Recomended pass through the study plan

Name of the pass: Cybernetics and Robotics - Passage through study

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: Follow-up master 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
BEZM	**Safety in Electrical Engineering for a master´s degree** *Vladimír Kůla, Radek Havlíček, Ivana Nová, Josef Černohous, Pavel Mlejnek **Radek Havlíček** Vladimír Kůla (Gar.)*	Z	0	2BP+2BC	Z	P
B3M38DIT1	**Diagnostics and Testing** *Radislav Šmíd **Radislav Šmíd** Radislav Šmíd (Gar.)*	Z,ZK	6	2P+2L	Z	P
B3M35LSY1	**Linear Systems** *Petr Hušek **Petr Hušek** Petr Hušek (Gar.)*	Z,ZK	6	4P+2C	Z	P
2021_MKYRPV1	**Povinně volitelné předměty programu - skupina 1** *B4M33MPV,B3M35OFD,..... (see the list of groups below)*	Min. cours. 3 Max. cours. 6	Min/Max 18/36			PV
2021_MKYRPV2	**Povinně volitelné předměty programu - skupina 2** *B3M38ASE,B3M35DRS,..... (see the list of groups below)*	Min. cours. 4 Max. cours. 19	Min/Max 24/114			PV
2021_MKYRVOL	**Volitelné odborné předměty**	Min. cours. 0	Min/Max 0/999			V

Number of semester: 2

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
B3M33ARO1	**Autonomous Robotics** *Karel Zimmermann, Vojtěch Vonásek **Karel Zimmermann** Karel Zimmermann (Gar.)*	Z,ZK	6	2P+2L	L	P
B3MPVTY1	**Team Project** *Martin Šipoš, Petr Drábek, Tomáš Drábek, Ondřej Drbohlav, Martin Hlinovský, Pavel Mužák **Ondřej Drbohlav** Tomáš Drábek (Gar.)*	Z	6	0P+4C	L	P
2021_MKYRPV1	**Povinně volitelné předměty programu - skupina 1** *B4M33MPV,B3M35OFD,..... (see the list of groups below)*	Min. cours. 3 Max. cours. 6	Min/Max 18/36			PV
2021_MKYRPV2	**Povinně volitelné předměty programu - skupina 2** *B3M38ASE,B3M35DRS,..... (see the list of groups below)*	Min. cours. 4 Max. cours. 19	Min/Max 24/114			PV

2021_MKYRVOL	**Volitelné odborné předměty**	Min. cours. 0	Min/Max 0/999			V

Number of semester: 3

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
B3MPROJ6	**Project** *Tomáš Drábek, Martin Hlinovský, Kamila Krupková, Petr Pošík, Jana Zichová, Šárka Hejtmanová, Drahomíra Hejtmanová*	Z	6	0p+6s	Z,L	P
2021_MKYRPV1	**Povinně volitelné předměty programu - skupina 1** *B4M33MPV,B3M35OFD,..... (see the list of groups below)*	Min. cours. 3 Max. cours. 6	Min/Max 18/36			PV
2021_MKYRPV2	**Povinně volitelné předměty programu - skupina 2** *B3M38ASE,B3M35DRS,..... (see the list of groups below)*	Min. cours. 4 Max. cours. 19	Min/Max 24/114			PV
2021_MKYRVOL	**Volitelné odborné předměty**	Min. cours. 0	Min/Max 0/999			V

Number of semester: 4

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
BDIP30	**Diploma Thesis**	Z	30	22s	L	P

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
2021_MKYRPV1	**Povinně volitelné předměty programu - skupina 1**	**Min. cours. 3 Max. cours. 6**	**Min/Max** 18/36			**PV**

B4M33MPV	Computer Vision Methods	B3M35OFD	Estimation, filtering and detect ...	B3M35ORR	Optimal and Robust Control
B3M38SPD1	Data Acquisition and Transfer	BE4M33SSU	Statistical Machine Learning	B3M38ZDS1	Analog Signal Processing and Dig ...

2021_MKYRPV2	**Povinně volitelné předměty programu - skupina 2**	**Min. cours. 4 Max. cours. 19**	**Min/Max** 24/114			**PV**

B3M38ASE	Automotive Sensors and Networks	B3M35DRS	Dynamics and Control Networks	B3M33HRO	Humanoid robots
B3M35HYS	Hybrid Systems	B3M38INA1	Integrated Avionics	B3M35KOA	Combinatorial Algorithms
B2M32MKSA	Mobile Networks	B3M33MRS	Multi-robot aerial systems	B3M35NES	Nonlinear Systems and Chaos
B3M33PKR	Advanced robot kinematics	B3M38POS	Advanced Sensors	B3M35PSR	Real -Time Systems Programming
B3M38PSL1	Aircraft Avionics	B3M35RSA	Automotive Control Systems	B3M35SRL	Flight Control Systems
B4M33TDV	Three-dimensional Computer Visio ...	B4M36UIR	Artificial Intelligence in Robot ...	B3M38VBM1	Videometry and Contactless Measu ...
B3M38VIN1	Virtual Instrumentation				

2021_MKYRVOL	**Volitelné odborné předměty**	**Min. cours. 0**	**Min/Max** 0/999			**V**

List of courses of this pass:

Code	Name of the course	Completion	Credits
B2M32MKSA	Mobile Networks	Z,ZK	6
The lectures introduce principles and functionalities of mobile networks with special focus on currently deployed technologies and future mobile networks. Furthermore, architecture and fundamental principles of GSM, UMTS, LTE/LTE-A, and 5G will be explained. Then, selected key technologies for future mobile networks (6G) will be explained.			
B3M33ARO1	Autonomous Robotics	Z,ZK	6
The Autonomous robotics course will explain the principles needed to develop algorithms for intelligent mobile robots such as algorithms for: (1) Mapping and localization (SLAM) sensors calibration (lidar or camera). (2) Planning the path in the existing map or planning the exploration in a partially unknown map and performing the plan in the world. IMPORTANT: It is assumed that students of this course have a working knowledge of optimization (Gauss-Newton method, Levenberg Marquardt method, full Newton method), mathematical analysis (gradient, Jacobian, Hessian), linear algebra (least-squares method), probability theory (multivariate gaussian probability), statistics (maximum likelihood and maximum aposteriori estimate), python programming and machine learning algorithms. This course is also part of the inter-university programme prg.ai Minor. It pools the best of AI education in Prague to provide students with a deeper and broader insight into the field of artificial intelligence. More information is available at https://prg.ai/minor.			
B3M33HRO	Humanoid robots	Z,ZK	6
The course focuses on human-centered robotics: humanoid robots and human-robot interaction. Motivated by the vision of robot companions in our homes, this course introduces humanoid robot technology and its specific challenges and opportunities: (i) design, kinematics and inverse kinematics of humanoids, (ii) multimodal sensing - vision, touch, hearing, inertial sensing, etc., (iii) walking and balancing, and (ii) grasping. The second part of the course centers on human-robot interaction (HRI), which includes physical HRI (safety aspects, collaborative robots) and cognitive/social HRI - how to design robots and behaviors to be acceptable for people.			
B3M33MRS	Multi-robot aerial systems	Z,ZK	6
The course offers the introduction to multirotor autonomous aerial systems (UAV). Standard senzors and principles of estimate and control of UAV will be introduced. The problems of motion planning, path planning, localization, mapping and exploration will be discussed for sigle moving UAV as well as multiple UAVs moving in a formation.			
B3M33PKR	Advanced robot kinematics	Z,ZK	6
We will explain and demonstrate techniques for modelling, analyzing and identifying robot kinematics. We will explain more advanced principles of the representation of motion in space and the robot descriptions suitable for identification of kinematic parameters from measured data. We will explain how to solve the inverse kinematic task of 6DOF serial manipulators and how it can be used to identify its kinematic parameters. Theory will be demonstrated on simulated tasks and verified on a real industrial robot.			
B3M35DRS	Dynamics and Control Networks	Z,ZK	6
This course responds to an ever-increasing demand for understanding contemporary networks large-scale complex systems composed of many components and subsystems interconnected into a single distributed entity. Herein, we will consider fundamental similarities between diverse areas such as e.g. forecasting the spread of global pandemics, public opinion dynamics and manipulation of communities through social media, formation controls for unmanned vehicles, energy generation and distribution in power grids, etc. Understanding such compelling issues goes far beyond the boundaries of any single physical, technological or scientific domain. Therefore, we will analyze phenomena across different domains, involving societal, economic and biological networks. For such networked systems, the resulting behavior depends not only on the characteristics of their individual components and details of their physical or logical interactions, but also on a precise way those components are interconnected the detailed interconnection topology. For that reason, the first part of the course introduces fundamental theoretical and abstract computational network analysis concepts; in particular, the algebraic graph theory, network measures and metrics and fundamental network algorithms. The second part of the course subsequently views networks as dynamical systems, studies their properties and ways in which these are controlled, using mainly methods of automatic control theory.			
B3M35HYS	Hybrid Systems	Z,ZK	6
Hybrid dynamical systems, sometimes also referred to as cyber-physical systems, contain both subsystems governed by physical laws and subsystems behaving according to logical rules and regulations, often encoded in the form of algorithms and implemented in software. The behaviour of the former can be described by real quantities whose evolution in continuous or discrete time is commonly modelled by differential or difference equations. The behaviour of the latter is commonly described by quantities taking on a countable or finite number of values (or even just two in the case of binary quantities), whose evolution is modelled by logical models such as finite state automata or Petri nets. In the modelling and analysis of hybrid systems and the design of control systems for them, these two classes of models intersect. However, the control system itself can also be hybrid. And the industrial reality is that practical control systems contain, in addition to the continuous subsystems represented by PID controllers or Kalman filters, a subsystem or component evaluating the satisfaction of logic conditions. Switched linear controllers (gain scheduling), supervisory control, sliding mode control or reset control are examples of such controllers with hybrid dynamics. Hybrid control methods are also becoming particularly important in a networked environment, where measurements or controls are sent over the network only when some condition is met, in order to minimize network traffic (event triggered control). Hybrid dynamical systems thus represent a suitable theoretical and extremely practical framework for modelling, analysis and synthesis of a large number of practical control systems. The aim of this advanced course is to help students acquire basic competences (knowledge but also practical design/computational skills) in this practically very relevant and theoretically still intensively developed area.			
B3M35KOA	Combinatorial Algorithms	Z,ZK	6
The goal is to show the problems and algorithms of combinatorial optimization (often called discrete optimization; there is a strong overlap with the term operations research). Following the courses on linear algebra, graph theory, and basics of optimization, we show optimization techniques based on graphs, integer linear programming, heuristics, approximation algorithms and state space search methods. We focus on application of optimization in stores, ground transportation, flight transportation, logistics, planning of human resources, scheduling in production lines, message routing, scheduling in parallel computers.			
B3M35LSY1	Linear Systems	Z,ZK	6
The purpose of this course is to introduce mathematical tools for the description, analysis, and partly also synthesis, of dynamical systems. The focus will be on linear time-invariant multi-input multi-output systems and their properties such as stability, controllability, observability and state realization. State feedback, state estimation, and the design of stabilizing controllers will be explained in detail. Partially covered will be also time-varying and nonlinear systems. Some of the tools introduced in this course are readily applicable to engineering problems such as the analysis of controllability and observability in the design of flexible space structures, the design of state feedback in aircraft control, and the estimation of state variables. The main motivation, however, is to pave the way for the advanced courses of the study program. The prerequsites for this course include undergraduate level linear algebra, differential equations, and Laplace and z transforms.			
B3M35NES	Nonlinear Systems and Chaos	Z,ZK	6
The goal of this course is to introduce basics of the modern approaches to the theory and applications of nonlinear control. Fundamental difference when dealing with nonlinear systems control compared with linear case is that the state space approach prevails. Indeed, the frequency response approach is almost useless in nonlinear control. State space models are based mainly on ordinary differential equations, therefore, an introduction to solving these equations is part of the course. More importantly, the qualitative methods for ordinary differential equations will be presented, among them Lyapunov stability theory is crucial. More specifically, the focus will be on Lyapunov function method enabling to analyse stability of nonlinear systems, not only that of linear ones. Furthemore, stabilization desing methods will be studied in detail, among them the so-called control Lyapunov function concept and related backstepping method. Special stress will be, nevertheless, given by this course to introduce and study methods how to transform complex nonlinear models to simpler forms where more standard linear methods would be applicable. Such an approach is usually refered to as the so-called exact nonlinearity compensation. Contrary to the well-known approximate			

	linearization this method does not ignore nonlinearities but compensates them up to the best possible extent. The course introduces some interesting case studies as well, e.g. the planar vertical take off and landing plane ("planar VTOL"), or a simple 2-dimensional model of the walking robot.		
B3M35OFD	Estimation, filtering and detection	Z,ZK	6
	This course will cover description of the uncertainty of hidden variables (parameters and state of a dynamic system) using the probability language and methods for their estimation. Based on bayesian problem formulation principles of rational behavior under uncertainty will be analyzed and used to develop algorithms for parameter estimations (ARX models, Gaussian process regression), filtering (Kalman filter) and detection (likelihood ratio theory) . We will demonstrate numerically robust implementation of the algorithms applicable in real life problems for the areas of industrial process control, robotics and avionics.		
B3M35ORR	Optimal and Robust Control	Z,ZK	6
B3M35PSR	Real -Time Systems Programming	Z,ZK	6
	The goal of this course is to provide students with basic knowledge about software development for real-time systems, for example in control and embedded applications. The focus is on embedded systems equipped with a real-time operating system (RTOS). Lectures will cover real-time systems theory, which can be used to formally verify timing correctness of such systems. Another set of lectures will introduce methods and techniques used for development of safety-critical systems, whose failure may have catastrophic consequences. During labs, students will first solve a few simple tasks to familiarize themselves with basic components of VxWorks RTOS and to benchmark the used OS and hardware (Xilinx Zynq). The obtained metrics represent the typical criteria for assessing the suitability of a given platform for the given application. After the simple tasks, students will solve a complex task of time-critical motion control application which will require full utilization of RTOS features. All the tasks at the labs will be implemented in C (or C++) language.		
B3M35RSA	Automotive Control Systems	Z,ZK	6
B3M35SRL	Flight Control Systems	Z,ZK	6
	The course is devoted to classical and modern control design techniques for autopilots and flight control systems. Particular levels are discussed, starting with the dampers attitude angle stabilizers, to guidance and navigation systems. Next to the design itself, important aspects of aircraft modelling, both as a rigid body and considering flexibility of the structure, are discussed.		
B3M38ASE	Automotive Sensors and Networks	Z,ZK	6
	The course provides students with a deeper insight into the functional principles of advanced sensor systems in cars, methods of signal processing in sensors and explains how to use them in vehicle subsystems. It also deals with distributed vehicle systems for real-time control and methods of their testing. Theoretical lectures are complemented by practical laboratory teaching with real elements (ECUs, sensors) of modern vehicles.		
B3M38DIT1	Diagnostics and Testing	Z,ZK	6
	The course aims to introduce students to the problems of modelling and fault detection, ensuring fault tolerance, monitoring the operational status of complex industrial components and autonomous systems, non-destructive testing and diagnostics of electronic devices with analogue and digital circuits.		
B3M38INA1	Integrated Avionics	Z,ZK	6
	The course Integrated Modular Avionics (IMA) focuses on a modern concept of the approach to the development and design of aircraft electronics (avionics), where the transition from distributed HW systems to SW blocks. They use high-speed connections to exchange data in applications related to paid air transport. The existing regulatory basis and airspace sharing define the requirements for the accuracy, reliability, and functionality of electronic systems even in the event of a failure. In the course, students will learn details about the requirements for so-called safety-critical multi-sensor systems, methods of data processing from predetermined systems, fault detection methods, selection of primary computer and control system in parallel architectures, bus technology, and methods of testing/certification of aircraft instruments.		
B3M38POS	Advanced Sensors	Z,ZK	6
B3M38PSL1	Aircraft Avionics	Z,ZK	6
	The course acquaints students with the current technology used in aircraft instruments and unmanned aerial vehicles, ie systems and sensors working in the low frequency range and methods used to process their data. The course includes a detailed description of aircraft instrumentation and its resistance to external influences, a description of aircraft power sources, analysis of instruments and systems for measuring engine and aerometric quantities, and a description of emergency and operational diagnostics. The course also deals with the field of inertial navigation aids, used sensors and systems, their modeling and description. It analyzes in detail the principles of calculations of navigation equations, including methods of fusion of navigation data and their processing.		
B3M38SPD1	Data Acquisition and Transfer	Z,ZK	6
B3M38VBM1	Videometry and Contactless Measurement	Z,ZK	6
	This course focuses on CCD and CMOS video sensors, and optoelectronic sensors in general and their use in contactless videometric measurement systems. Further optical radiation, its features, behavior and its use for acquiring object parameters, optical projection system, design of measurement cameras and processing of their signal will be presented. Students will design, realize and debug an independent project - 'Optoelectronic reflective sensor', during labs.		
B3M38VIN1	Virtual Instrumentation	Z,ZK	6
B3M38ZDS1	Analog Signal Processing and Digitalization	Z,ZK	6
B3MPROJ6	Project	Z	6
B3MPVTY1	Team Project	Z	6
	Teamwork is the basis of most of the activities that people perform in companies and their personal lives. In this course, students can try how to solve a technical task in a team, how to cooperate, how to communicate together and how to solve problems such as project delays, how to include external influences in the plan, etc.		
B4M33MPV	Computer Vision Methods	Z,ZK	6
	The course covers selected computer vision problems: search for correspondences between images via interest point detection, description and matching, image stitching, detection, recognition and segmentation of objects in images and videos, image retrieval from large databases and tracking of objects in video sequences. This course is also part of the inter-university programme prg.ai Minor. It pools the best of AI education in Prague to provide students with a deeper and broader insight into the field of artificial intelligence. More information is available at https://prg.ai/minor.		
B4M33TDV	Three-dimensional Computer Vision	Z,ZK	6
	This course introduces methods and algorithms for 3D geometric scene reconstruction from images. The student will understand these methods and their essence well enough to be able to build variants of simple systems for reconstruction of 3D objects from a set of images or video, for inserting virtual objects to video-signal source, or for computing ego-motion trajectory from a sequence of images. The labs will be hands-on, the student will be gradually building a small functional 3D scene reconstruction system and using it to compute a virtual 3D model of an object of his/her choice.		
B4M36UIR	Artificial Intelligence in Robotics	Z,ZK	6
	The course aims to acquaint students with the use of planning approaches and decision-making techniques of artificial intelligence for solving problems arising in autonomous robotic systems. Students in the course are employing knowledge of planning algorithms, game theory, and solving optimization problems in selected application scenarios of mobile robotics. Students first learn architectures of autonomous systems based on reactive and behavioral models of autonomous systems. The considered application scenarios and robotic problems include path planning, persistent environmental monitoring, robotic exploration of unknown environments, online real-time decision-making, deconfliction in autonomous systems, and solutions of antagonistic conflicts. In laboratory exercises, students practice their problem formulations of robotic challenges and practical solutions in a realistic robotic simulator or consumer mobile robots. This course is also part of the inter-university programme prg.ai Minor. It pools the best of AI education in Prague to provide students with a deeper and broader insight into the field of artificial intelligence. More information is available at https://prg.ai/minor.		

BDIP30	Diploma Thesis	Z	30
Independent final comprehensive work for the Master's degree study programme. A student will choose a topic from a range of topics related to his or her branch of study, which will be specified by branch department or branch departments. The diploma thesis will be defended in front of the board of examiners for the comprehensive final examination.			
BE4M33SSU	Statistical Machine Learning	Z,ZK	6
The aim of statistical machine learning is to develop systems (models and algorithms) for learning to solve tasks given a set of examples and some prior knowledge about the task. This includes typical tasks in speech and image recognition. The course has the following two main objectives 1. to present fundamental learning concepts such as risk minimisation, maximum likelihood estimation and Bayesian learning including their theoretical aspects, 2. to consider important state-of-the-art models for classification and regression and to show how they can be learned by those concepts.			
BEZM	Safety in Electrical Engineering for a master´s degree	Z	0
The course provides for students of all programs periodic training guidelines for health and occupational safety and gives knowledge of electrical hazard of given branch of study. Students receive indispensable qualification according to the current Directive of the Dean.			

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