TECHNISCHE UNIVERSITÄT WIEN
Vienna | Austria

Institute of Mechanics and Mechatronics
Getreidemarkt 9
1060 Vienna
Austria
www.tuwien.at/en/mwbw/imm

Advanced Control Technologies

For optimal control, condition monitoring and state of health as well as high fidelity tests of powertrains and fuel cells

The components and systems used in industry, and especially in aerospace, are becoming increasingly complex and their loads are growing. There is a demand for increasing speed and acceleration. In addition, there is a need for greater flexibility of the systems - for example, with different areas of use, environments, fuels - while at the same time reducing maintenance costs and increasing operational reliability. This places ever new demands on the control technology needed to operate most complex systems. In particular, the focus is on control performance and the reliability of realistic control models, their real-time capability and self-optimization, as well as on fault detection and failure safety.

Without modern closed-loop control, most aircraft - all those that cannot inherently fly in a stable manner - cannot be used, and the full savings potential of modern propulsion concepts cannot be exploited. Powerful control technology is therefore needed for optimum operation, especially during changes in direction and in transient states – whether these are intentional or environmental. At the same time, high demands are also placed on the automation of test benches. Hybrid powertrains driven by more than one energy source are particularly challenging.

Objective

Research at the Institute of Mechanics and Mechatronics (IMM) aims to use modern methods of control engineering to achieve better performance at reduced costs for our cooperation partners. We aim to achieve simple, robust parametrization (the ability to correctly estimate model parameters from existing data). In this way, implementation in concrete industrial applications can be done easily and quickly. The performance of control models depends upon the ability to identify, select and precisely determin those operating parameters that are best suited as input variables for control.

In the field of aeronautics, the optimization of flight controllers and the automation of reliable test benches are our main targets, as well as conducting research on the optimized operation and testing of hybrid hydrogen systems.

TU Wien contributes to load attenuation and active vibration suppression for Airbus' future blended-wing-body airplane

Approach taken

In terms of success at the industrial tasks we have been assigned, we here at IMM have had the best experiences using methods of data-driven modeling supplemented by structured expert models. This is especially true with respect to the real-time capability of models tailored to specific applications. We apply and specialize both linear (e.g. $H\infty$-control) and nonlinear (e.g. adaptive) methods to the problem at hand. In addition, we apply algorithms for fault detection and isolation as well as virtual sensors for state estimation (soft sensors) to control models.

Results

As far as load attenuation and active vibration suppression are concerned, a special flight controller specifically designed for future blended-wing-body passenger airplanes was developed together with Airbus, EADS, Onera, DLR, Alenia and others*. IMM's concept was then selected from four available candidates as the best method for the final validation of flight control.

A control system for a compound split gearbox with two speed variators is currently being designed for a new type of hybrid helicopter drivetrain capable of variable speed. This enables a modern hybrid drive to provide highly dynamic transient characteristics.

* *www.acfa2020.eu*

The optimized operation of fuel cells is of central importance to the future use of hydrogen technology; it's essential to increase a fuel cell's service life and enable highly dynamic operation. Broad background knowledge and experience of fuel cells are available at IMM for both condition monitoring and control of operation. Industrial test benches for testing stacks are equipped with IMM's automation software and can detect both production-related faults and aging, i.e. identify the so called State of Health (SoH) of fuel cells. Existing know-ledge and experience are currently being adapted and implemented through the project "FlyHy"**.

IMM developed innovative control algorithms for the stabilization of imaging sensors. The algorithms optimally control multi-stage actuators of a gimbal suspension. Via H∞-control, robust performance can be guaranteed over the entire range of application.

** *www.airbus.com/en/innovation/zero-emission/hydrogen/zeroe*

Various developers use IMM software for their test benches, which enables highly realistic and highly dynamic load cycles in closed-loop operation. Currently, the test benches are used for fuel cells and for automotive powertrains, but special test benches for aviation can also be implemented.

Your Benefits

Many years of experience with modern control engineering as well as the technology developed by IMM enable in particular:

- The first-time realization of highly dynamic HiL operation on powertrain test benches in order to be able to run and analyze highly realistic load scenarios with a high bandwidth.
- In the case of fuel cells, intelligent load management together with real-time condition monitoring enables their use in series products. This makes it possible to guarantee the long service life of sensitive and expensive components, at the same time maintaining high performance.
- Rapid implementation of robust control models in practical use, which can be easily parameterized in the course of projects together with industrial partners.

Notes

Contact

Prof. Dr. Stefan Jakubek
TU Wien – Institute of Mechanics and Mechatronics
www.tuwien.at/en/mwbw/imm
+43 1 58801 325510
stefan.jakubek@tuwien.ac.at, rema@tuwien.ac.at