Scan-Specific Machine Learning Reconstruction for MRI

Technology No. 20170326

IP Status: US Patent Issued; US Patent #: US 11,694,373

Faster MRI Scan Time

An accelerated MRI reconstruction approach, Robust Artificial-neural-networks for k-space Interpolation (RAKI) improves the noise properties of GeneRalized Autocalibrating Partial Parallel Acquisition (GRAPPA), which translates to image acceleration (i.e., faster scan times). This method learns a deep non-linear convolutional neural network (CNN) from limited scan-specific auto-calibration signal (ACS) data, and extends the linear convolutional kernels of GRAPPA while performing both training and reconstruction on a per image basis, leading to marked performance improvement. The method also extends to k-space interpolation techniques other than GRAPPA, and it is directly applicable to 3D parallel imaging, simultaneous multi-slice imaging, random undersampling and non-Cartesian sampling.

Machine Learning Applied in K-space

Long scan times remain a limiting factor in MRI, often necessitating trade-offs with spatial and temporal resolution or coverage. Accelerated imaging techniques are commonly required, with parallel imaging, e.g. SENSE or GRAPPA, being the most clinically used approach. However, image acceleration in parallel imaging is limited by the noise properties when estimating missing k-space points in GRAPPA (linear). While machine learning has previously been used in MRI, it required large databases of MR images for rigorous training, and relied on patterns across the training set rather than within each individual image. Until now, no other methods use deep learning in k-space in a self-contained manner. Applying machine learning techniques to train neural networks for interpolating missing points in k-space achieves higher acceleration rates and better noise properties. Once the CNN is trained, the reconstruction takes on the order of milliseconds.

BENEFITS AND FEATURES:

- Convolutional neural networks (CNN) nonlinearly estimate missing k-space points
- Deep learning of networks performed on scan-specific ACS data takes individual variability into account

- Suitable for precision medicine
- Improves noise properties and image acceleration (i.e., faster scan times and higher resolution imaging)
- Software can be implemented in MRI scanners as needed
- Requires no change to data acquisition compared to standard parallel imaging (e.g., GRAPPA); can therefore be used in conventional MRI scans and existing datasets to improve performance
- Extends to other k-space interpolation techniques for different settings, including simultaneous multi-slice imaging, random undersampling and non-Cartesian sampling

APPLICATIONS:

- Magnetic resonance imaging (MRI)
- Improving image reconstruction
- Parallel imaging (PI) reconstruction in MRI
- K-space interpolation techniques (e.g., 3D parallel imaging, simultaneous multi-slice imaging, random undersampling and non-Cartesian sampling)

Phase of Development - Pilot scale demonstration

Researchers

Mehmet Akcakaya, PhD
Assistant Professor, Electrical and Computer Engineering, Center for Magnetic Resonance Research
External Link (ece.umn.edu)

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