Lecture Title: Wireless Computations by Digital Communications

Lecture Abstract (250 words): The need of running machine learning (ML) services over wireless networks is promoting the design of new communication protocols. In fact, in wireless networks, ML services face major challenges in terms of computation, bandwidth, scalability, privacy, and security. One proposal to overcome such challenges is Over-the-air computation (OAC), which is a known technique where wireless devices transmit values by analog amplitude modulation so that a function of these values (e.g., Federated Learning gradient aggregations) is computed over the communication channel at a common receiver. OAC dramatically reduces communication energy use, amplify spectrum efficiency of several order of magnitudes, and achieve privacy protections. The physical reason is the superposition properties of the electromagnetic waves, which naturally return sums of analog values. Consequently, the applications of OAC are almost entirely restricted to analog communication systems. However, the use of digital communications for OAC would have several benefits, such as error correction, synchronization, acquisition of channel state information, and easier adoption by current digital communication systems. Nevertheless, a common belief is that digital modulations are generally unfeasible for computation tasks because the overlapping of digitally modulated signals returns, in general, meaningless values. In this lecture, we will present a fundamentally new computing method, named ChannelComp, for performing OAC by any digital modulation. We will show how digital modulation formats allow us to compute a wider class of functions than OAC can compute. We show by analysis simulation the superior performance of ChannelComp in comparison to OAC.