DeepFLAIR: a neural network approach to mitigate signal loss in temporal lobe regions of 7 Tesla FLAIR images

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Abstract

Introduction: Epilepsy affects approximately 1% of the world-wide population, with temporal lobe epilepsy being the most common focal epilepsy type[1]. In recent years, Ultra High Field Magnetic Resonance Imaging (UHF MRI), which encapsulates magnet strengths 7T and higher, has been shown to improve the detection of subtle potential epileptogenic lesions in patients with focal epilepsy[2,3]. Unfortunately, the higher magnetic field strength in UHF imaging introduces increased magnetic field inhomogeneities leading to image artifacts and signal attenuations[3,4]. The T_2-weighted FLAIR sequence is of particular interest to neuroradiologists due to its strong tissue contrast and suppressing the cerebral spinal fluid[4,5], however it can suffer severely from the magnetic inhomogeneity artifacts especially within the temporal lobe regions. In this study we aimed to aid this issue and improve the 7T FLAIR image quality by utilizing a machine learning approach.

Methods: Eight patients (mean age 31y; range 21-46y; 5 females) with chronic, drug-resistant epilepsy with a suspected epileptogenic zone (2 patients with 3T-positive lesions) were selected for this study. A non-linear regression multilayer perceptron using MP2RAGE and T_2-weighted images as inputs was set up to generate a new FLAIR-like image. The training was performed on the extratemporal-lobe voxels of the acquired 7T FLAIR image. After the training, the entire scanned area was reconstructed using the trained model to form the deepFLAIR image. The quality of the output image was evaluated by calculating the signal-to-noise ratio of the white matter (SNR_{WM}) and contrast-to-noise ratio (CNR) between the grey matter and white matter in the left and right manually delineated temporal lobe regions-of-interest.

Results: The deepFLAIR approach showed an increase in both SNR_{WM} and CNR for 10 out of 16 temporal lobes. Furthermore, a statistically significant improvement was found for both SNR_{WM} and CNR in the right temporal lobes.

Conclusion: This conceptual study presented a possibility to generate FLAIR-like images with reduced inhomogeneity artifacts in the temporal lobe regions and overall improved tissue contrast. Further optimization of the network and the training dataset might provide a significant boost in the image quality and its ability to fully reconstruct the attenuated temporal lobe areas.

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