

Control of Mobile Sensors for Optimal State Estimation

John. A. Burns and Eugene. M. Cliff
Interdisciplinary Center for Applied Mathematics
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061-0531.

ABSTRACT

In this paper we consider an optimal control problem that arises in the design and control of mobile sensors for state estimation. The development of unmanned aerial vehicles (UAVs) and micro aerial vehicles (MAVs) has produced a new mechanism for practical sensing and tracking with mobile sensors. The potential applications of this technology range from estimating biohazard sources to estimating the state of a contaminant as it moves through a building to target identification and estimation. It is clear that mobile sensors offer improved capability for accurate state estimation. It is not always clear how one should manage and control these sensors in order to optimize a desired performance. For example, it is well known in the case of infinite dimensional systems that dynamically mobile sensors/actuators can produce observability and controllability when static sensors/actuator pairs fail. However, the theoretical basis of these results are not always helpful in determining (computing) optimal sensor paths especially if one considers the mobile sensor dynamics.

We focus on a particular problem of controlling a mobile sensor in order to minimize the state estimation variance. The problem is naturally formulated as an optimal control problem with Ricatti equation constraints and with various weights on the desired covariance, sensor gain and control. We present simple numerical examples to illustrate the idea, suggest a framework to extend the approach to more complex PDE systems and suggest future research needs in this area. The issue of sensitivity with respect to the optimal controller is also briefly discussed.