Lecture Title: Use-case Driven Machine Learning for Wireless Sensing, Communications and Networking

Lecture Abstract (250 words): Machine learning (ML) will impact all faces of wireless, including the three critical pillars of sensing and communications at the device level and then multi-node networking at a systems level. Using several practical examples, this tutorial will describe the foundations and advances in how to preprocess data to make it suitable for RF decision pipelines, models that are customized for running inference tasks and are able to fuse information from multiple sources for enhanced decision making. We will begin with the use case of RF Fingerprinting that involves detecting a specific device out of several hundred using convolutional neural networks (CNNs), even if they transmit the same waveform and identifier. The second use case will cover the topic of waveform classification, demonstrating how transformers can perform better than classical CNNs for such inference tasks. While both these use cases are at the device-level, we will next discuss how cellular networks, specifically Open Radio Access Networks, can utilize ML for traffic classification tasks and the role of explainable AI for deepening our trust in these models, without which operators are unlikely to deploy them at-scale. The final use cases will show how multimodal sensing can be deployed for wireless tasks like directional beamforming, combining information from camera and LiDAR and thus going beyond RF-only approaches.