Estimation and Control under Sensor and Communication Constraints

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In this talk we present recent results on estimation and control when measurements are conveyed through dynamically varying low capacity communication links. Our work is motivated by several defence applications.

Consider the problem of remotely controlling the behaviour of a dynamical system (such as an unmanned vehicle) through a low capacity data link. The measured system output must be coded and sent to the control centre which then uses this data to generate a command signal for the system input actuator. We are interested in the effect of data link capacity on achievable system performance and in determining the minimal capacity required to guarantee closed loop stability. We are also interested in knowing what the optimal measurement coder and decoder/controller is for such situations. We present solutions to some of these problems.

Secondly consider the problem of estimating the state of a dynamical system using data from sensors connected via low capacity data links. We distinguish and discuss a number of different cases characterized by the amount of computation located at the sensor and whether or nor a two way data link is available. Estimation and data fusion problems involving low and variable capacity data links are widespread and include robotics, target tracking and unattended ground sensor networks. Consider for example an unattended ground sensor network consisting of a possibly large number of low accuracy bearing measurement sensors located at known positions. We wish to provide accurate position and speed information on objects which are moving through this field of sensors. Furthermore we want to achieve this with minimal communication between sensors. This capacity constrained estimation problem can be formulated as a partially observed stochastic control problem with a switched control. We will discuss this application in some detail.

A closely related application concerns target tracking where we wish to estimate the state of a manuevering target (modeled by a jump Markov system) using noisy measurements obtained from a sensor system capable of switching rapidly between several different measurement modes. An example of such a sensor system is a radar with a flexible waveform generator which can rapidly switch among different waveforms (hence different ambiguity functions). The target trajectory estimation problem again becomes a partially observed stochastic optimal control problem with a finite set of controls where the aim is to select the waveform switching sequence which minimizes the estimation error.