LS-SVM Identification of a Distillation Column

Bart Huyck, Jos De Brabanter
KaHo Sint Lieven - Department Industrieel Ingenieur
Email: bart.huyck@kahosl.be jos.debrabanter@kahosl.be

Filip Logist, Jan Van Impe
K.U.Leuven - Department of Chemical Engineering (CIT)
Email: filip.logist@cit.kuleuven.be jan.vanimpe@cit.kuleuven.be

Kris De Brabanter, Bart De Moor
K.U.Leuven - Department of Electrical Engineering (ESAT - SCD)
Email: kris.debrabanter@esat.kuleuven.be bart.demoor@esat.kuleuven.be

1 Introduction

In a world where economic and environmental issues become more and more important, efficient knowledge of the behavior of a process has become indispensable. Mathematical models are heavily exploited for the predicting of process behaviour, e.g., in view process monitoring and control. In the case of control, prediction and simulation is mostly done by linear models [1]. In the academic world, however, an evolution towards nonlinear models can be observed. For nonlinear systems, a variety of possible model structures and techniques exist , e.g., neural networks, wavelets, fuzzy models and Least Squares Support Vector Machines[2]. In this paper [3], we focus on the applicability of LS-SVMs for black-box system identification of a pilot scale binary distillation column. The LS-SVM models are compared to standard linear techniques as transfer function models, subspace state-space models and the Box-Jenkins type models.

2 Experimental set-up

In the pilot-scale distillation set-up, four variables can be manipulated (MV): the reboiler duty, the duty of the feed heater and the reflux and feed flow rate. The controlled variables (CV) of the system are the temperatures in the reboiler and at the top of the column. Only these variables are employed in de modeling of the column as they are strongly related to the quality of the final products. Other measurements are available, but are currently omitted for control.

3 Results

Comparision of the 10-fold crossvalidation is performed on an estimation dataset for both the reboiler and the top temperature. For the reboiler temperature, a MISO model with lag 16 is selected based on the clear minimum of the mean squared error (MSE) of cross-validation (CV-MSE). Despite the clear minimum in CV-MSE, calculation of a fit value as defined in [4] and the MSE on a completely new validation dataset, a model with lag 28 fits the measured data tighter. The fit value changes from 80% for lag 16 to 86% for lag 28. For the top temperature a clear minimum cannot be found. This is probaly caused by an inproper model class. From lag 30 on, the CV-MSE hardly changes, so any model with a higher lag can be chosen. Based on the Akaike Information Criterion and a fit value, the model with lag 35 is selected. Comparison of the LS-SVM models with linear transfer function, state-space and polynomial models models demonstrate that there is always a slight inprovement for the simulation of both temperatures for the LS-SVM model compaired to the linear models but the difference is not more than a 3 to 5% for the fit value.

4 Conclusion

The use of LS-SVMs to simulate a measured temperature compared to some well-known linear models types for a binary distillation column is discussed. In this real life example, there is always a linear model describing the measured temperature very accurately for both the top as well as the reboiler temperature. The LS-SVM always compete with the best linear model, but is only slightly better.

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