# Physics

**Physics-I** *Machine Learning in MRI: design, acquisition, and analysis*
*(3 speakers, 90 min)*

**Physics-II** *Chemical Exchange Saturation Transfer: signal origin, animal model, and human applications*
*(3 speakers, 90 min)*

**Physics-III** *Diffusion MRI: from basic principles to advanced applications*
*(3 speakers, 90 min)*

**Physics-IV** *Quantitative MRI: from parametric mapping to multi-parametric application*
*(2 speakers, 60 min)*

**Physics-V** *Novel MRI modalities*
*(2 speakers, 60 min)*

Hsiao-Wen Chung, PhD
鍾孝文 教授

# Time Table

Saturday, May 21, 2022
Room 203

| Time | Topics | Speakers | Moderators |
|---|---|---|---|
| 08:30-09:00 (30mins) (Korea time 09:30-10:00) | Deep Reinforcement Learning-designed Radiofrequency Waveform in MRI | Jongho Lee | Teng-Yi Huang<br>Ming-Long Wu |
| 09:00-09:30 (30mins) (China time 09:00-09:30) | Acceleration of Dynamic MRI in the Lung and Abdomen in Free-breathing Empowered by Machine Learning | Yiping Du | Teng-Yi Huang<br>Ming-Long Wu |
| 09:30-10:00 (30mins) | CNN-based Lesion Delineation of Vestibular Schwannoma and Meningioma for Gamma Knife Radiosurgery using Stereotactic Magnetic Resonance Images | Yu-Te Wu | Teng-Yi Huang<br>Ming-Long Wu |

# Machine Learning in MRI: design, acquisition, and analysis

Organizer: Hsiao-Wen Chung

## Overview:

Machine learning is now revolutionizing the scientific community, with no exception in MRI. Applications of machine learning in MRI consist of many different possibilities, for instance on the acquisition technique, during the data acquisition procedure, or for analysis after images are obtained. In this session, Prof. Jongho Lee from Korea will share with us their recent advances in the use of machine learning in the design of radiofrequency pulses; Prof. Yiping Du from China will talk about how machine learning helps scan acceleration for free-breathing dynamic MRI; and Prof. Yu-Te Wu from Taiwan will address machine-learning lesion delineation in MRI for radiosurgery.

# *Deep-designed Radiofrequency Waveform in MRI*

- Professor, Department of Electrical and Computer Engineering, Seoul National University
- Exploration of contrast mechanisms in MRI, development of novel neuroimaging methods, machine learning in MR imaging methods

Jongho Lee, Ph.D., Korea

# Deep-designed Radiofrequency Waveform in MRI

- **Synopsis:**
- In this lecture, a new area of deep learning research in MRI, data acquisition, is presented. After a brief overview of various proposals of deep learning in acquisition, I will introduce research efforts in building a sequence or a part of a sequence. Then, a new approach of designing an RF pulse, the simplest but complete design by itself, will be explained. This method, which is referred to as DeepRF, combines deep reinforcement learning and optimization to find a new RF pulse for a given specification by self-training. DeepRF has demonstrated to design well-known RF pulses with improved energy deposition. Compared to conventional approaches, the method requires no design rules nor training dataset and reveals new ways of manipulating magnetization, suggesting advantages of deep learning in data acquisition.
- **Key Reference:**


- Shin D, Kim Y, Oh C, An H, Park J, Kim J, Lee J. Deep reinforcement learning-designed radiofrequency waveform in MRI. Nature Machine Intelligence. 2021 3:985-994
- Shin D, Ji S, Lee D, Lee J, Oh SH, Lee J. Deep Reinforcement Learning Designed Shinnar-Le Roux RF Pulse Using Root-Flipping: DeepRF(SLR). IEEE Trans Med Imaging. 2020;39:4391-4400.

# *Acceleration of Dynamic MRI in the Lung and Abdomen in Free-breathing Empowered by Machine Learning*

Yiping Du, Ph.D., China

- ZhiYuan Chair Professor of Biomedical Engineering, Director of Institute for Medical Imaging Technology, Shanghai Jiao Tong University
- Development of novel MRI technology including real-time imaging in therapy, 4D imaging of moving organs in the body, and quantitative imaging of the brain

# Acceleration of Dynamic MRI in the Lung and Abdomen in Free-breathing Empowered by Machine Learning

- **Synopsis:**
- Techniques for free-breathing 4D MRI of the lung and abdomen have been developed using radial acquisitions. An acceleration rate of up to 25x has been achieved using machine learning based reconstruction algorithms. These techniques have the potential applications in the correction of respiratory motion artifacts in PET-MR and real-time tracking of treatment targets in MR-LINAC.

- **Key Reference:**


- Zhang Y, She H, Du YP. Dynamic MRI of the abdomen using parallel non-Cartesian convolutional recurrent neural networks. Magn Reson Med. 2021;86:964-973.
- Chen Q, She H, Du YP. Whole Brain Myelin Water Mapping in One Minute Using Tensor Dictionary Learning With Low-Rank Plus Sparse Regularization. IEEE Trans Med Imaging. 2021;40:1253-1266.

# *Combining analysis of multi-parametric MRI into a convolutional neural network: Precise target delineation for vestibular schwannoma treatment planning*

- Professor of Biomedical Imaging and Radiological Sciences, National Yang Ming Chiao Tung University
- Advancements in artificial intelligence techniques for medical imaging and signal analysis, with applications such as structural network analysis in spinocerebellar ataxia type 3

## Yu-Te Wu, Ph.D., Taiwan

# *Combining analysis of multi-parametric MRI into a convolutional neural network: Precise target delineation for vestibular schwannoma treatment planning*

- **Synopsis:**
- Manual delineation of vestibular schwannoma (VS) by magnetic resonance (MR) imaging is required for diagnosis, radiosurgery dose planning, and follow-up tumor volume measurement. A rapid and objective automatic segmentation method is required, but problems have been encountered due to the low through-plane resolution of standard VS MR scan protocols and because some patients have non-homogeneous cystic areas within their tumors. In this talk, a two-pathway U-Net model using multiparametric MR images (T1-weighted, T2-weighted (T2W), and T1-weighted with contrast images.) with different image contrasts as input for effectively segmenting tumors will be discussed.

- **Key Reference:**


- Lee WK, Wu CC, Lee CC, Lu CF, Yang HC, Huang TH, Lin CY, Chung WY, Wang PS, Wu HM, Guo WY, Wu YT. Combining analysis of multi-parametric MR images into a convolutional neural network: Precise target delineation for vestibular schwannoma treatment planning. Artif Intell Med. 2020;107:101911.
- Lee CC, Lee WK, Wu CC, Lu CF, Yang HC, Chen YW, Chung WY, Hu YS, Wu HM, Wu YT, Guo WY. Applying artificial intelligence to longitudinal imaging analysis of vestibular schwannoma following radiosurgery. Sci Rep. 2021;11:3106.