Plenary Talk
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New Opportunities for Measurement and Sensor Technology through Digitization

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Summary:

Digitization offers completely new possibilities for the productivity, use and informative value of measurement and sensor technology. The most important requirement and achievement is that we have smart sensors with the necessary data pre-processing and communication capabilities with the "Internet of Things" in IoT EcoSystems. Therefore, many optimizations are possible regarding the statements of the measurement, utilizing redundant information, optimization calibration cycles and cost-optimized maintenance.

Keywords: Internet of Things, IoT Ecosystem, Soft Sensors, Smart calibration strategies and maintenance,

Industry 4.0 is comprised by the use of digital technologies, including especially the IoT technologies, in industrial automation and all spheres of life. This transformation will lead to enormous gains in productivity and flexibility. Measurement and sensor technology are not only an essential component of automation and is therefore doomed to participate in this transformation, but it will more and more influence our ordinary life - from leisure activities to life planning. Because of its late entry, however, it can rely on already existing, mature technologies and infrastructures, such as powerful hardware controllers, networks and cloud architectures from the IT and consumer world.

Smart sensors in an IoT Ecosystem

With a view to be able to maximum profit and benefit from the methods of digitization, several important prerequisites must be met: the essential elements have to be integrated component of the technical system, the sensors, but also the actuators must be "smart" [1]. They must have connectivity and communication capabilities to be part of the Internet of Things (IoT). And they must be capable of self-diagnosis and - as a goal - also be capable of their own maintenance, such as self-validation or even self-calibration. Then, an adapted architecture of the control system and a platform for the execution of the methods, the IoT ecosystem, is needed. For new technical systems to be created, this ecosystem can be including into the control system. However, still majority of today's implementations are based on the existing architecture of the automation/traceability pyramid and connect the IoT ecosystem via a separate communication channel at the field level.

Diagnostics and predictive maintenance

One potential, digitization offers is to move from preventive maintenance to real predictive maintenance, thus reducing maintenance costs and increasing the technical health of the system too. There are two different approaches. On the one hand, statistical methods, with which maintenance events can be predicted from a large amount of other information, and on the other hand - in knowledge of the underlying physical and chemical interrelationships - the recording of suitable indicators for maintenance requirements using sensors. In [2] the requirements for these sensors for condition monitoring and predictive maintenance for use in chemical process plants are clearly described.

Calibration and one-step traceability

To maintain its metrological quality, a sensor needs regular calibration, where its measured value must be traceable (within an appropriate measurement uncertainty) to a reliable reference and thus ultimately to the SI. In many cases, today, this requires the sensor to be removed from the system, which is (very) costly

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and disadvantageous for operation. This traditional requirement is clearly opposed to the necessary sharp increase in the use and application of measuring and sensor systems in automated and partially autonomous production. Desirable here would be sensors that either ideally no longer need to be calibrated I or having exceptionally long calibration intervals that are in line with the maintenance cycles of the respective technical system. One approach to the solution is sensor-internal verification. This involves subjecting all or most of the components relevant to the metrological quality of a sensor to ongoing internal sensor verification based on the available sensor internal and external information, including the use of redundant information of the system under consideration., This therefore allows to reduce the probability of erroneous measurements combined with a reduction of the calibration effort. Of course, it would be ideal if a reference directly traceable to the SI were part of a sensor and calibration could be performed anywhere and anytime without external intervention. Such developments are already underway in some large metrology laboratories. There are interesting developments such as the NIST on a Chip [3] The NIST-on-a-Chip project [3] appears to be particularly advanced with micro-technologically realized traceable quantum-based reference standards built into the sensor [3].

Soft Sensors

Soft sensors are measuring systems where difficult to measure variables are determined from several more easily to measure variables (measurands). Either because the measurand cannot be measured directly, the measurement location is not accessible or a value to be measured in the future is required. The relationship of the measured quantities to the target quantity is either known, i.e., model-driven, or must be learned, i.e., data-driven. The latter is more appropriate, because it allows the mapping of complex dependencies with many input variables that are no longer easy to model [4]. However, there are also combinations of both methods in place. For the data-driven methods, the technique of machine learning comes into play. Machine learning has been booming in recent years. However, the necessary completeness and quality of training data is still a challenge. IoT Ecosystems are ideal platforms for implementing such Soft Sensors.

Information security for measurement and sensor technology

Smart sensors in IoT ecosystems are more vulnerable to cyberattacks than in isolated, proprietary systems because of their principle greater openness. Sensor data can be manipulated or unauthorized "overheard"; communication connections can be interrupted. Here too, measurement and sensor technology can build on the experience already acquired in information technology. A large arsenal of procedures and techniques is available for the information security of technical systems [5].

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