



1 Classification of different materials from recycling, coffee grading and nut inspection – the outcome of the Fraunhofer IFF's soft sensor solutions.

## SOFT SENSORS: GET MORE OUT OF YOUR SAMPLES

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### Measure Complex Values

Temperature is measured with a thermometer, weight with a scale. What is to be done when the measured value desired is more complex and unobtainable with a direct, physical measurement system? The Fraunhofer IFF relies on so-called soft or virtual sensors in such cases. Consisting of hardware sensors and relevant software, these units measure complex values.

The principle: One or more different hardware sensors measure data and signals, which are then processed by software. The hardware sensors deliver an intermediate model from which target values can be computed. The software can be modified for the hardware sensors based on the signal or data. This makes soft sensors versatile, e.g. they can determine process variables, material categories or biochemical properties of complex mixtures

of substances. Additional physical, directly obtained values can frequently be measured with a soft sensor, too.

### Learn from Data

When the relationship between the physically measured intermediate model and the target values cannot be described mathematically, the soft sensor is calibrated specifically with measured data. They are referenced to model and thus determine the unknown mathematical relationship.

In the process, data mining methods based on principles of big data are employed. To do so, reference data on your specific process, which already exists or has been collected by us, is automatically entered into a system model. Such models are ideal for production equipment in operation under real-time requirements.



Depending on the concrete measuring task, we select state-of-the-art methods from pattern recognition and multivariate statistics. Frequently, these are methods of machine learning. Our mission is to adapt current methods from science and research to your concrete measuring task and thus to implement them in robust, self-learning systems usable in industry and laboratories.

#### Technology Partner for Soft Sensors

We will support your development of soft sensors from an initial feasibility study through the implementation and validation of a system for use in the field. We can build upon the sensors you have and configure their data or test novel sensor systems.

#### Soft Sensors – Benefits at a Glance

1. New target values: Measure process variables or properties of products or materials for which you have been unable to find any commercially available specialized in-line sensors.
2. Online: We rely on algorithms that, following a teaching phase, measure a desired target value online at high throughput and are suitable for 100% inspection in a process.
3. Integrated: We work closely together with you to integrate our analysis algorithms in your existing control and measurement software.
4. Optimized: You receive a system customized for your needs, which optimizes existing sensors systems' evaluation of data and optimally integrates additional sensor systems in hardware and software.
5. Variable: Soft sensors can be adapted for different measuring tasks by modifying the software or the mathematical models they contain.
6. Process understanding: Understand the variables that influence your product quality better through objective, statistical data evaluation, which reveals input parameters' relevance for the specification of target values.

#### 1. Systematic Data Collection

In the first step, we systematically evaluate available measured data or organize measurements using reference materials you provide. The data acquisition covers the stipulated complex of tasks.

#### 2. Measurement Model Development

Taking the data acquisition as the starting point, a system model is created, which describes the non-trivial correlation between the hardware sensor's data and the target values you define. This includes material identity or chemical properties identified for the teaching phase, .e.g. supported by laboratory testing. We draw on a variety of methods of machine learning and select or modify the best model for your tasks.

#### 3. Model Validation

We comprehensively validate the system model's performance. Building upon this, we deliver information on the soft sensor's expected features, e.g. precision and real-time capability.

#### 4. System Development and Integration

Based on the findings from the validation of the model, we customize a soft sensor for you. Then, we integrate it in your existing production environment.

<sup>1</sup> Nutrient distribution in a leaf, determined with a hyperspectral camera as the hardware sensor and a regression model that maps the spectral data (intermediate value) for the relevant target value.