Title: Discrete Polynomial Methods and their Application to Measurement Systems

Performing calibration and measurement in the presence of uncertainty, e.g., noise, is fundamentally an inverse problem. Since mathematical models are merely approximations to a system's behavior, the key is formulating a model which is sufficiently accurate to achieve a given measurement specification. The mathematical methods used should also facilitate the computation, or at least an estimate, of the confidence interval for the measurement. This tutorial presents an introduction to matrix algebraic techniques for the solution of computational tasks associated with instrumentation and measurement systems.

In general measurements are discrete observations of continuous systems. Discrete basis functions are required to deal correctly with discrete data; their algebraic formulation is different from continuous basis functions. DFT techniques have become very popular because of the ability to produce reliable estimates for continuous systems. However, their application is limited to the analysis of periodic data. This tutorial introduces methods for discrete orthogonal basis functions to describe continuous behavior. The Fourier basis and DFT are special cases of these general methods. A major advantage of the algebraic techniques is that they enable a direct computation of the covariance propagation and with this an estimation for the confidence interval.

There are many Engineering problems where only indirect measurements can be performed, e.g., inertial navigation and the monitoring of structures with inclinometers.

Many of these systems can be modeled by differential equations, in the case of measurements they need to be solved in an inverse manner. Inverse boundary value problems are the more general class of such systems of equations. The algebraic techniques presented here yield an intuitively understandable solution to this type of problem.

The monitoring of constrained structures using inclinometers is used throughout this tutorial as an example to demonstrate the application of the proposed techniques to real Engineering problems. Additionally, a MATLAB toolbox is made available which implements all the functions required to apply these techniques to the processing of measurement data.

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