



## INTELLIGENT PROCESS SENSOR SYSTEM

### Task

Process monitoring during welding and cladding places special demands on system technology due to high processing speeds. To satisfy these demands, Fraunhofer ILT has developed a multi-spectral, imaging sensor system for process monitoring which provides a clear quality fingerprint. A particular challenge here was the real-time data processing. For this, different sensor data streams had to be analyzed simultaneously during the process in order to be able to classify the current process status into a defined quality category.

### Method

The process fingerprint is composed of several features, such as the cooling rate of the component surface or the melt pool surface geometry. These features are determined from multi-spectral process image data. Since determining and processing the features requires considerable processor power, a field programmable gate array (FPGA) had to be used to evaluate the cognitive data in real time. To generate the training data for the artificial intelligence generated in the FPGA, a binding error, the so-called »false friend«, was artificially provoked and recorded for laser-beam welding. Subsequently, the cognitive system was trained with these as well as with data from further process imperfections.

1 *Experimental setup with integrated sensors.*

2 *Prediction of weld quality and associated sample.*

### Results

The system is classified with different algorithms from the machine learning family and can distinguish between five categories of weld quality (Figure 2). The accuracy of the classification results reaches over 99 percent in the laboratory. During the development, 150 features were determined, based on image data of different spectral ranges. It has been shown that the uniqueness of the quality assessment also depends on the spectral range in which the process images were generated.

### Applications

Within the scope of the project, the cognitive system has been applied for the industrial laser-beam welding of automotive components. In addition, artificial intelligence can be used in other processes, especially in the context of »Industry 4.0« in industrial applications for process monitoring.

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