SYSTEM ANALYSIS, PROGNOSIS AND CONTROL

In the area of electrical power grids, we deal with the modeling, monitoring, and control of energy production units, energy distribution grids and the efficient use of energy by consumers. In particular, an important part of our work is the analysis of up to now unknown interactions between conventional and renewable producers.

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DR. ANDREAS WIRSEN
HEAD OF DEPARTMENT

ANALYSIS, PROGNOSIS, AND CONTROL OF COMPLEX SYSTEM AND PROCESS BEHAVIORS

The dynamic systems we consider from the fields of energy management, plant and machine control, as well as medicine and biology are often complex, because they map a network of different sub-systems and structures.

Each of these systems is equipped with specific sensors and actor configurations. In many cases, when we want to obtain information about system behavior from measurements, we have to consider that sensor data is overlaid with interference. Usually, this situation is compounded by incomplete system and structural descriptions.

Typical tasks include the identification of dynamic system parameters (by means of mathematical state estimations), the classification of system behavior (by means of machine learning), the preparation of online-enabled simulation models for system analyses or for the development of controllers, and the validation of the behavior of electronic control units (within a hardware-in-the-loop setting).

The department draws on its core competencies in the field of systems and control theory and machine learning. We have special expertise in the areas of differential-algebraic equations, the use of sequential Monte Carlo approaches (particle filter methods) for the simulation and state estimation of stochastic processes, in statistical learning theory as well as in machine learning with deep architecture (Deep Learning).

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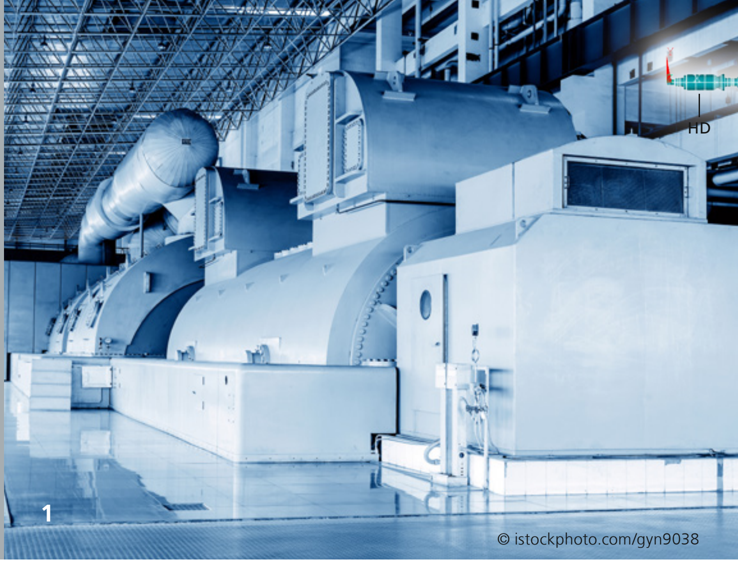
MAIN TOPICS

- Power Generation and Distribution
- Machine Monitoring and Control
- Bio-sensors and Medical Devices
- Machine Learning
- Controller Design for Complex Systems
- Model Identification and State Estimation



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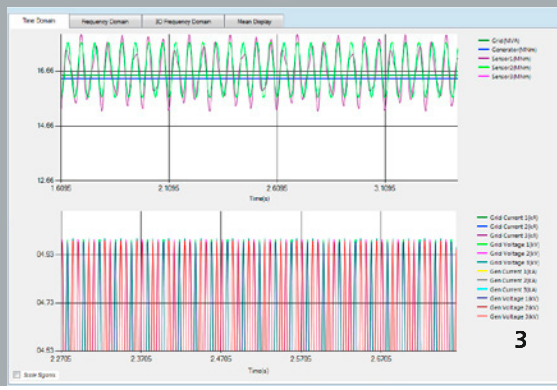


TORGRID – MONITORING SYSTEM REACTIONS AT CONVENTIONAL ENERGY PRODUCERS

1 *Power generation unit with generator, and turbine*

2 *A power turbine generator unit scheme with generator (GEN), low pressure turbine (ND), medium pressure turbine (MD) and high pressure turbine (HD)*

3 *Screenshot TorVis – TorGrid*

The significant increase in the power generation of renewable energies and the coupling of high voltage DC transmissions over converters produces novel dynamical effects in the power grid. The management of previously unknown system interactions on conventional power plants, in particular, takes on increasing importance.

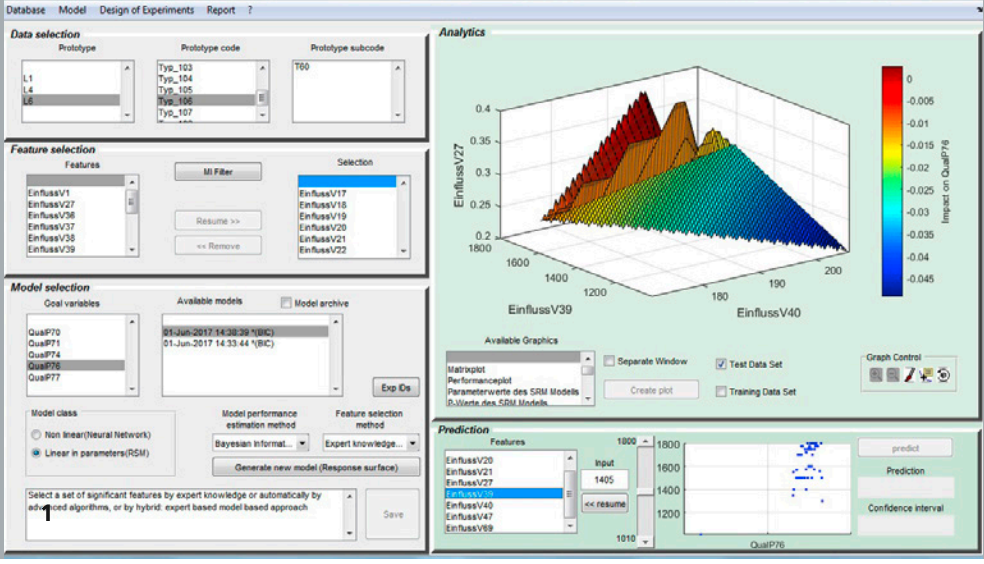
We developed TorGrid, an online monitoring system to detect grid interactions on turbine generator shaft lines. This monitoring system synchronously records the torsional vibrations of the drive shaft and the respective 3-phase electrical voltages and current at the generator as well as at the grid side of the transformer. TorGrid monitors the measurement signals based on intelligent trigger criteria to detect events that have been defined as critical by the operator. In addition to the measured values of up to three non-contact torque sensors and the three instantaneous currents and voltages, in the case of an event, TorGrid also stores the resulting electrical power of the generator and the transformer at the grid side.

Analysis of interaction between grids and turbines with TorVis

TorVis, an integrated visualization software, enables the subsequent analysis of the torques, power, currents, and voltages in time and in frequency domain. TorVis enables the users to determine the cause of the torsional vibration on the drive shaft at the time of a detected event: external reactions/perturbations from the electrical grid, vibrations caused by internal mechanisms at the generation unit, or interactions between turbine generator shaft line and electrical grid as sub-synchronous resonances.

Improved revision planning

Our customers in the conventional power generation sector (i. a. Uniper Anlagen Service) use TorGrid to improve planning of inspections and service activities. The long term goal is to use the signals recorded by TorGrid to compensate for reactions in the grid.



MACHINE LEARNING IN MANUFACTURING

The department has long been involved in finding solutions to a wide range of industrial problems, using machine learning methods. One focus of our research is so-called Deep Learning – machine learning with deep architectures.

1 *Quantification of the dependency of a measured quantity of product quality by means of three significant influence variables of a plastic extrusion process*

Data analytics ensures product quality

Modern production plants face a great challenge in trying to understand the relationship between the various influencing factors in the manufacturing process and the quality of a product. Optimizing the production processes requires quantifying the effects on quality and performance variables when individual process parameters change. Fundamental in this effort is the possibility of using machine learning to predict quality variables from process parameters or features derived from these.

At the department, we develop feature selection/construction algorithms as well as process models based on measurement data from the real manufacturing process, expert knowledge about the process, and related theory.

Optimizing predictive maintenance – through machine learning

Ideally, a technical system is considered reliable and economical, if it is repaired promptly and available when required. This is only possible if the company can reliably predict the maintenance requirements of the systems, taking into account the current production plan and past load history, while guaranteeing the availability of the appropriate resources such as specialists, spare parts, logistics, etc.

Reliable prediction of future events is an integral part of any Predictive Maintenance (PM) system. An important key lies in the analysis of patterns in past events. In a joint modeling approach, we model not only the continuously measured sensor data, but also repetitive discrete event data and failure data. We develop machine learning methods to recognize and visualize complex high dimensional patterns as well as the dynamics and trends of production process states. Furthermore, we use machine learning algorithms to predict and characterize the condition of technical systems.

NEWS

KL-CONTROL SYSTEMS SEMINAR: EXCHANGING EXPERIENCE AND BROADENING HORIZONS

Since autumn 2016, the department has been organizing the KL-Control Technology Seminar once a month, together with research groups from several departments of the TU Kaiserslautern. Discussions focus on ongoing or just completed graduate work as well as current research projects; the spectrum ranges from mathematical methods to technical implementations. The speakers usually present results, but the presentations can also be open-ended in order to provide an opportunity for partner input on open issues.

INTERACTIVE PAPER PRIZE

Six participants reached the final round of the "Interactive Paper Prize" at the 20th IFAC (International Federation of Automatic Control) World Congress 2017 in Toulouse, France. Both the written version of the paper as well as its presentation are evaluated. Among the finalists were Ferdinand Küsters, Stephan Trenn, and Andreas Wirsen with Switch Observability for Homogeneous Switched DAEs.

NEW FUNCTIONALITIES INTEGRATED IN knowCube®

knowCube® provides tools for interactive knowledge management and multi-criteria graphic decision aids and, among other things, also enables any manner of search expressions for freely formulated research in public domain and Fraunhofer-licensed Internet sources. These processes work at two levels: The results list is dynamically displayed on the graphic user interface while, parallel to this, the selected documents are analyzed in the background to provide the details for continued navigation if required.

Front, left to right: Dr. Christian Salzig, Dr. Andreas Wirsen, Hans Trinkaus, Dr. Alex Sarishvili,
Dr. Jan Hauth, Jens Göbel, Michael Sendhoff, Dimitri Morgenstern, Ferdindand Küsters