# MINIATURIZED SYSTEM FOR INTELLIGENT SIGNAL PROCESSING IN MECHANICAL ENGINEERING

Dr. Constanze Tschöpe, Dr. Frank Duckhorn, Dipl.-Ing. (FH) Christian Richter, Dipl.-Ing. (FH) Matthias Eiselt, Dipl.-Ing. (FH) Peter Blüthgen

Intelligent signal processing is needed in mechanical engineering for in-line quality control, life cycle analysis of wear parts, and structural health monitoring. Fraunhofer IKTS has developed a miniaturized system for intelligent signal processing within the scope of the joint project "MiSIS" funded by the German Federal Ministry of Education and Research (BMBF). The heart of the system is a base module containing a digital signal processor (DSP) and a field-programmable gate array (FPGA), along with the required memory, power supply, and peripheral interfaces. Taking the form of a mini PCI express card (30 x 50.95 mm), the module can be operated in various systems, for instance, in many laptops. Complex and real-time critical algorithms for acoustic pattern recognition using deep neural networks (DNNs) or hidden Markov models (HMMs) can be realized by the combination of DSP and FPGA. The base module can be connected to various signal acquisition and signal output modules via flat ribbon cables. The system is thus capable of audio and ultrasonic signal processing as well as processing of other signal sources. Partner company SINUS Messtechnik GmbH has developed a signal acquisition module for high-quality processing of audio signals in the audible range (up to 24 kHz) with up to four independent channels. With these two modules, the system performance was demonstrated, e.g., in the automated detection of defects in glass bottles in cooperation with the Communications Engineering Group at Brandenburg University of Technology Cottbus-Senftenberg. For this reason, the complete feature analysis (windowing, Fourier analysis, and temporal and spectral smoothing by filter matrices) and the classification algorithms (density calculation for hidden Markov models, search in finite state machines) were implemented in the base module. By embedding these CPU-intensive algorithms on the FPGA, it was possible to decrease the computing time significantly, thereby also enabling the feature analysis and classification techniques to be used at higher-frequency signals. Fraunhofer IKTS also successfully uses intelligent signal processing and acoustic pattern recognition for in-line quality control of gears, estimation of

## Calculating time in relation to signal length

| Algorithm | DSP | FPGA |
|---|---|---|
| Feature analysis | 9.4 % | 1.1 % |
| Density calculation | 59 % | 34 % |
| Search | 32 % | 3.1 % |

remaining useful life time of valves, early fault detection in rollers and bearings in spinning frames, structural health monitoring of airplane materials, and automatic softness testing of tissue products during production. The technology is very well suited to testing of machine components or as test units in production plants.

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**1** *Integration in measurement system.*

**2** *Base module of miniaturized system for intelligent signal processing.*