Studijní plán

Název plánu: Cybernetics and Robotics

Součást ČVUT (fakulta/ústav/další): Fakulta elektrotechnická
Katedra:
Obor studia, garantovaný katedrou: Úvodní stránka
Garant oboru studia.:
Program studia: Cybernetics and Robotics
Typ studia: Navazující magisterské prezenční
Předepsané kredity: 102
Kredity z volitelných předmětů: 18
Kredity v rámci plánu celkem: 120
Poznámka k plánu:

Název bloku: Povinné předměty programu
Minimální počet kreditů bloku: 60
Role bloku: P

Kód skupiny: 2021_MKYREP
Název skupiny: Compulsory subjects of the programme
Podmínka kredity skupiny: V této skupině musíte získat 30 kreditů
Podmínka předměty skupiny: V této skupině musíte absolvovat 5 předmětů
Kredity skupiny: 30
Poznámka ke skupině:

Kód	Název předmětu / Název skupiny předmětů *(u skupiny předmětů seznam kódů jejích členů)* *Vyučující,* ***autoři*** *a garanti (gar.)*	Zakončení	Kredity	Rozsah	Semestr	Role
BE3M33ARO1	**Autonomní robotika** *Karel Zimmermann, Vojtěch Vonásek, Václav Hlaváč* ***Karel Zimmermann*** *Karel Zimmermann (Gar.)*	Z,ZK	6	2P+2L	L	P
BE3M38DIT1	**Diagnostics and Testing** *Radislav Šmíd* ***Radislav Šmíd*** *Radislav Šmíd (Gar.)*	Z,ZK	6	2P+2L	Z	P
BE3M35LSY1	**Linear Systems** *Petr Hušek* ***Petr Hušek*** *Petr Hušek (Gar.)*	Z,ZK	6	3P+2S	Z	P
BE3MPROJ6	**Project**	Z	6	0p+6s	Z	P
BE3MPVTY1	**Teamwork** *Tomáš Drábek, Martin Hlinovský, Petr Drábek, Ondřej Drbohlav, Pavel Mužák, Martin Šipoš* ***Ondřej Drbohlav*** *Tomáš Drábek (Gar.)*	Z	6	0P+4C	L	P

Charakteristiky předmětů této skupiny studijního plánu: Kód=2021_MKYREP Název=Compulsory subjects of the programme

BE3M33ARO1	Autonomní robotika	Z,ZK	6

Předmět Autonomní Robotika naučí pricipům potřebným k vývoji algoritmů pro inteligentní mobilní roboty jako jsou například algoritmy pro: (1) Mapování a lokalizaci (SLAM) a kalibraci sensorů (např. lidaru či kamery). (2) Plánová í cesty v existující mapě, či planování explorace v částečně neznámé mapě. Důležité: Očekává se, že studenti mají pracovní znalost optimalizace (Gauss-Newton method, Levenberg Marquardt method, full Newton method), matematické analýzy (gradient, Jacobian, Hessian, vícerozměrný Taylor polynom), linear algebra (least-squares method),pravděpodobnostní teorie (vícerozměrný gaussian), statistiky (maximum likelihood a maximum aposteriori estimate), programování v pythonu a algoritmů strojového učení.

BE3M38DIT1	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.

BE3M35LSY1	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.

BE3MPROJ6	Project	Z	6
BE3MPVTY1	Teamwork	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.

Kód skupiny: 2021_MKYREDIP

Název skupiny: Diploma Thesis
Podmínka kredity skupiny: V této skupině musíte získat 30 kreditů
Podmínka předměty skupiny: V této skupině musíte absolvovat 1 předmět
Kredity skupiny: 30
Poznámka ke skupině:

Kód	Název předmětu / Název skupiny předmětů *(u skupiny předmětů seznam kódů jejích členů)* *Vyučující,* ***autoři*** *a garanti (gar.)*	Zakončení	Kredity	Rozsah	Semestr	Role
BDIP30	**Diplomová práce - Diploma Thesis**	Z	30	22s	L	P

Charakteristiky předmětů této skupiny studijního plánu: Kód=2021_MKYREDIP Název=Diploma Thesis

BDIP30	Diplomová práce - Diploma Thesis	Z	30

Samostatná závěrečná práce inženýrského studia komplexního charakteru. Téma práce si student vybere z nabídky témat souvisejících se studovaným oborem, která vypíše oborová katedra či katedry. Práce bude obhajována před komisí pro státní závěrečné zkoušky.

Název bloku: Povinně volitelné předměty
Minimální počet kreditů bloku: 42
Role bloku: PV

Kód skupiny: 2021_MKYREPV1
Název skupiny: Compulsory elective subjects of the programme - Group 1
Podmínka kredity skupiny: V této skupině musíte získat alespoň 18 kreditů (maximálně 36)
Podmínka předměty skupiny: V této skupině musíte absolvovat alespoň 3 předměty (maximálně 6)
Kredity skupiny: 18
Poznámka ke skupině:

Kód	Název předmětu / Název skupiny předmětů *(u skupiny předmětů seznam kódů jejích členů)* *Vyučující,* ***autoři*** *a garanti (gar.)*	Zakončení	Kredity	Rozsah	Semestr	Role
BE4M33MPV	**Computer Vision Methods** *Georgios Tolias, Jiří Matas, Jan Čech, Dmytro Mishkin* ***Ondřej Drbohlav*** *Jiří Matas (Gar.)*	Z,ZK	6	2P+2C	L	PV
BE3M38SPD1	**Data acquisition and transfer** *Radislav Šmíd* ***Radislav Šmíd*** *Radislav Šmíd (Gar.)*	Z,ZK	6	2P+2L	L	PV
BE3M35OFD	**Estimation, Filtering and Detection** *Vladimír Havlena* ***Vladimír Havlena*** *Vladimír Havlena (Gar.)*	Z,ZK	6	2P+2C	Z	PV
BE3M35ORR	**Optimal and Robust Control** *Zdeněk Hurák* ***Zdeněk Hurák*** *Zdeněk Hurák (Gar.)*	Z,ZK	6	2P+2C	L	PV
BE3M38ZDS1	**Signal processing and digitization** *Jan Holub* ***Jan Holub*** *Jan Holub (Gar.)*	Z,ZK	6	2P+2L	Z	PV
BE4M33SSU	**Statistical Machine Learning** *Jan Drchal, Vojtěch Franc, Boris Flach* ***Vojtěch Franc*** *Boris Flach (Gar.)*	Z,ZK	6	2P+2C	Z	PV

Charakteristiky předmětů této skupiny studijního plánu: Kód=2021_MKYREPV1 Název=Compulsory elective subjects of the programme - Group 1

BE4M33MPV	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.

BE3M38SPD1	Data acquisition and transfer	Z,ZK	6

The aim of the course is to acquaint students with the principles and limits of data transmission from sensors and similar sources of information for IoT and M2M communication, wireless sensor networks and specific algorithms used in them, respecting the limiting conditions of their function. The basic algorithms of distributed information processing in sensor networks will be studied, as well as technologies for obtaining energy for powering wireless nodes of the network.

BE3M35OFD	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.

BE3M35ORR	Optimal and Robust Control	Z,ZK	6
BE3M38ZDS1	Signal processing and digitization	Z,ZK	6

Students will gain knowledge for the design and implementation of systems for processing and digitization of analog signals. They will deepen the knowledge acquired in previous theoretical subject and gain practical experience in the design and analysis of systems for signal processing, AD conversion and data acquisitation. Emphasis is placed on reducing uncertainties, speed, stability and resistence to interfering signals.

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.

Kód skupiny: 2021_MKYREPV2
Název skupiny: Compulsory elective subjects of the programme - Group 2
Podmínka kredity skupiny: V této skupině musíte získat alespoň 24 kreditů (maximálně 114)
Podmínka předměty skupiny: V této skupině musíte absolvovat alespoň 4 předměty (maximálně 19)
Kredity skupiny: 24
Poznámka ke skupině:

Kód	Název předmětu / Název skupiny předmětů *(u skupiny předmětů seznam kódů jejích členů)* *Vyučující,* ***autoři*** *a garanti (gar.)*	Zakončení	Kredity	Rozsah	Semestr	Role
BE3M38POS	**Advanced sensors** *Antonín Platil* ***Antonín Platil*** *Antonín Platil (Gar.)*	Z,ZK	6	2P+2L	Z	PV
BE3M38PSL1	**Aircraft Avionics** *Martin Šipoš, Jan Roháč* ***Jan Roháč*** *Jan Roháč (Gar.)*	Z,ZK	6	2P+2L	Z	PV
BE4M36UIR	**Artificial Intelligence in Robotics** *Stefan Edelkamp, Tomáš Kroupa, Jan Faigl* ***Jan Faigl*** *Jan Faigl (Gar.)*	Z,ZK	6	2P+2C	Z	PV
BE3M35RSA	**Automotive Control Systems** *Tomáš Haniš* ***Tomáš Haniš*** *Tomáš Haniš (Gar.)*	Z,ZK	6	2P+2S		PV
BE3M38ASE	**Automotive sensors and networks** *Antonín Platil, Jiří Novák, Jan Sobotka* ***Jiří Novák*** *Jiří Novák (Gar.)*	Z,ZK	6	2P+2L	L	PV
BE3M35KOA	**Combinatorial Algorithms** *Zdeněk Hanzálek* ***Zdeněk Hanzálek*** *Zdeněk Hanzálek (Gar.)*	Z,ZK	6	2P+2C	L	PV
BE3M35DRS	**Dynamics and Control of Networks** *Kristian Hengster-Movric* ***Kristian Hengster-Movric***	Z,ZK	6	2P+2C	Z	PV
BE3M35SRL	**Flight Control Systems** *Martin Hromčík* ***Martin Hromčík*** *Martin Hromčík (Gar.)*	Z,ZK	6	2P+2L	Z	PV
BE3M33HRO	**Humanoidní roboti** *Matěj Hoffmann* ***Matěj Hoffmann*** *Matěj Hoffmann (Gar.)*	Z,ZK	6	2P+2C	L	PV
BE3M35HYS	**Hybrid Systems** *Zdeněk Hurák* ***Zdeněk Hurák*** *Zdeněk Hurák (Gar.)*	Z,ZK	6	2P+2C		PV
BE3M38INA1	**Integrated avionics** *Martin Šipoš, Jan Roháč* ***Jan Roháč*** *Jan Roháč (Gar.)*	Z,ZK	6	2P+2L	L	PV
BE2M32MKSA	**Mobile Networks** *Robert Bešťák, Zdeněk Bečvář, Pavel Mach* ***Pavel Mach*** *Zdeněk Bečvář (Gar.)*	Z,ZK	6	2P + 2L	Z	PV
BE3M33MRS	**Multirobotické letecké systémy** *Tomáš Báča, Martin Saska, Robert Pěnička* ***Martin Saska*** *Martin Saska (Gar.)*	Z,ZK	6	2P+2L	Z	PV
BE3M35NES	**Nonlinear Systems** *Sergej Čelikovský* ***Sergej Čelikovský*** *Sergej Čelikovský (Gar.)*	Z,ZK	6	2P+2C	Z	PV
BE3M33PKR	**Pokročilá kinematika robotů** *Viktor Korotynskiy, Tomáš Pajdla, Vladimír Smutný* ***Tomáš Pajdla*** *Tomáš Pajdla (Gar.)*	Z,ZK	6	2P+2C	Z	PV
BE3M35PSR	**Real-time Systems Programming** *Michal Sojka* ***Michal Sojka***	Z,ZK	6	2P+2C	Z	PV
BE4M33TDV	**Three-dimensional Computer Vision** *Radim Šára* ***Radim Šára*** *Radim Šára (Gar.)*	Z,ZK	6	2P+2C	Z	PV
BE3M38VBM1	**Videometry and Contactless Measurement** *Jan Fischer* ***Jan Fischer*** *Jan Fischer (Gar.)*	Z,ZK	6	2P+2L	Z	PV
BE3M38VIN1	**Virtual Instrumentation** *Antonín Platil, Jaroslav Roztočil* ***Antonín Platil*** *Antonín Platil (Gar.)*	Z,ZK	6	2P+2L	L	PV

Charakteristiky předmětů této skupiny studijního plánu: Kód=2021_MKYREPV2 Název=Compulsory elective subjects of the programme - Group 2

BE3M38POS	Advanced sensors	Z,ZK	6

Overview of sensors of physical quantities used in industry and research and associated methods of signal processing. Students will gain advanced knowledge of sensors and methods of signal processing. They will gain practical experience with measurement of physical quantities with various types of sensors.

BE3M38PSL1	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.

BE4M36UIR	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.

BE3M35RSA	Automotive Control Systems	Z,ZK	6

BE3M38ASE	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.			
BE3M35KOA	Combinatorial Algorithms	Z,ZK	6
Cílem předmětu je seznámit studenty s problémy a algoritmy kombinatorické optimalizace (často se nazývá diskrétní optimalizace, významně se překrývá s pojmem operační výzkum). V návaznosti na předměty z oblasti lineární algebry, algoritmizace, diskrétní matematiky a základů optimalizace jsou ukázány techniky založené na grafech, celočíselném lineárním programování, heuristikách, aproximačních algoritmech a metodách prohledávání prostoru řešení. Předmět je zaměřen na aplikace optimalizace ve skladech, pozemní a letecké dopravě, logistice, plánování lidských zdrojů, rozvrhování výrobních linek, směrování zpráv, rozvrhování v paralelních počítačích. Výsledek studentské ankety předmětu je zde: http://www.fel.cvut.cz/anketa/aktualni/courses/A4M35KO			
BE3M35DRS	Dynamics and Control of Networks	Z,ZK	6
The course offers a response to the increasing demand for understanding of networks - large-scale and complex dynamical systems that are created by interconnecting components and subsystems. We will not restrict ourselves to one physical or technological domain. Quite the opposite, we will analyze the network-related phenomena found in several domains, including societal, economic, or biological. We will analyze the fundamental similarities among flight control of formations of unmanned aerial vehicles, tigh distance regulation in platoons of trucks on highways, generation and distribution of energy in smart grids, realization of a phone call in a cellular phone network, manipulation of a community through Facebook, or even forecasting the epidemics spread over a globe. For such networks, the resulting behavior is given not only by the individual components and subsystems but also by the way in which they are interconnected (topology of the network). Understanding these issues goes far beyond the boundaries of individual physical and technological or scientific domains. In the first part of the course we will introduce fundamental theoretical and computational concepts for analysis of networks, in particular, we will introduce basics of algebraic graph theory and network algorithms. In the second half of the course we will view the network as a dynamic system and we will study its properties and the ways in which these properties can be affected (controlled). We will use the methodologies from the automatic control theory. Finally, we will introduce some interesting tools for analysis and synthesis of networked systems such as wave and scattering description and distributed optimization.			
BE3M35SRL	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			
BE3M33HRO	Humanoidní roboti	Z,ZK	6
Předmět se zaměřuje na “robotiku orientovanou na člověka”: humanoidní roboty a interakci člověka s robotem. Motivací je vize robotů jako asistentů či společníků v domácnostech. Kurz uvádí do technologie humanoidních robotů se specifickými výzvami a příležitostmi: (i) chůze a udržení rovnováhy; (ii) pohyb rukou, uchopování a koordinace dvou rukou; (iii) vnímání více smysly - zrak, hmat, sluch, propriocepce, inerciální senzory, apod. Druhá část předmětu se soustředí na interakci člověka s robotem (human-robot interaction, HRI), což zahrnuje jak fyzickou interakci (bezpečnost, kolaborativní robotika), tak kognitivní/sociální interakci - jak navrhnout roboty a jejich chování tak, aby bylo pro lidi přijatelné a přirozené.			
BE3M35HYS	Hybrid Systems	Z,ZK	6
BE3M38INA1	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.			
BE2M32MKSA	Mobile Networks	Z,ZK	6
Předmět seznamuje s principy a funkcemi mobilních buňkových sítí zejména s ohledem na aktuálně nasazované a budoucí technologie pro mobilní komunikace. Student pochopí architekturu a principy fungování jednotlivých generací mobilních sítí od GSM, přes UMTS a LTE až k LTE-A. Předmět studenty seznámí i s vybranými technikami a způsoby komunikace pro buňkové mobilní sítě příští generace (5G). Po absolvování předmětu se studenti dokáží orientovat v problematice buňkových mobilních sítí a budou schopni řešit problémy spojené s provozem a plánováním těchto sítí.			
BE3M33MRS	Multirobotické letecké systémy	Z,ZK	6
Předmět poskytne úvod do problematiky vícemotorových bezpilotních létajících prostředků (UAV). Studenti se seznámí se standardními palubními senzory a s principy odhadu a řízení stavu UAV. Budou diskutovány techniky plánování pohybu, plánování cesty, lokalizace, mapování a průzkumu pro samostatně se pohybující UAV a jejich skupiny. Kromě toho se studenti seznámí s metodikou pro řízení roje více robotů, letu formace UAV a manipulací s prostředím pomocí UAV.			
BE3M35NES	Nonlinear Systems	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.			
BE3M33PKR	Pokročilá kinematika robotů	Z,ZK	6
Předmět vysvětlí a předvede metody pro popis, kalibraci a analýzu kinematiky průmyslových robotů. Hlouběji vysvětlí principy reprezentace prostorového pohybu a popisy robotů pro kalibraci jejich kinematických parametrů z měřených dat. Vysvětlíme řešení inverzní kinematické úlohy pro obecný 6DOF manipulátor a použití pro identifikaci parametrů robotu. Základním teoretickým výpočetním nástrojem pro řešení kinematických, kalibračních a analytických úloh bude lineární a polynomiální algebra a metody výpočetní algebraické geometrie. Teoretické techniky budou demonstrovány v simulacích a ověřovány na datech z reálných průmyslových robotů.			
BE3M35PSR	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 main 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 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 them 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 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.			
BE4M33TDV	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.			

BE3M38VBM1	Videometry and Contactless Measurement	Z,ZK	6
The course deals with optoelectronic sensors and their use in non-contact measurement systems based on the principles of videometry; problems of radiation and waves, their properties, behavior; optical projection system. The course deals with the lab. tasks, it is further solved, practically realized and presented the evaluated project of the optoelectric sensor.			
BE3M38VIN1	Virtual Instrumentation	Z,ZK	6
The subject deals with modern measuring instruments, virtual instruments (VI) and data acquisition and processing systems (DAQ). It presents principles of instruments and measurement systems in laboratory and industrial environment, selected measurement methods and standards for programming of VI and DAQ systems.			

Název bloku: Volitelné předměty
Minimální počet kreditů bloku: 0
Role bloku: V

Kód skupiny: 2021_MKYREVOL
Název skupiny: Elective subjects
Podmínka kredity skupiny:
Podmínka předměty skupiny:
Kredity skupiny: 0
Poznámka ke skupině: ~Student can choose arbitrary subject of themagister's program (EEM - Electrical Engineering, Power Engineering and Management, EK - Electronics and Communications, KYR - Cybernetics and Robotics, OI - Open Informatics, OES - Open Electronics Systems) which is not part of his curriculum. Student can choose with consideration of recommendation of the branch guarantee.You can find a selection of optional courses organized by the departments on the web site http://www.fel.cvut.cz/cz/education/volitelne-predmety.html

Seznam předmětů tohoto průchodu:

Kód	Název předmětu	Zakončení	Kredity
BDIP30	Diplomová práce - Diploma Thesis	Z	30
Samostatná závěrečná práce inženýrského studia komplexního charakteru. Téma práce si student vybere z nabídky témat souvisejících se studovaným oborem, která vypíše oborová katedra či katedry. Práce bude obhajována před komisí pro státní závěrečné zkoušky.			
BE2M32MKSA	Mobile Networks	Z,ZK	6
Předmět seznamuje s principy a funkcemi mobilních buňkových sítí zejména s ohledem na aktuálně nasazované a budoucí technologie pro mobilní komunikace. Student pochopí architekturu a principy fungování jednotlivých generací mobilních sítí od GSM, přes UMTS a LTE až k LTE-A. Předmět studenty seznámí i s vybranými technikami a způsoby komunikace pro buňkové mobilní sítě příští generace (5G). Po absolvování předmětu se studenti dokáží orientovat v problematice buňkových mobilních sítí a budou schopni řešit problémy spojené s provozem a plánováním těchto sítí.			
BE3M33ARO1	Autonomní robotika	Z,ZK	6
Předmět Autonomní Robotika naučí pricipům potřebným k vývoji algoritmů pro inteligentní mobilní roboty jako jsou například algoritmy pro: (1) Mapování a lokalizaci (SLAM) a kalibraci sensorů (např. lidaru či kamery). (2) Plánová í cesty v existující mapě, či planování explorace v částečně neznámé mapě. Důležité: Očekává se, že studenti mají pracovní znalost optimalizace (Gauss-Newton method, Levenberg Marquardt method, full Newton method), matematické analýzy (gradient, Jacobian, Hessian, vícerozměrný Taylor polynom), linear algebra (least-squares method),pravděpodobnostní teorie (vícerozměrný gaussian), statistiky (maximum likelihood a maximum aposteriori estimate), programování v pythonu a algoritmů strojového učení.			
BE3M33HRO	Humanoidní roboti	Z,ZK	6
Předmět se zaměřuje na “robotiku orientovanou na člověka”: humanoidní roboty a interakci člověka s robotem. Motivací je vize robotů jako asistentů či společníků v domácnostech. Kurz uvádí do technologie humanoidních robotů se specifickými výzvami a příležitostmi: (i) chůze a udržení rovnováhy; (ii) pohyb rukou, uchopování a koordinace dvou rukou; (iii) vnímání více smysly - zrak, hmat, sluch, propriocepce, inerciální senzory, apod. Druhá část předmětu se soustředí na interakci člověka s robotem (human-robot interaction, HRI), což zahrnuje jak fyzickou interakci (bezpečnost, kolaborativní robotika), tak kognitivní/sociální interakci - jak navrhnout roboty a jejich chování tak, aby bylo pro lidi přijatelné a přirozené.			
BE3M33MRS	Multirobotické letecké systémy	Z,ZK	6
Předmět poskytne úvod do problematiky vícemotorových bezpilotních létajících prostředků (UAV). Studenti se seznámí se standardními palubními senzory a s principy odhadu a řízení stavu UAV. Budou diskutovány techniky plánování pohybu, plánování cesty, lokalizace, mapování a průzkumu pro samostatně se pohybující UAV a jejich skupiny. Kromě toho se studenti seznámí s metodikou pro řízení roje více robotů, letu formace UAV a manipulací s prostředím pomocí UAV.			
BE3M33PKR	Pokročilá kinematika robotů	Z,ZK	6
Předmět vysvětlí a předvede metody pro popis, kalibraci a analýzu kinematiky průmyslových robotů. Hlouběji vysvětlí principy reprezentace prostorového pohybu a popisy robotů pro kalibraci jejich kinematických parametrů z měřených dat. Vysvětlíme řešení inverzní kinematické úlohy pro obecný 6DOF manipulátor a použití pro identifikaci parametrů robotu. Základním teoretickým výpočetním nástrojem pro řešení kinematických, kalibračních a analytických úloh bude lineární a polynomiální algebra a metody výpočetní algebraické geometrie. Teoretické techniky budou demonstrovány v simulacích a ověřovány na datech z reálných průmyslových robotů.			
BE3M35DRS	Dynamics and Control of Networks	Z,ZK	6
The course offers a response to the increasing demand for understanding of networks - large-scale and complex dynamical systems that are created by interconnecting components and subsystems. We will not restrict ourselves to one physical or technological domain. Quite the opposite, we will analyze the network-related phenomena found in several domains, including societal, economic, or biological. We will analyze the fundamental similarities among flight control of formations of unmanned aerial vehicles, tigh distance regulation in platoons of trucks on highways, generation and distribution of energy in smart grids, realization of a phone call in a cellular phone network, manipulation of a community through Facebook, or even forecasting the epidemics spread over a globe. For such networks, the resulting behavior is given not only by the individual components and subsystems but also by the way in which they are interconnected (topology of the network). Understanding these issues goes far beyond the boundaries of individual physical and technological or scientific domains. In the first part of the course we will introduce fundamental theoretical and computational concepts for analysis of networks, in particular, we will introduce basics of algebraic graph theory and network algorithms. In the second half of the course we will view the network as a dynamic system and we will study its properties and the ways in which these properties can be			

affected (controlled). We will use the methodologies from the automatic control theory. Finally, we will introduce some interesting tools for analysis and synthesis of networked systems such as wave and scattering description and distributed optimization.

BE3M35HYS	Hybrid Systems	Z,ZK	6
BE3M35KOA	Combinatorial Algorithms	Z,ZK	6

Cílem předmětu je seznámit studenty s problémy a algoritmy kombinatorické optimalizace (často se nazývá diskrétní optimalizace, významně se překrývá s pojmem operační výzkum). V návaznosti na předměty z oblasti lineární algebry, algoritmizace, diskrétní matematiky a základů optimalizace jsou ukázány techniky založené na grafech, celočíselném lineárním programování, heuristikách, aproximačních algoritmech a metodách prohledávání prostoru řešení. Předmět je zaměřen na aplikace optimalizace ve skladech, pozemní a letecké dopravě, logistice, plánování lidských zdrojů, rozvrhování výrobních linek, směrování zpráv, rozvrhování v paralelních počítačích. Výsledek studentské ankety předmětu je zde: http://www.fel.cvut.cz/anketa/aktualni/courses/A4M35KO

BE3M35LSY1	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.

BE3M35NES	Nonlinear Systems	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.

BE3M35OFD	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.

BE3M35ORR	Optimal and Robust Control	Z,ZK	6
BE3M35PSR	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 main 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 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 them 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 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.

BE3M35RSA	Automotive Control Systems	Z,ZK	6
BE3M35SRL	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

BE3M38ASE	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.

BE3M38DIT1	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.

BE3M38INA1	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.

BE3M38POS	Advanced sensors	Z,ZK	6

Overview of sensors of physical quantities used in industry and research and associated methods of signal processing. Students will gain advanced knowledge of sensors and methods of signal processing. They will gain practical experience with measurement of physical quantities with various types of sensors.

BE3M38PSL1	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.

BE3M38SPD1	Data acquisition and transfer	Z,ZK	6

The aim of the course is to acquaint students with the principles and limits of data transmission from sensors and similar sources of information for IoT and M2M communication, wireless sensor networks and specific algorithms used in them, respecting the limiting conditions of their function. The basic algorithms of distributed information processing in sensor networks will be studied, as well as technologies for obtaining energy for powering wireless nodes of the network.

BE3M38VBM1	Videometry and Contactless Measurement	Z,ZK	6
The course deals with optoelectronic sensors and their use in non-contact measurement systems based on the principles of videometry; problems of radiation and waves, their properties, behavior; optical projection system. The course deals with the lab. tasks, it is further solved, practically realized and presented the evaluated project of the optoelectric sensor.			
BE3M38VIN1	Virtual Instrumentation	Z,ZK	6
The subject deals with modern measuring instruments, virtual instruments (VI) and data acquisition and processing systems (DAQ). It presents principles of instruments and measurement systems in laboratory and industrial environment, selected measurement methods and standards for programming of VI and DAQ systems.			
BE3M38ZDS1	Signal processing and digitization	Z,ZK	6
Students will gain knowledge for the design and implementation of systems for processing and digitization of analog signals. They will deepen the knowledge acquired in previous theoretical subject and gain practical experience in the design and analysis of systems for signal processing, AD conversion and data acquisitation. Emphasis is placed on reducing uncertainties, speed, stability and resistence to interfering signals.			
BE3MPROJ6	Project	Z	6
BE3MPVTY1	Teamwork	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.			
BE4M33MPV	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.			
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.			
BE4M33TDV	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.			
BE4M36UIR	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.			

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