Loss Method: A Static Estimator Applied for Product Composition Estimation From Distillation Column Temperature Profile

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Assuring the quality of products is a necessity for many processes in order to optimize plant economy and reduce unwanted emissions. Unfortunately, because of delay in composition analysers or their offline operations, the product qualities cannot be monitored in real time. To overcome the lack of instrumentation for direct measurement of such parameters, techniques capable of estimating them based on the information from other measurable variables are developed and are commonly referred as soft sensor among other nomenclatures.

In this work, we have a presented a static estimator to estimate such immeasurable parameters from other measurements in the plant. Our estimation method (we call it Loss method) is a reformulation of the well-developed Self-optimizing method proposed by Skogestad (2000) to make it adequate for the purpose of estimation. The idea behind self-optimising control is to find a variable which characterise operation at the optimum, and the value of this variable at the optimum should be less sensitive to variations in disturbances than the optimal value of the remaining degrees of freedom. Thus if we close a feedback loop with this candidate variable controlled to a setpoint, we should expect that the operation will be kept closer to optimum when a disturbance occur, and minimising control loss will be equivalent to minimising estimation error.

Figure 1 shows the block-diagram of the Loss method. The objective is to find the optimal H matrix which minimizes the prediction error which is defined as the difference between the estimated and real values of the primary variables.

We have formulated the Loss method for open-loop and closed-loop estimator. With the term “open-loop” estimator, it is implied that the predicted variables are not used for control purposes. It should be noted that this is not the same as implying that variables in a given system are uncontrolled. We could use an “open-loop” estimator to predict a primary variable that are in fact controlled by some other means than the prediction.

From this, we can think of three main types of “open-loop” estimators

1. Predicting primary variables from a open-loop system (no control of variables).

2. Predicting primary variables from a closed-loop system where the primary variables are controlled by manipulating suitable input variables.

3. Predicting primary variables from a closed-loop system where the secondary variables are controlled (not by the predicted variable).

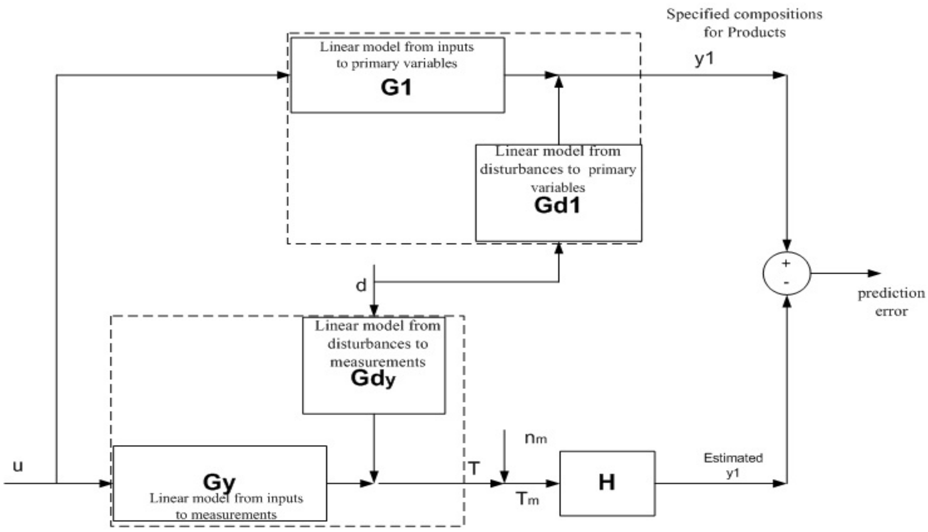

Figure 1. Block diagram for the Loss Method.

The Loss Method is also compared to Partial Least Squares or Projection to Latent Structures (PLS) which is a family of multivariate analysis techniques used to extract useful information from correlated data. This method is used to compress the predictor data into a set of latent variable. There are several different algorithms generating bases but which all give the same predictor. We have chosen the interpretation of Di Ruscio (2000) as the PLS solution we compared with our method, because their interpretation of the method is the closest and most comparable to our method. Instead of introducing scores and loadings, they present a non-iterative solution based on some weights which are the only degrees of freedom in their method. We have applied this method and compared it with partial least square on a distillation column case. In this case, the predictors are the temperatures sensed by thermocouples and the output variables are the composition of the products. Despite the fact that these two methods are developed in two different contexts, it was interesting to find out that the results from both are very similar.

References

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