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Some Applications of the Best Linear Approximation in Nonlinear Block-oriented Modelling

Modelling nonlinear systems is a hot research topic! The main reason for this is that most real-life phenomena are inherently nonlinear in nature. This work focuses on the modelling of nonlinear block-oriented systems which have the advantage of giving the user some physical insight into the system under test. We start from the well-established linear modelling framework by using the Best Linear Approximation (BLA) as a basic modelling tool and present a nonlinear block structure model selection method and a novel initialization procedure.

Since not every model structure allows the user to model the system under test equally well, some user guidelines are provided for the selection of a suitable nonlinear block structure. The method consists in applying a Gaussian-like input signal and performing a series of experiments in which the power spectrum of the excitation signal is varied. According to the resulting behaviour of the BLA, an analysis can be made about the capability of some nonlinear block structures to identify the system under test.

The identification of one specific nonlinear block structure is studied in depth: the Wiener-Hammerstein model. A novel initialization procedure for the different blocks of this model structure is presented based on its BLA. The idea is to write the linear dynamic blocks as a linear combination of basis functions containing the poles and the zeros of the BLA. The initial values are then further optimized using a nonlinear optimization algorithm to fully identify the system.

Modelling can lead to nice practical results with a direct impact on human life. In the medical world, functional Magnetic Resonance Imaging (fMRI), used to visualize neural activity in the brain, faces the challenge of detecting a periodic signal that is buried in zero-mean Gaussian noise. It is well-known that fMRI magnitude data follow a Rice distribution which is characterized by two parameters. To estimate these parameters, we present a Bayesian approach and apply it successfully to fMRI measurement data leading to a more accurate fMRI analysis.