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Applications in Speciality Chemical Industry
- waiting for Nature Inspired Solutions?

Beyond innovation and diversification, operational excellence is the most urgent concern for the European manufacturing industries. An improved performance of production plants in terms of cost-effectiveness, capacity exploitation, loss reduction, control of quality as well as compliance with environmental and safety standards is crucial for the processing industries. Operational Excellence as a generic term comprises all measures to keep a running process in an optimal state. Any deviation from this optimal point may cause loss of efficiency or productivity and financial damages in magnitudes of hundred thousands to millions of Euro in a single plant.

To meet this demand digital storage and processing of data obtained from the running processes has almost completely made its way into base level control equipment and distributed control systems of today’s industrial production plants. Hence, process data describing the performance of these plants is available. These data are employed in order to perform process supervision and control as individual signals. Visualization, archiving, and investigation are (at best) done on a level, which is comparable to office-related software products. However in most cases performance monitoring of production plants is based on the aggregation of individual data streams, because the information of process states in general is represented by data correlations and patterns. Applications, in which data are aggregated and used for intelligent information retrieval and further processing are only available to a limited extent and are costly to apply.

Accordingly, much of the interpretation of process data is left to the perceptive faculty and individual skills of the operators. Thus qualification and individual experience of the operators are most important for process industries. But human capability is limited in terms of precision, repeatability and reliability and thus leaving much freedom for further improvement of operational excellence.

Current state-of-the-art systems used in the process industry are based on mathematical models to predict the performance of production plants. Basically, the production processes obey physico-chemical laws, which can be validated through a numerical analysis of real process data in terms of correlations or patterns. The idea is to aggregate and consolidate process data by means of statistical and numerical analysis, to enhance these data towards the accurate estimate of the state of the complete process (rather than an individual quantity) and to use them as a basis for process control and supervision.

In the past various intelligent modelling methods have been developed using techniques from statistics, pattern recognition, and machine learning to develop soft sensors. These methods are now being applied in commercial applications.

It is apparent that a vast majority of soft sensors are used for a one-time predictive model design from a finite training data set. Once the soft sensors has been designed, it is used without any mechanism for “on-line learning” or “adaptation” in fact being static from that point on. However, reality is different. Industrial environment requires high flexibility of predictive models. Process regimes shift due to aging, fouling, blocking or wear out phenomena. Raw materials may unexpectedly change in quality or composition. Pieces of equipment are exchanged or modified as consequence of maintenance or process optimisation measures. A downtime or a changing behaviour of e.g. a temperature or pressure sensor, the usage of a new catalyst, a new dryer or increase of the process temperature or throughput times is a daily work in the industry.

In other words, while the modelling approaches are often very powerful, they are simply not adaptive to potentially changing environments which can very quickly lead to a significant decrease in predictive performance and the need for adjustment or, even worse, complete redesign of the models.

It is beneficial to develop architectures and concepts for constructing and implementing self understanding and self healing soft sensors for processes of the specialty chemistry industry. So methods are to be described how to develop models to adapt soft sensors according to changed environments.

Ideas for that are - beside the possibility of classification diverse process states – an automated online model validation or event driven reaction of the adaptive soft sensors. Methods are to be described how to develop models to adapt soft sensors according to changed environments.

The new idea is to explore nature phenomenons which can lead to new techniques to make soft sensors self aware, self repairing and so to achieve self healing soft sensors. After invoking soft sensors it is aimed to keep them alive by implementing self healing and self restructuring mechanisms.

One request for building adaptive soft sensors is online data pre-processing with problems like data flood, searching information from huge amount of data, looking for exceptions, outliers, searching for valid ranges. All these tasks have to be done automaticly. The model itself has to recognize its own duration of validity, has to have a learning aptitude, ability of judgement, a center of evaluation or recognition. The model should know the quality of the measured values and should know when to generate a new automatic genereted model, has to have a memory (short-term, long-term), learning abitity and a generalisability. Changing environment has to be detected and the model of the soft sensor should recognize its limits. All this has to be done in an accepted performance.

Models are preferable which are adaptable and transportable (to other processes or environments), also for commercial reasons.

The new idea is looking to nature and building nature inspired self healing models with some new aspects coming from nature like cognition (Recognition of structure changes), learning (finding or completing models), adaption (adaption to changing environments), communication behaviour (recognition of changing environments) or self healing (adaption of the model).