Linear Parameter Varying System Identification: State-Space Approaches

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Presently, linear parameter varying (LPV) systems are broadly used in a wide range of applications such as in aerospace, energy, health, mechatronics, process control, computational systems, etc. Essentially, an LPV system is a linear system whose parameters are functions of a scheduling signal. It can be described by state-space or input/output models, in continuous or discrete-time. The increasing importance of LPV systems in control system design motivated the rise of a new identification problem. Essentially, there are two approaches for the LPV system identification: local and global. In the local approach several linear time invariant (LTI) models are identified for several fixed values of the scheduling signal values. Then the LTI models are interpolated to build an LPV model. This approach benefits from the fact that well-known efficient LTI identification algorithms can be used to estimate the local LTI models. However, it can only be used in systems that can run in fixed operating conditions. Moreover, the interpolation can lead to unstable LPV models. In the global approach the input, output and scheduling signals are processed simultaneously to produce an LPV model. The system doesn't have to run in fixed operating conditions and stability is more easily achieved. The major drawbacks are the difficulty of formulating algorithms and the cost functions complexity. There are global LPV System Identification algorithms for both input-output and state-space models using linear least squares instrumental variables, non linear optimization, orthonormal basis functions, set membership methods, least squares support vector machines, etc. In this talk three global approaches for the identification of state-space LPV models will be considered. The Successive Approximations algorithm estimates LPV discrete-time state-space models with affine dependence on the scheduling signal and is based on a convergent sequence of linear deterministic-stochastic state-space approximations that are identified by a subspace LTI identification method. It has been used to identify an LPV model of high pressure natural gas pipelines in a leak detection and location method . The Separable Least Squares (SLS) algorithm can be used to identify LPV or Affine Parameter Varying (APV) in a canonical form. It minimises a quadratic criterion of the output error has been employed to estimate Affine Parameter Varying models for adaptive interventions in Fibromyalgia treatment. The Separable Least Squares Support Vector Machines (SLS-SVM) algorithm is similar to the SLS algorithm but estimates the output parameters by a Least Squares Support Vector Machine (LS-SVM) algorithm. This is a very promising approach because it increases the flexibility to describe complex functions and makes it possible to learn the underlying dependencies of the model coefficients from the data