Energy and Delay: Network Optimization in Cyber Physical Human Sensing Systems
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Wireless body area sensing networks (WBANs) have the potential to revolutionize health care in the near term and enhance other application domains including sports, entertainment, military and emergency situations. These WBANs represent a novel cyber-physical system that unites engineering systems, the natural world and human individuals. The coupling of bio-sensors with a wireless infrastructure enables the real-time monitoring of an individual's health, environment and related behaviors continuously, as well as the provision of real-time feedback with nimble, adaptive, and personalized interventions. Our prior work has shown that WBAN systems present new challenges due to the following features: (a) sensors and sensed data are heterogeneous in fidelity, informativeness and costs; (b) the fusion center, in addition to the sensors, have energy limitations; and (c) the communication channel and the utility of sensors are dependent on individual's state. Our research objective is to investigate the complex interactions and interdependencies among sensing, communication and control in WBANs and leverage them to optimize resource utilization and system performance for enhanced health care monitoring.

We have made contributions in the following areas: (1) for remote estimation with limited and event based communication, we have shown that threshold based strategies are optimal for certain choices of the estimation method; (2) for real-time encoding and decoding for zero-error communication we have developed a simple sufficient condition for zero-error communication in the case of point-to-point communication for Markov or iid sources over memoryless channels; (3) in the design of optimal strategies for decentralized control problems we have shown the existence of simple and recursively computable sufficient statistics; and (4) for active state tracking with heterogeneous sensors, we have developed a Kalman-like filter for the tracking of discrete states, as relevant to our physical activity detection application via a wireless body area sensing network. The original work focused on the heterogeneous properties of the sensors; we are currently examining the analysis of a simplified system in order to drive heuristics for larger state spaces.