Plenary Lecture 3, 4

PL3

Ultrafast MR Spectroscopic Imaging

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Magnetic resonance spectroscopic imaging (MRSI) has long been recognized as a powerful tool for non-invasive, label-free molecular imaging and a lot of outstanding work has been done over the past three decades, resulting in significant advances in MRSI data acquisition, pulse sequences, data processing, and image reconstruction. However, in spite of these enormous progresses, current MRSI technology still falls short of providing adequate spatial resolution, speed, and signal-to-noise ratio (SNR) for routine clinical and research applications.

This talk will discuss our recent advances in overcoming the long-standing technical barriers for label-free molecular imaging using intrinsic MR signals. The ultrafast MRSI technology (known as SPICE: SPectroscopic Imaging by exploiting spatiospectral CorrElation), resulting from many years of research efforts, is based on a new approach to spatiospectral imaging, which includes rapid data acquisition, sparse sampling of (k, t)-space, constrained image reconstruction, and learning-based spectral quantification using spectral basis from quantum mechanical simulations. SPICE has demonstrated an unprecedented combination of resolution, speed and SNR for MRSI. For example, 1H-SPICE can provide high-resolution simultaneous mapping of brain tissue iron deposition, macromolecules, metabolites, neurotransmitters, and myelin water fraction. In this talk, I will give an overview of SPICE and show some “SPICY” experimental results that we have obtained so far.

Plenary Lecture 3, 4

PL4

AI-powered Fast MR Acquisition

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Recently, deep learning approaches with various network architectures have achieved significant performance improvement over existing iterative reconstruction methods in accelerated MRI problems. However, it is still unclear *why* these deep learning architectures work for specific problems. Moreover, in contrast to the usual evolution of signal processing theory around the classical theories, the link between deep learning and the classical image processing approaches re not yet well understood. In this talk, I review the recent advances of deep learning approaches for accelerated MRI and their link between compressed sensing approaches.

In particular, we first review the variational neural network that was first proposed in MR field, and the popular feed-forward neural network approaches using U-Net, which can remove undersampling artifacts from the aliasing artifact corrupted image. Then, we review several advanced approaches such as AUTOMAP, CascadeNet, KiKi-Net, MoDL, etc. Finally, we demonstrate that the neural network approaches can be directly implemented in k-space domain to interpolate the missing k-space data.

In order to explore the theoretical origin of the success of the neural network for accelerated MRI, we review some of the mathematical principles that have been proposed to explain the neural networks for inverse problems, which includes unfolding, convolution framelets, etc. Then, we introduce recent mathematical discovery of the expressivity, generalization power and optimization landscape that give us hint to understand the power of AI for accelerated MRI.

We also introduce several clinical applications of neural network approach for accelerated MRI, such as cardiac MRI, TWIST, fMRI, etc. The talk will be concluded with the outlook in this field.