Lecture Title:

Introduction to ML Challenge: Channel Charting in Distributed mMIMO Measurements

Lecture Abstract:

Massive Multiple-Input-Multiple-Output (MIMO) systems improve spectral efficiency through spatial multiplexing and therefore play a crucial role in future wireless communication standards. The large number of base station (BS) antennas enables channel observation with high spatial resolution, paving the way for additional applications such as Joint Communication and Sensing (JCaS) and localization services. Channel state information (CSI), which must be collected for communication purposes, is reused for these applications. While classical source localization techniques require strong model assumptions and therefore suffer under multipath conditions, CSI fingerprinting-based localization methods can be applied in more complex environments. However, the need for accurate ground truth position labels makes these machine learning methods expensive and impractical.

Channel charting, on the other hand, is a fully self-supervised learning technique that aims to reconstruct a two- or three-dimensional map of the radio environment (the "channel chart") without relying on position labels. The goal of channel charting is to preserve the spatial consistency of the environment in the channel chart by utilizing similarity relationships in the high-dimensional CSI. For this purpose, a suitable dissimilarity metric is defined that determines dissimilarities ("pseudo-distances") between CSI samples. Learning the mapping from the high-dimensional CSI to the low-dimensional channel chart is an optimization problem that minimizes the discrepancy between the point-to-point distances in the channel chart and the respective dissimilarities. Neural networks are generally well suited for channel charting because inference on new samples is very efficient.