Data-driven Decision Making and Estimation in CPS/IoT Networks

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The modern instantiation of a sensor network is a cyberphysical (CPS) system where CPS subsystems can be interconnected by a shared communication network of limited bandwidth. A common problem in CPS networks is the sensing and communication of spatio-temporal signals. However, there are fundamental differences between estimation (sensing) and communication. For example, the type of signal one would design to optimize sensing is very different from that for optimized communication. In this talk, we explore some of these differences and discuss how joint communication and sensing should occur in different problem settings. In particular, we examine problems where multiple sensors make observations and must share the communication medium to transmit these signals to a fusion center that will endeavor to perform remote estimation all of the sensed signals. A new class of remote estimation problems, where the communication resources are allocated dynamically based on the observations at the sensors, rather than purely on their statistical description is examined. We address the optimal design of a collision avoidance policy by selecting the most informative sensor to transmit at a time. We first establish person-by-person optimal policies for the scheduling of sensors. Then, we will show how our theoretical results can be applied to design scheduling policies where the joint probability density of the observations is unknown using machine learning techniques. We will extend our results to the case when the scheduler uses an energy harvesting battery as well as to the case of purely decentralized decision making. Time permitting, applications to the case of microbial decision making in quorum sensing networks will be discussed.