METTI5 Tutorial T10 on

“Kalman and partical filters”

Authors

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Duration

1h30

Type

Methodological/numerical

Content

State estimation problems, also designated as nonstationary inverse problems, are of great interest in innumerable practical applications. In such kinds of problems, the available measured data is used together with prior knowledge about the physical phenomena and the measuring devices, in order to sequentially produce estimates of the desired dynamic variables. This is accomplished in such a manner that the error is minimized statistically.

The solution of state estimation problems can be obtained within the Bayesian framework of statistics. The most widely known Bayesian filter method is the Kalman filter. However, the application of the Kalman filter is limited to linear models with additive Gaussian noises. Extensions of the Kalman filter were developed in the past for less restrictive cases by using linearization techniques. Similarly, Monte Carlo methods have been developed in order to represent the posterior density in terms of random samples and associated weights. Such Monte Carlo methods, usually denoted as particle filters among other designations found in the literature, do not require the restrictive hypotheses of the Kalman filter. Hence, particle filters can be applied to non-linear models with non-Gaussian errors.

In this tutorial we present in a didactical manner the Kalman filter, as well the Sampling Importance Resampling (SIR) algorithm of the Particle Filter. Such filters are then applied to a simple heat transfer problem involving a lumped system, aiming at the student’s comprehension of the algorithms and of the computational coding with MATLAB. Applications to more involved heat transfer problems are also presented.