Recomended pass through the study plan

Name of the pass: Subjects of the doctoral program Cybernetics and Robotics

Faculty/Institute/Others: Faculty of Electrical Engineering
Department:
Pass through the study plan: Cybernetics and Robotics
Branch of study guranteed by the department: Welcome page
Guarantor of the study branch:
Program of study: Cybernetics and Robotics
Type of study: Doctoral full-time
Note on the pass:

Coding of roles of courses and groups of courses:
P - compulsory courses of the program, PO - compulsory courses of the branch, Z - compulsory courses, S - compulsory elective courses, PV - compulsory elective courses, F - elective specialized courses, V - elective courses, T - physical training courses

Coding of ways of completion of courses (KZ/Z/ZK) and coding of semesters (Z/L):
KZ - graded assesment, Z - assesment, ZK - examination, L - summer semester, Z - winter semester

Number of semester: 1

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
2020_DKYR	**Předměty doktorského programu Kybernetika a robotika** *XP35FMC1,XP35CCM1,..... (see the list of groups below)*	Min. cours. 4 Max. cours. 7	Min/Max 16/28			PV

List of groups of courses of this pass with the complete content of members of individual groups

Kód	Name of the group of courses and codes of members of this group (for specification see here or below the list of courses)	Completion	Credits	Scope	Semester	Role
2020_DKYR	**Předměty doktorského programu Kybernetika a robotika**	**Min. cours. 4 Max. cours. 7**	**Min/Max** 16/28			**PV**

XP35FMC1	Fuzzy modeling and control	XP35CCM1	Cooperative control of multi-age ...	XP35LMI1	Linear matrix inequalities
XP35NES1	Nonlinear systems	XP35ESF1	Estimation and filtering	XP35ORC1	Optimal and robust control
XP35FSC1	Flexible structures control				

List of courses of this pass:

Code	Name of the course	Completion	Credits
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.			
XP35ESF1	Estimation and filtering	ZK	4
Methodology: experiment design, structure selection and parameter estimation. Bayesian approach to uncertainty description. Posterior probability density function and point estimates: MS, LMS, ML and MAP. Robust numerical implementation of least squares estimation for Gaussian distribution. Parameter estimation and state filtering - Bayesian approach. Kalman filter for white noise. Properties of Kalman filter. Kalman filter for colored/correlated noise.			

<table>
<tr><td>XP35FMC1</td><td>Fuzzy modeling and control</td><td>ZK</td><td>4</td></tr>
<tr><td colspan="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.</td></tr>
<tr><td>XP35FSC1</td><td>Flexible structures control</td><td>ZK</td><td>4</td></tr>
<tr><td colspan="4">The main aim of this course is introduction to methods of modeling flexible mechanics structures in order to optimization of placement of sensors and actuators. The robust control design of space modes will be follow.</td></tr>
<tr><td>XP35LMI1</td><td>Linear matrix inequalities</td><td>ZK</td><td>4</td></tr>
<tr><td colspan="4">Semidefinite programming or optimization over linear matrix inequalities (LMIs) is an extension of linear programming to the cone of positive semidefinite matrices. LMI methods are an important modern tool in systems control and signal processing. Theory: Convex sets represented via LMIs; LMI relaxations for solution of non-convex polynomial optimization problems; Interior-point algorithms to solve LMI problems; Solvers and software; LMIs for polynomial mehods in control. Control applications: robustness analysis of linear and nonlinear systems; design of fixed-order robust controllers with H-infinity specifications. For more information, see http://www.laas.fr/~henrion/courses/lmi Výsledek studentské ankety předmětu je zde: http://www.fel.cvut.cz/anketa/aktualni/courses/XP35LMI</td></tr>
<tr><td>XP35NES1</td><td>Nonlinear systems</td><td>ZK</td><td>4</td></tr>
<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>
<tr><td>XP35ORC1</td><td>Optimal and robust control</td><td>ZK</td><td>4</td></tr>
<tr><td colspan="4">This is an advanced course about modern control design methods that formulate the design as a mathematical optimization. Besides teaching practical design skills, the course will also help develop deeper understanding of fundamental concepts as well as build awareness of the latest results. Thanks to its background in mathematical optimization, the benefits of the course can certainly be seen beyond the borders of automatic control domain. The course can be viewed as an extension of the equal-named course in the master program (B3M35ORR). However, numerous topics are new and those few topics that already appeared in the master version will be discussed at a significantly deeper level. This time the motivation is not just to give practical tool but also to go through the proofs, discuss various interpretations, and survey the results from the latest literature. From the student perspective, the goal of this course is to acquire advanced competences (knowledge and skills) in the area of computational design of control systems (or rather control algorithms). The methods will almost exclusively assume availability of a mathematical model of the system to be controlled (hence model-based control design). We will consider dynamical systems in continuous as well as discrete time, linear and nonlinear, single and multiple inputs and outputs. Since all the design methods introduced in this course formulate the design task as an optimization, the crucial competences will come from the areas of optimization, both finite-dimensional (linear, quadratic, nonlinear and semidefinite programming) and infinite-dimensional (calculus of variations, operator theory, differential games).</td></tr>
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For updated information see http://bilakniha.cvut.cz/en/f3.html
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