Mads Clausen Institute
Technology Areas and Offers to Industry

Cyber-Physical Lab

Contact:	M. Hossein Ramezani Assistant Professor in Control Engineering Mechatronics, The Mads Clausen Institute Phone: +45 65 50 92 17 ramezani@mci.sdu.dk University of Southern Denmark Alsion 2, DK-6400 Sønderborg
Description:	The cyber-physical lab is a laboratory containing a set of physical apparatus (mostly electro-mechanical systems) or experiments equipped with a set of actuators and sensors, all linked to computers so that machine intelligence algorithms can be tested and evaluated. The implementation of these algorithms, whether they are targeted towards control, monitoring or fault diagnosis, can be done with current tools for rapid prototyping such as Matlab/Simulink. It is also possible to control some of the experiments using low cost embedded boards like Arduino, Raspberry pi and Beaglebone. Design and implementation of the controller can be done in Matlab/Simulink as well. Recently, we have been working on the implementation and challenges of Networked Control Systems (NCSs). NCSs have attracted intense attention from both academia and industry due to the multidisciplinary nature among the areas of communication networks, computer science and control. Other than the NCSs where feedback control loops are closed via communication networks, the more advanced case of distributed NCSs where many control loops are in contact is implemented in the lab. In this regard, we have developed a distributed networked control system where all nodes are raspberry pi boards communicating with each other and the server over the Internet. All code generation is done in Matlab/Simulink and then deployed to the boards over the Internet.
Services for Companies:	• Test of different classes of algorithms (control, estimation, fault-diagnosis, system identification, motion planning, reinforcement learning) and their comparison in terms of performance. • Continuing education and training throughout tailored courses of advanced techniques and hands-on experiments using Matlab/Simulink.
Technical specification of equipment:	The set of experiments includes: • Multidimensional system for torsional dynamics. Experiment to test control algorithms reducing oscillatory behaviors on motor systems with important inertia and elasticity (loop shaping). • Rotary flexible link. Used for advanced motion planning, feedforward and estimation, and networked control systems.

	• Combination of 2-3 Rotary flexible links: Used for networked control, distributed control and application of IoT principles. • Coupled process control experiment. Ideal experiment to test/learn nonlinear control, nonlinear identification and fault diagnosis through the generation of faults. • Heat flow experiment. Test of active machine learning algorithms in the area of ventilation and HVAC systems. • 3D crane and tower crane. Experiment to test motion planning and accurate position in motion control systems. • 6 degreed-of-freedom joint compliant control robot. Fully accessible robot to implement different control algorithms, including compliant ones.