Redefining MRI:
From Image to Insight

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Educational Session 1: MD-PhD

SY02-3

MRI with Deep Learning

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The integration of deep learning (DL) into MRI is transforming neuroradiology by addressing inherent trade-offs among scan time, image resolution, and diagnostic accuracy. From a clinical perspective, this lecture offers a concise overview of DL applications in MRI, intended to support radiologists in everyday practice while also providing MRI scientists with a clinically grounded perspective.

Image Reconstruction and Acceleration: Prolonged acquisition times and patient motion remain persistent challenges in MRI. DL reconstruction techniques that capture long-range contextual information with reduced computational complexity offer clinical relevance by shortening scan time while improving signal-to-noise ratio.

Generative AI and Synthetic MRI: Image-based generative AI, using Generative Adversarial Networks (GANs) and diffusion models, enables synthesis of missing MRI sequences, generation of high-quality scans from short low-quality inputs, and production of synthetic CTs to reduce radiation exposure. Quantitative synthetic MRI (syMRI) relaxometry is presented as an emerging biomarker.

Advanced Lesion Detection and Diagnosis: DL demonstrates strong performance in automated segmentation and classification. Recent studies have explored anomaly detection methods that leverage multi-contrast MRI information to identify various pathologies, offering clinical utility even without extensive annotated datasets.

Post-Deployment Monitoring and Good Machine Learning Practices (GMLP): Clinical translation of DL models requires adherence to GMLP. Key considerations include the limitations of "black box" algorithms, the role of Explainable AI (XAI), and post-deployment monitoring to mitigate performance degradation from data drift. Human-AI collaboration frameworks, such as the "human-on-the-loop" model, support safety, transparency, and workflow efficiency.

DL has reshaped MRI physics and clinical diagnostic pipelines, while demanding rigorous, continuous quality assurance to ensure safe and effective integration into radiological practice.

Keywords: *Deep learning reconstruction, Generative AI, Automated lesion detection, Post-deployment Monitoring*