Simplifying the Model of a Complex Industrial Process Using Input Variable Selection

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This paper deals with some important experiences gained from building a neural model of a Linz-Donawitz (LD) steel converter. Steelmaking with an LD converter is a complex physico-chemical process where many variables have effects on the quality of the resulted steel. During the process a converter is filled with waste iron, melted pig iron and many additives, then it is blasted through with pure oxygen to burn out the unwanted contamination. There are about 30-50 important, known input parameters of the process and two essentially important output parameters: the carbon content of the steel and its temperature at the end of the blasting. The complexity of the whole process and the fact that there are many effects that cannot be taken into consideration make this task difficult. The work we have done is the construction of a neural model and simplifying it using the experiences gained. During this work it turned out that perhaps the most important step of the whole modeling task was the analysis of the large amount of data, the selection of relevant parameters. The paper details the improvement of the neural model using input variable selection methods based on independent component analysis (ICA) and principal component analysis (PCA) techniques. It is believed that these experiments can be utilized in other complex industrial modeling tasks.

Neural networks are one of the possible means to build complex, highly nonlinear mappings between many inputs and some outputs. Experimental data are used to train the neural network, until its operation will be similar or almost identical to that of the real industrial process.

There are many steps of building a model for a complex industrial problem. Among them one of the most important task is to build reliable database that is to select, validate and preprocess the experimental data. These steps are especially important if the experimental data contain noisy, imprecise information, where in some cases there may be false parameter values, and where the problem space is rather large. The use of all measured input parameters makes the neural model very complex, and the learning of the network will be very slow. So the model should be as simple as possible, therefore the irrelevant input parameters are not to be used. For this goal the input parameters must be investigated. Basically three methods were used to select the really relevant parameters:

- Selection of the parameters using the expertise of the steelmaking experts. In this process the irrelevant parameters are simply omitted.
- Selection of the parameters based on principal component analysis (PCA). In this selection process a new parameter set is derived from the original one using a special linear transformation, then the new parameters are again investigated to determine which of them is to be used in the model.
- Selection of the parameters based on independent component analysis (ICA). This process is similar to the PCA based method but a different linear technique is used to produce the derived parameters.

The results of the three methods showed that the model can be significantly simplified when we apply independent component analysis on the original data.

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