Ph.D. in Information Technology
Thesis Defense

March 4th, 2025
at 14:00
Conference Room Emilio Gatti – building 20

Lorenzo CAZZELLA – XXXVI Cycle

Machine Learning Methods for Signal Processing with Applications to the Wireless Physical Layer

Supervisor: Prof. Matteo Matteucci

Abstract:

This multidisciplinary thesis, at the intersection of machine learning, signal processing, and wireless communications, aims to study and develop adaptive signal processing techniques that exploit prior knowledge on the features of systems and signals to produce accurate models of physical phenomena. The development of adaptive and data-efficient techniques in noisy and low-data settings is the goal of the recently emerged Machine Learning for Signal Processing research branch. Despite being noisy, real-world signals often retain intrinsic structures reflective of the physical systems that generated them. Nevertheless, the number of available observations that can be exploited to determine such hidden structure can be very limited, while physical systems can present complex nonlinear and time-variant behavior. Besides, highly computation-efficient methods are often required for applicability in challenging estimation settings. In this thesis, we tackle two of these estimation conditions: (i) the design of low-rank signal denoising methods by means of clustering-based and deep learning-based subspace estimation, with application to mmWave channel estimation in urban wireless vehicular communications, and (ii) the association of a radar target with the corresponding communication user in integrated sensing and communication (ISAC) systems, achieved by deep learning-based joint radar target detection and beam prediction and by performing data association in the beamspace. To obtain a realistic environment for the evaluation of the proposed methods, we integrated vehicular traffic, multi-sensor, V2X ray tracing channel simulation, and mmWave MIMO radar imaging in a single multi-modal co-simulation framework. We provide experimental results showcasing the effectiveness of the proposed techniques for the physical layer of wireless communications. We show that the design of adaptive techniques exploiting the representational power of machine learning and deep learning can lead to data-efficient estimation performance under the challenging high-mobility conditions of the wireless physical layer in urban vehicular settings, which can be instrumental in the context of the future 6G communications.

PhD Committee

Prof. Andrea Bonarini, Politecnico di Milano

Prof. Danilo Comminiello, Università Sapienza di Roma

Prof. Paolo Ceravolo, Università degli Studi di Milano