Study plan

Name of study plan: Cybernetics and Robotics

Faculty/Institute/Others: Faculty of Electrical Engineering
Department:
Branch of study guaranteed by the department: Welcome page
Garantor of the study branch:
Program of study: Cybernetics and Robotics
Type of study: Doctoral full-time
Required credits: 0
Elective courses credits: 30
Sum of credits in the plan: 30
Note on the plan:

Name of the block: Compulsory elective courses
Minimal number of credits of the block: 0
The role of the block: PV

Code of the group: 2020_DKYR
Name of the group: Subjects of the doctoral program Cybernetics and Robotics
Requirement credits in the group:
Requirement courses in the group:
Credits in the group: 0
Note on the group:

Code	**Name of the course / Name of the group of courses** ***(in case of groups of courses the list of codes of their members)*** *Tutors,* ***authors*** *and guarantors (gar.)*	Completion	Credits	Scope	Semester	Role
XP35FMC1	**Fuzzy modeling and control**	ZK	4	2P+2C		PV
XP35CCM1	**Cooperative control of multi-agent systems** *Kristian Hengster-Movric* ***Kristian Hengster-Movric*** *Kristian Hengster-Movric (Gar.)*	ZK	4	2P+2C		PV
XP35LMI1	**Linear matrix inequalities** *Didier Henrion* ***Didier Henrion*** *Didier Henrion (Gar.)*	ZK	4	2P+2C		PV
XP35NES1	**Nonlinear systems**	ZK	4	2P+2C		PV
XP35ESF1	**Estimation and filtering** *Vladimír Havlena* ***Vladimír Havlena*** *Vladimír Havlena (Gar.)*	ZK	4	2P+2C		PV
XP35ORC1	**Optimal and robust control** *Zdeněk Hurák* ***Zdeněk Hurák*** *Zdeněk Hurák (Gar.)*	ZK	4	2P+2C		PV
XP35FSC1	**Flexible structures control** *Martin Hromčík* ***Martin Hromčík*** *Martin Hromčík (Gar.)*	ZK	4	2P+2C		PV

Characteristics of the courses of this group of Study Plan: Code=2020_DKYR Name=Subjects of the doctoral program Cybernetics and Robotics

XP35FMC1	Fuzzy modeling and control	ZK	4

In the initial lectures, the control-related fundamentals of fuzzy logic, fuzzy sets, fuzzy operations and relations are covered. Then the methodology of approximate reasoning and its interpretation using a basis of fuzzy rules is explained while deriving various types of inference mechanisms. Fuzzy system is interpreted as a nonlinear mapping, its properties and possibilities for approximation are discussed. These are then exploited for modeling fuzzy systems from measured data using gradient and least-squares techniques. We then cover thoroughly methods of fuzzy clustering analysis using three most popular algorithms: fuzzy c-means, Gustafson-Kessel and Gath-Geva algorithms. We then dedicate the lectures to the analysis and synthesis of Takagi-Sugeno fuzzy systems, that is, systems based on a model that was obtained either by linearizing along a trajectory or method of sections - both approaches are then compared. Careful discussion of various Lyapunov functions is included - quadratic, piecewise quadratic, fuzzy sharing the same segmentation of the state space as the linear submodels. The problems are formulated as convex optimization invoking the frameworks of linear matrix inequalities (LMI) and sums of squares (SOS). Finally, we also show basic design methods for fuzzy adaptive regulators, both direct (backstepping, fuzzy sliding mode control) and indirect (Fuzzy Model Reference Adaptive Control). Similar methods are finally applied for control using neural networks.

XP35CCM1	Cooperative control of multi-agent systems	ZK	4

Cooperative distributed control is a relatively novel and rapidly developing area of control theory and engineering. Instead of centralized, large systems are considered composed of autonomous subsystems, with local computation and communication capabilities. The broad aim is solving classical problems e.g. stabilization, tracking, estimation and optimization, via local communication and team cooperation robust to changes in communication topology and disturbance. Relevant topics of classical control theory are revisited and a brief review of background mathematics needed for the course is also provided. The potential use of multi-agent cooperation in challenging applications involving environment to be controlled or observed is discussed. Theory: Review of qualitative properties of dynamical systems, Motivation for distributed multi-agent systems, Elements of algebraic graph theory, Distributed estimation and control, Consensus and synchronization of linear/nonlinear, continuous/discrete-time systems, Cooperative stability, optimality and robustness, Distributed optimization: multi-player game theory, Interactions with environment.

<table>
<tr><td>XP35LMI1</td><td>Linear matrix inequalities</td><td>ZK</td><td>4</td></tr>
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<tr><td colspan="4">The goal of this course is to help student develop a deeper and broader perspective on theory and applications of nonlinear systems. At the hearth of the course will be the so-called differential-geometric approach, which can be used for controllability and observability analysis of nonlinear systems, characterization of various types of exact feedback linearization and many other tasks. Great attention is paid to analysis of the structure of nonlinear systems from the perspective of control design. It follows from the state description of nonlinear systems and uses state transformations of the nonlinear model into a simpler form that is usable for control design. Differential-geometric conditions for existence of these transformations are studied in this course. Concepts of nonlinear controllability and observability are introduced in this course and their relation to stabilization and reconstruction is analyzed because it is not as clear as for linear systems. Some additional topics such nonsmooth stabilization and discontinuous stabilization will be covered. Examples of use of the presented theories in underactuated robotic walking, nonholonomic systems and optimization of biosystems will be given.</td></tr>
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List of courses of this pass:

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For updated information see http://bilakniha.cvut.cz/en/f3.html
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