quality brain images from low-field inputs using a paired dataset of multiple sclerosis (MS) patients scanned at 64mT and 3T.

## Hypothesis

We hypothesize that a generative adversarial network trained with paired 3T and 64mT data can qualitatively and quantitatively improve the quality of low-field images to levels comparable to 3T images.

## Methods

A total of 49 MS patients were scanned on portable 64mT and standard 3T scanners at Penn (n=25) or the National Institutes of Health (NIH, n=24) with T1-weighted, T2-weighted and FLAIR acquisitions. Using this paired multi-contrast data, we developed a generative adversarial network (GAN) architecture for low- to high-field image translation (LowGAN). We then evaluated synthesized images with respect to image quality, brain morphometry, and white matter lesions.

## Results

All results are derived from the test set. Synthetic high-field images demonstrated visually superior quality compared to low-field inputs (Figure 1) and significantly higher normalized cross-correlation (NCC) to actual high-field images for T1 ( $p=0.001$ ) and FLAIR ( $p < 0.001$ ) contrasts. LowGAN generally outperformed the current state-of-the-art for low-field volumetrics (Figure 2A-C). For example, thalamic, lateral ventricle, and total cortical volumes in LowGAN outputs did not differ significantly from 3T measurements. Synthetic outputs preserved MS lesions (Figure 2D-E) and captured a known inverse relationship between total lesion volume and thalamic volume.

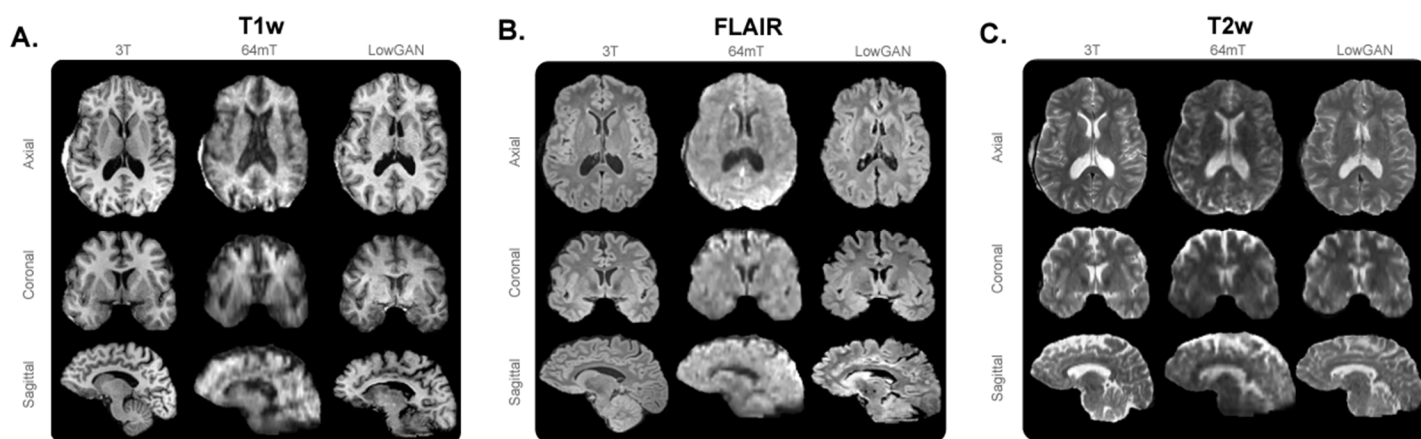
## Conclusion

LowGAN generates synthetic high-field images with comparable visual and quantitative quality to actual high-field scans. Enhancing portable MRI image quality could add value and boost clinician confidence, enabling wider adoption of this technology.

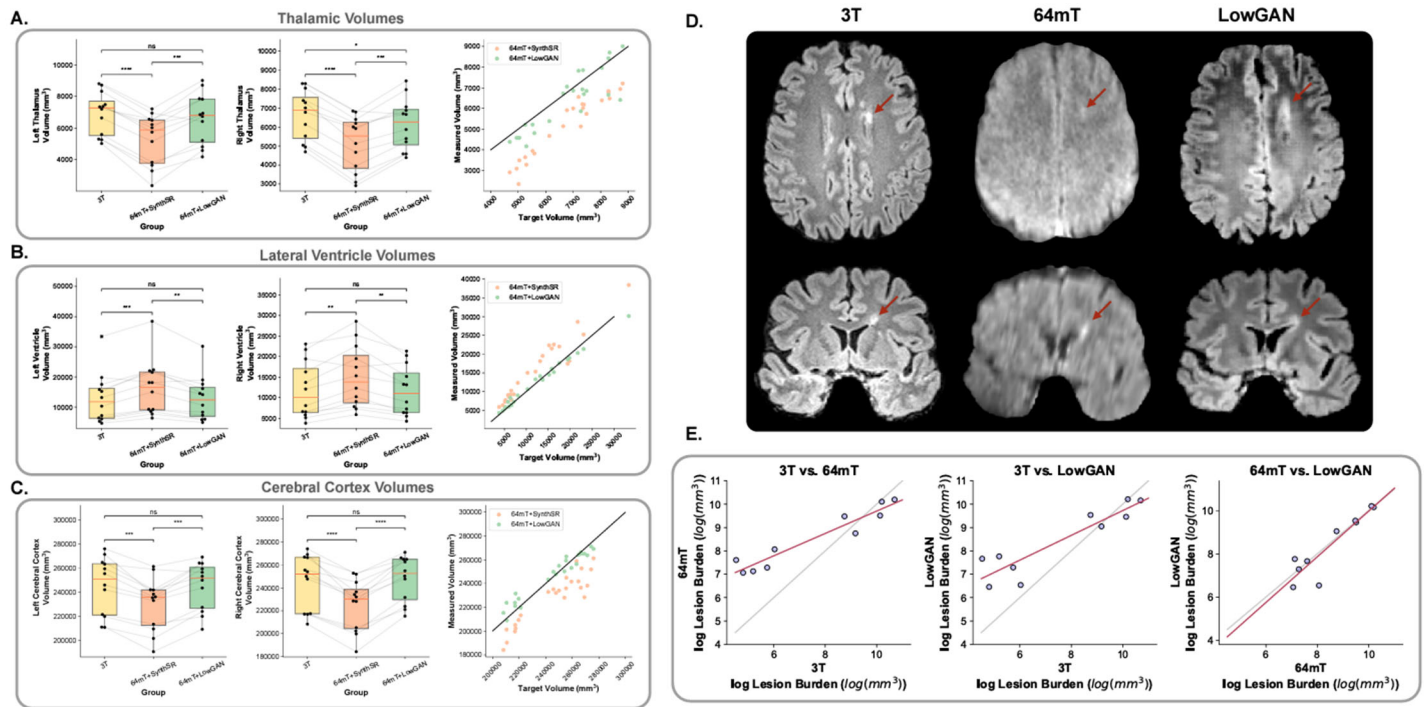
## Synopsis

We developed a multi-contrast generative adversarial network capable of generating 3T quality multi-contrast images from portable low-field (64mT) inputs.

## Figure(s)



**Figure 1.** Improved visual and quantitative quality: Panels A, B, and C show high-field (3T) and low-field (64mT) images and LowGAN outputs for a single test set case across T1w (A), FLAIR (B), and T2w (C) contrasts.



**Figure 2.** Improved volumetric measurements and lesion conspicuity: Panels A, B and C show estimated volumes for left and right thalamus (A), lateral ventricles (B), and cerebral cortex (C). Lines connect the same cases across the boxplots for volumes measured at 3T, 64mT reconstructed with SynthSR (64mT+SynthSR), and 64mT reconstructed with LowGAN (64mT+LowGAN). Scatterplots at the right compare the measured volumes for combined left and right sided structures from SynthSR and LowGAN synthesized outputs to the high-field target volumes. The black line represents perfect correspondence between high-field and synthesized volumes. Panel D. shows high-field (3T), low-field (64mT), and LowGAN output FLAIR images for a test set case with white matter lesions shown by arrows. Panel E shows scatterplots of the logarithm of lesion burden estimated in test set cases for: (left) high-field (3T) and low-field (64mT), (middle) high-field and LowGAN outputs, and (right) low-field and LowGAN outputs. The black line represents perfect correspondence between both measurements and the red line represents the line-of-best-fit.

## Keywords

Applications; Artificial Intelligence / Machine Learning; Emerging Technologies; Imaging Research