Title: **Motion correction in MRI using deep learning**

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Introduction

Subject motion in MRI remains an unsolved problem; motion during image acquisition may cause artefacts that severely degrade image quality. In the clinic, if an image with motion artefacts is acquired, it will often be reacquired. This provides a source from which a large number of motion-degraded images, along with their respective re-scans, could be collected. These pairs of images could be used to train a neural network to identify the mapping relationship between an image with motion artefacts and a high quality, artefact free image. Our initial – proof of concept – objective is to train a neural network to perform a motion corrected image reconstruction on image data with simulated motion artefacts. We simulate motion in previously acquired brain images and use the image pairs (corrupted + original) to train a deep neural network (DNN).

Methods

Data: The image data were obtained from an open source neuro MRI data set [1]. This data set consists of a T2* weighted FLASH acquisition with magnitude and phase images for 53 patients, each with 128 non-overlapping image slices. This data set thus provides thousands of unique 2D magnitude and phase images. ***Motion Simulation***: Each set of 2D magnitude and phase images, from the data set described above, was combined to create a single complex image which was then Fourier transformed to simulate the acquired k-space data. To simulate rigid motion, k-space lines were rotated and phase shifted, simulating the k-space inconsistencies that would occur if the data were acquired while the subject was moving. The motion profiles were generated randomly and parameterized by the time, magnitude and direction of motion.
Network architecture and training: The DNN was developed and trained using the open source library TensorFlow. The input layer is a vector of motion corrupted k-space data, and is fully connected to the first hidden layer, which is followed by a convolutional neural network with 3 convolutional layers. The output of the network is the reconstructed magnitude image. 3463 image pairs were used to train the network and 300 were reserved for validation. The network was trained for 6 hours using two 12 GB GPU's on Sharcnet.

Results

The images predicted by the network, from motion-corrupted k-space, have improved image quality compared to the motion corrupted images. The mean absolute difference between the motion corrupted and ground truth images is 17% while the mean absolute difference between the DNN predicted and ground truth images is only 10%.

Discussion

A motion corrected image reconstruction using deep learning was successfully achieved on brain images with simulated motion artefacts. This proof of concept work represents the first time machine learning has been used to perform motion correction on MRI images. Future work will focus on further optimization of the network, evaluation of the network's transfer learning potential as well as developing a network for motion correction of 3D images.

[1] Forstmann BU, Keuken MC, Schafer AS, Bazin P, Alkemade A, Turner R (2014) Multi-modal ultra-high resolution structural 7-Tesla MRI data repository. Scientific Data 1:14005