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Optimal Sensor Design in Estimation

Estimator performance depends on the sensors as well as the estimator design. This is particularly an issue for systems modeled by partial differential equations. For these systems, the location of the sensors can often be chosen. There is also generally a variety of sensor types available that measure different aspects of the state. Furthermore, the development of smart materials means that in some cases, the shape of the sensor can also be designed. It is reasonable to use the same criteria for sensor design and location as for the estimator design. The solution to an operator Riccati equation minimizes the steady-state error variance. This extends a result previously known for finite-dimensional systems. The trace of the Riccati operator is thus a reasonable cost function. A framework for calculation of the best sensor locations using approximations is established. This allows the question of sensor choice to be investigated since each sensor type can be assumed to be optimally located. The problem of optimal sensor shape is mathematically complex. It is first stated formally, and then it is shown to be well-posed and to possess optimal solutions under certain conditions. The results are illustrated by several examples.