**374c A Federated Sensor Network Architecture for Data Rectification and Process Monitoring**

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Rational use of the large volume of data generated by manufacturing plants requires the application of suitable techniques to improve their accuracy and to extract useful information about the operational status of the process. A number of technologies (data reconciliation, trend analysis, fault diagnosis, etc) have been the subject of active research during the last 20 years with important advances. However, their implementation was always considered at the higher level in the control hierarchy of a manufacturing plant with the inherent increase in computational load as well as inherent complexity due to its typically large-scale nature. This in some cases limited their application and wider use within practical manufacturing.

The intelligent sensor network is a rapidly expanding area in the fields of electrical engineering and computer science. An intelligent sensor network is characterized by a network of sensors having data processing and communication capabilities. Its popularity stems from the inherent properties of distributed and collaborative processing. A complex task can be decomposed into manageable sub-tasks that can be distributed to each sensor to process. Through collaboration of the sensors, the sub-tasks are then recomposed, yielding solution to the originally complex task. As a result, the intelligent sensor network can perform tasks more complex or more efficiently than what an aggregate of processors or a single super-processor can accomplish.

Applying the intelligent sensor network to process monitoring has the potential to overcome the limitation currently faced by process monitoring, i.e. in terms of complexity. The distributed processing nature of the sensor network can be leveraged to tackle the complex computational processing of the process monitoring techniques. A process plant is naturally spatially distributed into unit operations and functionally distributed into plant sections, where each unit operation or plant section is monitored by several sensors. The decomposition of process monitoring task along these lines of distributions is hence feasible, facilitating the distributed processing of the task.

An important enabling technology for the intelligent sensor network is the embedded systems. Embedded systems are special purpose computers that perform specific tasks for or control the larger system in which they are embedded. Much less bulky and simpler than the conventional general-purpose computers, many embedded computers consist of only a single board or even a chip, with “just adequate” functionalities integrated. The integrated functionalities (processor, I/O, memory, communication) enable the systems to function as a stand-alone and to communicate with other systems. It is clear then, that the embedded systems play the integral role of incorporating intelligence to the sensors and enabling the sensors to network among themselves.

This paper proposes a revolutionary approach, namely an intelligent sensor network framework for process monitoring. Its basic characteristics are networked intelligent sensors with inherent distributed and collaborative processing capabilities. There are two main aspects of the presented work. The first is the empowerment of sensors with processing and communication capabilities by building on the embedded system technology as the hardware platform. The second aspect is the decomposition and reformulation of process monitoring problems according to the sensor network architecture. The outcome is a new generation of intelligent sensor nodes with capabilities such as signal modeling (self-learning), sensor validation (self-checking) and univariate monitoring techniques. Furthermore, the communication capabilities enable these sensors to collectively solve multivariate monitoring problems. A flexible, two-tier federated sensor network architecture is laid down as the infrastructure for the collaboration scheme.

The monitoring and data rectification of a subsection of a pilot facility is implemented as a case study for the proposed intelligent sensor network framework. The problem decomposition for monitoring and data rectification will be outlined. Simple fault diagnostics based on primitive trending and simple rules are employed. For data rectification, the partially-adaptive data reconciliation strategy is adopted. Problem decomposition results in sub-tasks that can be distributed to the sensors to process. These sub-tasks also define the intelligence or functionalities of the sensors, and in turn, define the processor and other system requirements for the embedded system to be incorporated at the sensors. Experiments are performed for some process operating scenarios, in normal and abnormal/ faulty situations. The results demonstrate the feasibility, and hence the potential of the proposed intelligent sensor network framework.