Advanced Digital Signal Processing Methods for AI-Based Condition Monitoring

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ABSTRACT:

This lecture presents real-world application domains addressed by the SignalLab research group, with a strong focus on industrial collaboration and practical deployment. The contribution highlights selected projects developed in cooperation with industry partners, covering advanced sensing systems, measurement based on virtual instrumentation, and implementation of signal processing solutions in real operational environments.
Particular attention is given to advanced digital signal processing methods, especially hybrid approaches combining model-based and data-driven techniques. The talk also addresses the creation of high-quality datasets in close collaboration with industrial partners, enabling the effective application of machine learning and hybrid AI methods in challenging real-world scenarios.
Furthermore, the lecture explores the concept of digital twins of sensors and measurement systems as a powerful tool for the development, testing, and optimization of intelligent monitoring solutions. Targeted applications include predictive maintenance and condition monitoring in industrial environments, with emphasis on acoustic emission analysis, vibration diagnostics, and image-based inspection.
The presented systems are primarily designed as hybrid multi-sensor solutions, integrating data from heterogeneous sources to achieve robust, reliable, and interpretable results. The overall message of the lecture highlights the critical role of high-quality signal acquisition and processing as a fundamental prerequisite for both artificial and human intelligence in modern condition monitoring systems.