Sensor Lattices - #1035345

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Abstract

Using the newly introduced idea of a sensor lattice, this project conducts a systematic study of the “granularity” at which the world can be sensed and how that affects the ability to accomplish common tasks with cyberphysical systems (CPSs). A sensor is viewed as a device that partitions the physical world states into measurement-invariant equivalence classes, and the sensor lattice indicates how all sensors are related. Several distinctive characteristics of the pursued approach are: 1) Virtual sensor models are developed, which correspond to minimal information requirements of common tasks and are independent of particular physical sensor implementations. 2) Uncertainty is decoupled into disturbances and preimages, the latter of which yields the measurement-invariant equivalence classes and sensor lattice. 3) The development of particular spatial and temporal filters that are based on minimal information requirements of a task. 4) Formally establishing the conditions that enable sensors in a CPS to be interchanged, and then determining the relative complexity tradeoffs. The intellectual merit is to understand how mappings from the physical world to sensor outputs affect the solvability and complexity of commonly occurring tasks. This is a critical step in the development of mathematical and computational CPS foundations. Broader impact is expected by improving design methodologies for CPS solutions to societal problems such as assisted living, environmental monitoring, and automated agriculture. The sensor lattice approach is transformative because it represents a new paradigm with which to address basic sensor-based inference issues, which extend well beyond the traditional academic boundaries.