Program Overview - Computerized automation and robotics

Year I							
Semester I			Hours/Week				
Nr.	M/E	Courses	L	NE	Lab	ECTS	Teacher
1.	M	Robotic sensors and actuators	2	1	1	5	From Industry Lavdim Kurtaj
2.	M	Process Automation	2	1	1	5	Avni Skeja
3.	M	Modern Control Theory	2	1	1	5	Avni Skeja
4.	M	Dedicated computer systems	2	1	1	5	Lavdim Kurtaj
5.	E	Elective courses (2 courses): 1. Servomotors 2. Mechatronic systems 3. Discrete Event Systems 4. Networked Control Systems 5. Systems for computerized numerical control	 2 2 2 2 2	 1 1 1 1 1	 1 1 1 1 1	 5 5 5 5 5	 1.Avni Skeja 2.Lavdim Kurtaj 3.Ilir Limani 4. From Industry 5. From Industry
Semester II							
1.	M	Optimal Control	2	1	1	5	Avni Skeja
2.	M	Stochastic Systems and Estimation	2	1	1	5	Ilir Limani
3.	M	Robotics and automation	2	1	1	5	Lavdim Kurtaj
4.	M	System Identification	2	1	1	5	Ilir Limani
6.	E	Elective courses: (2 courses) 1. System analysis using finite elements 2. Computer process control 3. .Real-time operating systems 4. Control of Electric Power System 5. Human-machine interface 6. Methodology of scientific research	 2 2 2 2 2 2	 1 1 1 1 1 1	 1 1 1 1 1 1	 5 5 5 5 5 5	 1. Gurakuq Dajaku 2. From Industry, Lavdim Kurtaj 3.Lavdim Kurtaj 4. Gazmend Pula 5. From Industry 6. Ilir Limani

Year II							
Semester III			Hours/Week				
Nr.	M/E	Courses	L	NE	Lab	ECTS	Teacher
1.	M	Remote Control Systems	2	1	1	5	From Industry Avni Skeja

2.	M	Adaptive systems	2	1	1	5	Avni Skeja
3.	M	Artificial intelligence in automation, robotics and games	2	1	1	5	Lavdim Kurtaj
4.	M	Mobile robotics	2	1	1	5	Lavdim Kurtaj
6.	E	Elective courses (2 courses)					
		1.Design and development of simulation and interactive systems	2	1	1	5	1.Ilir Limani
		2.Neural network and fuzzy logic control	2	1	1	5	2. Lavdim Kurtaj
		3.Advanced methods of control	2	1	1	5	3. Arben Mashkulli
		4.Machine vision	2	1	1	5	4. Lavdim Kurtaj
		5.Control of Electrical Drives	2	1	1	5	5. Nysret Avdiu, Naim Imeraj
		6.Automation project management	2	1	1	5	6.Avni Skeja ,Ilir Limani

Semester IV				
1.	M	Master Thesis	30	

1.1.1. Course Descriptions

Course title: Robotic sensors and actuators (Mandatory, Sem I, 5 ECTS)
The goal: The goal of the course is to introduce students with structure of robots in working environment. Introduction to drives and adequate actuators, as well as sensors for internal state and for surround space, including necessary data processing for using them into control loop.
Learning outcomes: On successful completion of the course, students will be able to: 1. know robot control structure; 2. select and use adequate actuators for robot implementation; 3. select and process sensor data for predicting internal state of robot and using them into control loop; 4. know, to select, and to use sensors for navigation and orientation in space; 5. use visual sensors and extract basic information from them;
Course content: Introduction to the subject, structure of robot in working environment. Structure of control system and dependence on type of sensor as source of information. Actuator types, electric (motor) drives, hydraulic drives, pneumatic drives, mechanisms for connection with system. Physical models and interconnection with control system, nonlinearities and limitations. Servomechanisms and sensors for internal robot state (proprioceptive), multiple control loops, motion sensors (position, speed), force and torque, pressure, tactile sensors. Orientation (inertial) sensors, gyroscopes, acceleration sensors. Sensors for monitoring surrounding space and objects in it, external state (exteroceptive), localization (GPS, beacons), object distance (optic, laser, ultrasound) and speed (Doppler). Vision sensors, grey and color (BW, RGB), passive and active for depth (stereo, TOF, Kinect). Information processing for spatial motion, orientation, and recognition. Higher level control loops, visual feedback.
Methods of teaching:30 hours of lectures, 30 hours of laboratory exercises.
Grading System: Mid-term exams 10%+10%, Lab. work 20%, Project 30%, Final exam 30%.
Literature:

1. K.S. Fu, R.C. Gonzales, C.S.G. Lee, *ROBOTICS, Control, Sensing,Vision, and Intelligence*, McGraw-Hill
2. Clarence W. de Silva, *Sensors and Actuators: Control System Instrumentation*, CRC, 2007
3. Peter Corke, Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer, 2011
4. Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo, *Robotics - Modelling, Planning and Control*, Springer, 2009

Course title: Process Automation *(*Mandatory, Sem. I, 5 ECTS)
The goal : The subject is a general introduction to various techniques of process automation. Practical examples of process automation will be introduced and their implementing details will be discussed.
Learning outcomes: On successful completion of the course, students will be able to: 1. To have a detailed knowledge of PLC structured and their methods of programming. Identify situations where PLC use would be appropriate. **2.** Properly select sensor depending on what should me sensed (analog or digital) 3. Program PLC in different programming methods including ladder logic programming and block programming. 4. Understand the situations where microcontrollers and microcomputer systems should can be used to perform automation action. 5. Understand the concept of SCADA systems, their general properties and the current level of their use.
Course content: Introduction to programmable logic controllers. Their hardware structure and the flexibility in use. Input/output modules and the necessary signal conditioning circuitry for connection to a PLC. The standard electronics in automation. Measuring weight and temperature. Strain gauges, thermocouples, RTDs and thermistors. Working principles and the wiring diagrams. Motors, pistons and

valves: their most frequent use and their wiring diagrams. Basic of PLC programming: ladder programming. PLC working cycle and functional block programming. Using microcontroller systems to perform process automation. Conventional control strategies: feedback controllers, PID controller and their tunin. Introduction to SCADA systems: types of processes and their control structures. Distributed sensory systems. Communication protocols.
Methods of teaching: 30 hours of lectures + 15 hours of auditorial exercises + 15 hours of laboratory exercises. Approximately 100 hours of personal study and exercise including seminars.
Grading System: Seminar 10%, Mid-term exams 30 %, Final Exam 60 %
Literature:

1. F. Petruzella, *Programmable Logic Controllers,* McGraw Hill
2. J. Love, Process Automation Handbook

Course title: Modern Control Theory (Mandatory, Sem. I, 5 ECTS)
The goal : The course is an introduction to the modern control approach and it's theoretical background. Complete state-space analysis of systems will be performed and feedback state controllers will be discussed.
Learning outcomes: On successful completion of the course, students will be able to: 1. Perform system analysis completely in state-space domain so that both analysis and design of controller can be performed in state-space. **2.** Use the analytical results to design state-feedback controllers and tune their parameter for proper system response. 3. Fully describe the Kalman feedback controller and appreciate its importance, and also be familiar with its implementing variants.
Course content: Introduction to modern control systems. Engineering design and mechatronic systems. Fundamental properties of feedback control systems. Error signal analysis and disturbance signal in the feedback path. Performance specification in the frequency domain. Design of feedback control systems and their advantages. The influence of filtering on the performance of feedback controllers. Fundamental techniques for obtaining optimal control strategies. Mathematical models for noise/disturbance and controller design for noise suppression performance
Methods of teaching: 30 hours of lectures + 15 hours of auditorial exercises + 15 hours of laboratory exercises. Approximately 100 hours of personal study and exercise including seminars.
Grading System: Seminar 10%, Mid-term exams 30 %, Final Exam 60 %
Literature:

1. R.C. Dorf & R. H. Bishop, *Modern Control Theory*
2. U. A. Bakshi & M.V. Bakshi, Modern Control Theory, Pune Technical Publications

Course title: Dedicated computer systems (Mandatory, Sem I, 5 ECTS)
The goal: The goal of the course is to introduce students with structure of dedicated computer systems that cooperate with physical plant and with the process for designing them. Emphasis is on behaviour coherence between implemented system and the system models, including the one of software part and of physical system dynamics.
Learning outcomes: On successful completion of the course, students will be able to: 1. know structure of dedicated computer system, its interconnection and cooperation with physical plant; 2. master design process for dedicated computer systems;3. design system according to specifications with some formal language (ore descriptive); 4. implement and program designed system, including implementation of specialized functional blocks with programmable devices (PLD, CPLD, FPGA, etc.); 5. integrate implemented system with real physical plant and collect functional and quantitative results for purpose of analysis and verification of accordance with initial specifications.
Course content:

Dedicated computer systems, structure, use, characteristics, and technologies. Design process: modeling, design and analysis. Modeling dynamic behavior, continuous, discrete and hybrid dynamics. Models and languages. Models based on state, on activity, on data and heterogenic models. State machines, with finite, extended, with data, timed, hierarchical, concurrent states. Specification languages (natural descriptive, formal), VHDL, Verilog, state diagrams, UML. Embedded system design, processors, parallelism, memory architecture, input/output, specialized units (PLD, FPGA, CPLD, µCont, SoC, DSP). Operating system, multitasking, processes and mesage passing, atomic operations, planing. Distributed systems, communication units and networks, interfaces, protocols. Time synchronization. analysis and verification, requirement fulfillment, specifications, timed logic, equality and refinements, model verification, qunatitative analysis, security. User and implementer viewpoint. Documentation.

Methods of teaching:30 hours of lectures, 30 hours of laboratory exercises.

Grading System: Lab. work 30%, Project 50%, Final exam 20%.

Literature:

1. Edward Ashford Lee, Sanjit Arunkumar Seshia, *Introduction to Embedded Systems - A Cyber-Physical Systems Approach*, LeeSeshia.org, 2011
2. Wayne Wolf, *Computers as Components: Principles of Embedded Computer Systems Design*, Morgan Kaufman, 2000
3. Insup Lee , Joseph Y-T. Leung , Sang H. Son, *Handbook of Real-Time and Embedded Systems*, CRC, 2007
4. Ian Grout, *Digital Systems Design with FPGAs and CPLDs*, Newnes, 2008
5. Miro Samek, *Practical UML Statecharts in C/C++: Event-Driven Programming for Embedded Systems*, 2nd edition, Newnes, 2008

Course title: Servomotors (Elective, Sem. I, 5 ECTS)

The goal : The purpose of this course is to open the issue of servomotors as an important and common part of control systems. Discussions on the basic principles and implementing issues.

Learning outcomes: On successful completion of the course, students will be able to: 1. Chose the proper motor and control scheme based on the system requirements. **2.** Chose the proper sensing (sensory) part of the systems to functionalize a position/velocity control system. 3.Fully understand selsynes and their implementing variants for position and velocity control 4. Have solid knowledge on different kinds of sensors for measuring both analog and digital signals that are important in servo systems. 5. Fully understand the structures and basic features of type 0, 1 and 2 servo systems.

Course content: Modeling of dc motors. Control through rotor and stator current. Ward-Leonard group and amplidyne. Modeling of asynchronous two-phase motors and their control scheme: advantages in use and the difference from dc motors. Rough and precise control system for position and velocity control with selsynes. Synchronous circuit and its variants. Type 0 servo. Position control using the type 0 servo system. Type 1 servo: position and velocity control. Type 2 sevo: position and velocity control; implementing issues and steady state error. Modern control techniques and their advantages. Phase control and impulsive control of motors.

Methods of teaching: 30 hours of lectures + 15 hours of auditorial exercises + 15 hours of laboratory exercises. Approximately 100 hours of personal study and exercise including seminars.

Grading System: Seminar 10%, Mid-term exams 30 %, Final Exam 60 %

Literature:

1. A. Skeja, *Servomotorwt*, Authorized Lecture Notes
2. R. Riazollah, *Servomotors and Industrial Control Theory*, Springer
3. P. Moreton, *Industrial Brushless Motors*

Course title: Mechatronic systems (Elective, Sem. I, 5 ECTS)
The goal: The goal of the course is to introduce students with mechatronical systems, structure with construction blocks, and composition elements. Introduction to mechatronic design, analysis and implementation, as a rapid prototype and as a concrete microcomputer system, together with adequate software support.
Learning outcomes: On successful completion of the course, students will be able to: 1. know structure of mechatronic systems; 2. according to requirements to select elements of mechatronic system;3. explain difference between classic and mechatronic approach for product design; 4. by using modern computer tools to design mechatronic system; 5. develop adequate control algorithm (relay, PID and state) for concrete system;6. analyse effectiveness of real implementation of control algorithm, including cases when smart elements with networked communication are used; 7. develop rapid prototype with modern computer tools.
Course content: Machatronics as cooperative integration of technical mechanics, electronics, computer engineering and information technology. Fundamentals of mechatronic design. Components and interfaces of mechatronic system, functional blocks. Microcomputer control block as control unit and connection with sensors and actuators, data exchange between control unit and process. Integrating smart units with mechatronic system. Real time operation and requirements from microprocessor block. Criteria for selecting control system. Integration of rotary and translational electromechanical systems as examples of mechatronic systems, modeling, simulation, controller synthesis (relay, PID, state) and real time control. Estimating influence of processing time delays, planning order of actions. Systems for rapid control system prototype development.
Methods of teaching: 30 hours of lectures, 30 hours of laboratory exercises.
Grading System: Mid-term exams 10%+10%, Lab. work 20%, Project 30%, Final exam 30%.
Literature:

1. Clarence W. de Silva, *Mechatronics: A Foundation Course*, CRC, 2010
2. Clarence W. de Silva, *Sensors and Actuators: Control System Instrumentation*, CRC, 2007
3. Victor Giurgiutiu, Sergey Edward Lyshevski, *Micromechatronics: modeling, analysis, and design with MATLAB*, CRC, 2009
4. Lavdim Kurtaj, *Mechatronical Project*, WUS-Austria and University of Prishtina, 2011
5. Nikolay V. Kirianaki, Sergey Y. Yurish, Nestor O. Shpak, Vadim P. Deynega, *Data Acquisition and Signal Processing for Smart Sensors*, Wiley, 2002

Course title: Discrete Event Systems (Elective, Sem. I, 5 ECTS)
Course objectives: This course aims to provide an introduction to the modeling and analysis of discrete-event systems, and to cover some of the techniques that have been developed based on DES models for the design of supervisory control systems.
Learning outcomes: Upon the completion of the course students will be introduced to DES models, such as finite-state automata, that are used in the study of a wide range of problems in areas such as process control systems, communication networks, automated manufacturing systems, etc. For instance, in the context of control systems, DES models are used for studying sequencing and supervisory control.
Course content: Introduction to discrete-event systems. Modeling: languages, automata. Analysis: safety, blocking. Synthesis: supervisory control, controllability, modular control. Petri nets: modeling, analysis. Timed DES models.
Teaching methodology: 30 hours of lectures+30 hours of supervised exercises. Approximately 75 hours of personal study, including homework exercises.
Grading System: Homework 10%, Mid-term exams 30 %, Final Exam 60 %
Literature:

1. Cassandras C.G., and S. Lafortune, “*Introduction to Discrete Event Systems*”, Springer, 2008.
2. Banks J., Carson II J., Nelson B., and Nicol D.; “*Discrete Event System Simulation*”, Prentice Hall; 2009.

Course title: Networked Control Systems (Elective, Sem.I, 5 ECTS)
Course objectives: This course will provide an overview of the tools and techniques that have proven instrumental for studying networked control systems as well as outline potential development directions.
Learning outcomes: Student will understand principles of decentralized control and different network models, and how to use them on the tasks of controlling distant complex systems.
Course content: Network Models: graphs, random graphs, random geometric graphs, state-dependent graphs, switching networks. Decentralized Control: limited computational, communications, and controls resources in networked control systems. Multi-Agent Robotics: formation control, sensor and actuation models. Mobile Sensor Networks: coverage control, Voronoi-based cooperation strategies. LAN: mobile communications networks, connectivity maintenance.
Teaching methodology: 30 hours of lectures+30 hours of supervised exercises. Approximately 75 hours of personal study, including homework exercises.
Grading System: Homework 10%, Mid-term exams 30 %, Final Exam 60 %
Literature:

1. Mesbahi M. and Egerstedt M., “*Graph Theoretic Methods in Multiagent Networks*”, Princeton University Press, 2010.
2. Bullo F., Cortes J., and Martinez S., “*Distributed Control of Robotic Networks*”, Princeton, 2009.
3. Godsil C and Royle G., “*Algebraic Graph Theory*”, Springer, 2001.

Course title: Optimal Control (Mandatory, Sem. II, 5 ECTS)
The goal : The course is an introduction to the principle of optimality and optimal control strategies and their use. The importance of optimal control strategies in systems with limited power supply is emphasized.
Learning outcomes: On successful completion of the course, students will be able to: 1. Tell the difference between conventional control systems and optimal control systems . **2.** Understand the concept of the index of performance and make a proper selection of based on the problem nature. 3. Fully understand the method of dynamic programming and be able to implement its algorithm in digital computers . 4. Understand Pontryagin’s minimum principle and it’s importance regarding optimal control laws. 5. Have and understating on the numerical methods used to solve optimal control problems of different natures.
Course content: The necessary condition for optimal control. Proper modeling of systems in order to apply the optimal control strategies. Performance index. Choosing a performance measure for problem of terminal control, minimum time and minimum control effort. Introduction to the method of dynamic programming. Applying the method of dynamic programming in decision-taking and routing problems. Discrete linear controller problems an optimal feedback controller. Hamilton-Jacobian-Bellman equations and the calculus of variations. Introduction to the concept of functional and their importance in optmal control problems. The solution to problems related to minimum time, terminal control and minimum control effort. Introduction to numerical methods for solving optimal control problems and deriving optimal control trajectories. Introduction to stochastic control problems and the probability approach to systems with excessive disturbances.
Methods of teaching: 30 hours of lectures + 15 hours of auditorial exercises + 15 hours of laboratory exercises. Approximately 100 hours of personal study and exercise including seminars.
Grading System: Seminar 10%, Mid-term exams 30 %, Final Exam 60 %

Literature:

1. D. E. Kirk, *Optimal Control Theory, an Introduction*, Dover Publications
2. Bryson, Arthur & Yu-Chi Ho, Applied Optimal Control: Optimization, Estimation and Control, Taylor & Francis

Course title: Stochastic Systems and Estimation (Mandatory, Sem. II, 5 ECTS)
Course objectives: Students will be introduced in fundamental theories and applications of estimation, control, and stability for linear discrete-time and continuous-time stochastic systems.
Learning outcomes: The student will learn how to formulate models for the purposes of control, choosing models to capture essential dynamics and uncertainty. The course will provide several approaches to design control laws based on these models, and methods to approximate the performance of the controlled system.
Course content: Concepts from probability theory, random variables, random vectors, conditional distributions, functions of ransom variables. Estimation Theory. Random processes, Gauss-Markov processes, properties of random processes. Spectral factorizations of random processes. Prediction and filtering theory. Minimal variance control strategies.
Teaching methodology: 30 hours of lectures+30 hours of supervised exercises laboratory. Approximately 75 hours of personal study, including homework exercises.
Grading System: Homework 10%, Mid-term exams 30 %, Final Exam 60 %
Literature:

1. Brown R. and Hwang P.; "*Introduction to Random Signals and Applied Kalman Filtering*", John Wiley & Sons, 1996.
2. Siouris, G., "*An engineering approach to optimal control and estimation theory*", John Wiley & Sons, 1997.
3. Astrom, K.; "*Introduction to stochastic control theory*", Academic Press, 1970.

Course title: Robotics and automation (Mandatory, Sem. II, 5 ECTS)
The goal: The goal of the course is to introduce students with usage of robots in different automation tasks, industrial, processing, and service. Accent will be on designing system, implementation with PLC or dedicated computer, and programming for execution of requested actions.
Learning outcomes: On successful completion of the course, students will be able to: 1. know structure of automatic systems and place for robots on them; 2. know possibilities of using robots different tasks and relevant specifications;3. integrate robots with automation systems (PLCs) with signals or with communication interface; 4. program different working tasks on integrated systems; 5. understand and use for feedback control information from surrounding sensors (presence, distance, tactile, vision).
Course content: Introduction to the course and types of automation: fixed, changeable, programmable. Industrial robots (manipulators), mobile, modular, cooperating. Use of robots and action space. Automation in industry and processing, NC, CNC, robots. Working cell with robots. Robots for auxiliary and service tasks. Acting on dangerous environments. Robots for education and entertainment. Robot specifications. Industrial robots and construction, structure, kinematics, dynamics, control, hand, and gripper. Movement and working task, trajectory planning, point-to-point, continuous path, with contact and force application on environment. Robot programming, on-line, off-line, teach pendant and learning. Industrial robots and interconnection with automation system, PLCs, levels of interconnection (signal and communication interface). Methods of control (with or without surrounding sensor) and coordination with other devices (transport, machines, cooperants). Structured and unstructured environment. Adaption to changes, vision sensors and systems. Visual feedback. Action planning and utilization of artificial intelligence. Education robots and games (Lego NXT, FIRA). Simulators, graphics, and computer games.

Methods of teaching: 30 hours of lectures, 30 hours of laboratory exercises.
Grading System: Lab. work 30%, Project 50%, Final exam 20%.
Literature:

1. Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo, *Robotics - Modelling, Planning and Control*, Springer, 2009
2. K.S. Fu, R.C. Gonzales, C.S.G. Lee, *ROBOTICS, Control, Sensing,Vision, and Intelligence*, McGraw-Hill
3. Peter Corke, *Robotics, Vision and Control: Fundamental Algorithms in MATLAB®*, Springer, 2011
4. Bijoy K. Ghosh, Ning Xi, T.J. Tarn, (Eds.), Control in Robotics and Automation: Sensor-Based Integration, Academic Press, 1999
5. Antti J. Koivo, Fundamentals for Control of Robotic Manipulators, John Wiley & Sons, 1989

Course title: System Identification (Mandatory, Sem II., 5 ECTS)
Course objectives: This course aims to: Introduce students to the fundamentals of continuous and discrete systems modeling and basic identification procedures. To understand the tools for signals and systems simulation and identification, using by time, frequency and complex domain. Provide students with the ability to use the computer for simulation, modeling and systems identification.
Learning outcomes: This course concerns the description of identification techniques, with particular reference to the family of equation errors models used for prediction and control. At the end of the course the students should achieve the capability of using identification tools in modeling real processes and in evaluating the quality of the obtained models.
Course content: Model building approaches, mathematical models. Black box model representation. Nonparametric identification: time domain identification by correlation analysis, frequency response analysis, frequency response analysis by the correlation method, Fourier analysis, persistency of excitation. Parametric identification: prediction error methods, prediction models, least-squares method, analysis of the linear LS estimate, convergence and consistency. Model structure selection. Model validation.
Teaching methodology: 30 hours of lectures+20 hours of problem classes tutorial+10 hours of laboratory. Approximately 75 hours of personal study, including homework exercises.
Grading System: Homework 10%, Mid-term exams 30 %, Final Exam 60 %
Literature:

1. L. Ljung, "*System Identification: Theory for the User*", Prentice Hall, 1999.
2. T. Soderstrom and P. Stoica, "*System Identification*", Prentice Hall, 1989.
3. R. Isermann, "*Identification of Dynamic Systems: An Introduction with Applications*", Springer, 2005.

Course title: System analysis using finite elements (Elective, Sem II., 5 ECTS)
The goal: The purpose of the course is to learn about analysis and investigation of different systems using finite elements method (FEM).
Learning outcomes: On successful completion of the course, students will be able to: 1. To be familiar with the theory of finite elements method and their application on solving different electrical, magnetic, thermal and mechanical problems, 2. To learn the necessary steps for modeling of different system

components using FEM such as, modeling the real geometry, definition of materials and their assignment, definition of boundary conditions and excitation, and creating solutions and reviewing results, 3. To learn the co-simulation method for a real simulations of different systems, 4. Draft a paper on a particular issue or issues in the field of FEM modeling.

Course content: Introduction. Theory of numerical methods. Different modeling techniques with FEM. Application of FEM on the analysis of different systems. Electric systems. Magnetic systems. Thermal systems. Mechanical systems. Determination of electromagnetic parameters: resistance, inductivity, magnetic forces etc.. Determination of thermal parameters: heat transfer, thermal flux, temperature distribution, temperature effect on the system characteristics. Determination of mechanical parameters: mechanical robustness, mechanical stress, vibrations, noises. Co-simulation methods. Analysis of systems with the co-simulation methods. Conclusions. References.

Methods of teaching:30 hours of lectures, 30 hours of laboratory exercises.

Grading System: Mid-term exams 20%, Project 50%, Final Exam 30%

Literature:

1. D. Logan, "First Course in the Finite Element Method", 4th-Edit. Thomson Press 2006, ISBN-13: 978-8131502174.
2. E. Madenci, I. Guven, "The Finite Element Method and Applications in Engineering Using Ansys", Springer (Oktober 2007), ASIN: B008H05442.
3. G. Dajaku, "FEM in der Antriebstechnik", Lecture script, University of Federal Defence Munich, Germany.

Course title: Computer process control (Elective, Sem II., 5 ECTS)

The goal: The goal of the course is to introduce students with usage of computers fro process control, by using different forms of PID and digital controllers. It will be covered the process from design to final implementation, with dedicated computer and as a fast prototype.

Learning outcomes: On successful completion of the course, students will be able to: 1. know structure of computer system that is used for process control; 2. model processes and to control them with PID controller; 3. implement electronic and software part of auto-tuning PID controller based on relay feedback method; 4. design digital conventional and state controller for given processes; 5. design two degrees of freedom PID for control and disturbance rejection; 6. to understand and analyze interconnected multivariable systems.

Course content: Introduction. Structure of the process control system based on computer, system elements, process types (batch or sequential, continuous, combined or hybrid) , types of computer systems (supervising, direct digital control), architecture of computer system (centralized, distributed, hierarchical), human-machine interface (monitoring and control panels). Constructive and software structure of process control computer, data acquisition, processing, acting, network connection and communication, software for real time operation, auxiliary software. Control system specifications, controller design, tuning. Digital PID controller, integrator windup, variations, tuning methods. Modeling and identification, parametric models, test process. Relay feedback method, self-tuning PID. digital controllers with minimum delay time, dead-beat, increased order dead-beat. State controllers. Controllers for processes with dead-time (with pure dead-time). Behavior on disturbances, two degrees of freedom PID. Interconnected and multivariable control systems, PID and digital controllers. Digital controller implementation, quantization, filtering. Combining control algorithm with actuator. Rapid prototyping.

Methods of teaching:30 hours of lectures, 30 hours of laboratory exercises.

Grading System: Mid-term exams 10%+10%, Lab. work 20%, Project 30%, Final exam 30%.

Literature:

1. S. K. Singh, *Computer-Aided Process Control*, Prentice-Hall, 2005
2. Rolf Isermann, *Digital Control Systems*, Springer-Verlag, 1981
3. Karl J. Åström, Tore Hägglund, *Advanced PID Control*, ISA, 2006

4. Su Whan Sung, Jietae Lee, In-Beum Lee, *Process identification and PID control*, IEEE Press, 2009
5. Cheng-Ching Yu, *Autotuning of PID Controllers: A Relay Feedback Approach*, Springer, 2006

Course title: Real-time operating systems (Elective, Sem II., 5 ECTS)
The goal: The aim of the course is that students should learn how use, design and implement Real-Time Operating Systems, especially as applicable to embedded systems, including a relevant hardware review. Students will build a simple but relatively complete real-time operating system over the course duration.
Learning outcomes: On successful completion of the course, students will be able to: 1. list characteristics of real-time operating systems (RTOS) and compare hard and soft real-time systems; 2. build embedded system with some ready-made RTOS; 3. write applications that create and delete tasks, control task scheduling, and obtain task information; 4. design and program simple RTOS for specific computer system; 5. test and verify performance of RTOS; 6. understand and use distributed operating systems.
Course content: Introduction, operating systems, history, computer hardware, real-time vs. non real-time operating systems, proprietary, free, open source. Basic concepts, sequential processes, process cooperation, process communication, semaphores, conditional critical regions, event queues, deadlock, processor management, scheduling algorithms, queuing system model, memory storage management, I/O programming and interrupt structures, device management, information management, security. Analysis of real time system requirement, functional decomposition, hardware-software tradeoffs, embedded system concepts. Distributed operating systems concept, file systems, mode of computation, load balancing, event ordering, synchronization, distributed mutual exclusion, drinking philosophers problem, deadlocks in distributed systems.
Grading System: Lab work 20%, Project 50%, Final exam 30%.
Literature:

1. Abraham Silberschatz, Peter B. Galvin, Greg Gagne, *Operating System Concepts*, John Wiley & Sons, 2010
2. Jane W. S. Liu, *Real-Time Systems*, Prentice-Hall, 2000
3. Insup Lee , Joseph Y-T. Leung , Sang H. Son, *Handbook of Real-Time and Embedded Systems*, CRC, 2007
4. Rob Williams, *Real-Time Systems Developmen*, Butterworth-Heinemann, 2005
5. Andrew S. Tanenbaum, Maarten Van Steen, *Ditributed Systems: Priciples and Paradigms*, Pearson Education, 2007

Course title: Control of Electric Power System (Elective, Sem.II, 5 ECTS)
The goal: The objective purpose of the course is the introduction of the basic principles of electric power system control with the objective of its functional optimization
Learning outcomes: Upon successful completion of the course, students are expected to be able:
1. to be familiar with basic concepts of control of electric power systems 2. to know and be able to identify main segments and concepts of electric power system control and regulation and some of its key features 3. to know electric power consumption forecast and balance as a basis for electric power system planning, operation, control and optimization 4. to know main aspects of frequency and voltage control, power dispatching and its practical application in electric power systems
Course Content: General concepts of electric power system control. Importance and key features of electric power system control. Planning and practical application of power system regulation and control.

Forecast of electric power system demand. Losses of electric power and energy in power systems and possibilities for their reduction. Operational planning and optimization of power system operation. Control and regulation of frequency and active power. Operational process of frequency control. Principles of power system voltage control and regulation of reactive power. Principle of power dispatch and operational optimization of electric power systems.

Course Methodology : 30 hours of lectures and 30 hours of numerical exercises. Seminar paper. Individual and group consultations.

Evaluation: Intermediate evaluation through class activity, seminar paper and final examination.

Literature:

1. G.Pula, Elektroenergjetika, Enti per Botimin e Teksteve, Prishtine, 1984
2. A.Wood, Power Generation, Operation and Control, Wiley, New York, NY, 1996

Course title: Methodology of scientific research (Elective, Sem II, 5 ECTS)

Course objectives: To introduce some key elements of research methodology to first time research students.

Learning outcomes: At the end of this course, the students should be able to: understand some basic concepts of research and its methodologies, identify appropriate research topics, select and define appropriate research problem and parameters, prepare a project proposal (to undertake a project), organize and conduct research (advanced project) in a more appropriate manner, write a research report and thesis, write a research proposal (grants).

Course content: Overview of experimental and engineering methodological approaches to research; Basics of research design (e.g., hypothesis formulation); The research process: documenting research, sources of information, research funding, creativity and intellectual discovery; Guidelines and a framework for efficient development of research; legal and ethical issues; protecting and exploiting research; Intellectual Property rights; Managing the research project: supervision, planning and organization; problems and pitfalls; Presentation skills (written, oral); Use of relevant research tools (technology, experimental infrastructure, mathematical methods, etc.).

Teaching methodology: 30 hours of lectures+30 hours of supervised exercises. Approximately 75 hours of personal study, including homework exercises.

Grading System: Homework 10%, Mid-term exams 30 %, Final Exam 60 %

Literature:

1. Kothari B.L., "*Research Methodology: Tools and Techniques*", New Age International Publishers, 2009.
2. Boot C. W., "*The Craft of Research*", University Of Chicago Press, 2008.

Course title: ***Remote Control Systems*** (Mandatory, Sem. III, 5 ECTS)

The goal : The course is an introduction to remote control systems. The students will be introduction to typical strategies and implementation schemes for remote control

Learning outcomes: On successful completion of the course, students will be able to: 1. Have an understanding of remote control systems and its development with the development of digital electronics. **2.** Understand the implementing details of AM and FM circuits for signal transmission. 3 Implement fully functional systems based on RF signal for remote control purposes. 4. Understand different kind of circuits and their implementing issues for information exchange and remote control purposes.

Course content: Introduction to the principles of remote control. Nonelectrical remote control systems. Basics of signal and signal transmission. Transmitters and receivers. Introduction to transmission lines, RF lines, microwave lines, propagation methods and alternate structures. Current distribution and implementation details. Filtering in optimal control and their influence. Digital filters and their implementation. Different application of remote control. Implementing remote control system in microcomputer systems. Remote control, computer networks and wireless communications.

Methods of teaching: 30 hours of lectures + 15 hours of auditorial exercises + 15 hours of laboratory exercises. Approximately 100 hours of personal study and exercise including seminars.

Grading System: Seminar 10%, Mid-term exams 30 %, Final Exam 60 %

Literature:

1. F. Carden, R. Jedlicka & R. Henry, *Telemetry Systems Engineering,* ArtechHouse Publishing
2. D. Patranabis, Telemetry Principles, McGraw Hill

Course title: Adaptive systems (Mandatory, Sem. III, 5 ECTS)

The goal : The course is an introduction to adaptive techniques used to control systems of time varying nature. Methods of designing and implementing adaptive controllers will also be discussed. The proper control of systems with changing parameters.

Learning outcomes: On successful completion of the course, students will be able to:

1. Identify situations where conventional control strategies would be rendered ineffective due to the time varying nature of the system **2.** Implement basic principles of parameter estimation in digital computers. 3. Have an understanding of the stochastic approach to systems with excessive disturbances and processes whose parameter change with operating conditions . 4. Understand the basic principles of implementing time varying controllers and real time control. 5. Understand auto-tuning controllers and real-time parameter estimation.

Course content: Real-time parameter estimation. Regression models and the least squares method. The necessary experimental conditions for real-time estimation. Pole placement method, continuous self-tuners and design of controllers for disturbance rejection. Stochastic self-tuning controllers. Analysis of direct and indirect discrete time tuners. Introduction to stochastic adaptive controllers. Self-tuning techniques. Nonlinear systems dynamic and feedforward path adaption. Dual control and suboptimal strategies. Relay feedback method and process oscillations due to relay effect.

Methods of teaching: 30 hours of lectures + 15 hours of auditorial exercises + 15 hours of laboratory exercises. Approximately 100 hours of personal study and exercise including seminars.

Grading System: Seminar 10%, Mid-term exams 30 %, Final Exam 60 %

Literature:

1. K. J. Astrom, W. Wittenmark, Adaptive Control, Addison-Wesley Publishing
2. V. VanDoren, *Techniques for Adaptive Control,* Elsevier Science

Course title: Artificial intelligence in automation, robotics and games (Mandatory, Sem III., 5 ECTS)

The goal: The goal of the course is to give an introduction to artificial intelligence and efforts to implement intelligence in computer hardware and software, with applications in automation, robotics, and games.

Learning outcomes: On successful completion of the course, students will be able to: 1. understand the fundamental concepts of artificial intelligence and intelligent agents; 2. know basic concepts, methods, techniques, and tools for the use of intelligent agents in computer-based systems; 3. apply principles and methods of intelligent agents to a small-scale practical problem as part of individual or group project; 4. solve game problem with artificial intelligence methods; 5. design and program neural networks and fuzzy logic for some specific problem; 6. understand and explain natural language processing and vision systems; 7. implement simple real-time perception-action robotic agent.

Course content: Artificial intelligence, introduction, intelligent agents. Problems, problem spaces, and search. Problems in automation, robotics, and games. Solving problems by searching, search techniques. Knowledge and reasoning, logical agents, first-order logic, inference in first-order logic, classical planning, planning and acting in the real world, knowledge representation. Uncertain knowledge and reasoning, quantifying uncertainty, probabilistic reasoning, probabilistic reasoning over time, making decisions. Learning, learning from examples, knowledge in learning, learning probabilistic models, reinforcement learning. Neural networks and fuzzy systems. Communicating, perceiving, and acting. Game playing. Planning. Natural language processing. Vision systems. Real-time search, perception, action, industrial problems, robotics. Expert systems.
Grading System: Mid-term exams 10%+10%, Lab work 20%, Project 30%, Final exam 30%.
Literature:

1. S. Russell, P. Norvig, *Artificial Intelligence: A Modern Approach*, Prentice Hall, 2010
2. Elaine Rich, Kevin Knight, *Artificial Intelligence*, McGraw Hill, 1991
3. Dario Floreano, Claudio Mattiussi, *Bio-Inspired Artificial Intelligence*, MIT Press, 2008
4. B. Siciliano, O. Khatib (Eds.), *Springer Handbook of Robotics*, Springer, 2008
5. Sio-Iong Ao, Mahyar Amouzegar, Burghard B. Rieger, *Intelligent Automation and Systems Engineering*, Springer, 2011

Course title: Mobile robotics (Mandatory, Sem III., 5 ECTS)
The goal: The aim of the course is to provide an introduction to the fundamentals of mobile robotics, examining the basic principles of locomotion, kinematics, sensing, perception, and cognition that are key to the development of autonomous mobile robots.
Learning outcomes: On successful completion of the course, students will be able to: 1. classify mobile robots according to various criteria; 2. analyze driving mechanisms and sensor system suitable for intended application; 3. assemble sensors and actuators with the embedded computer system on mobile robot; 4. develop sensor fusion algorithms; 5. develop motion planning algorithms;6. develop motion of mobile robots localization; 7. develop algorithms of environment 2D map building.
Course content: General considerations regarding mobile robots: basic terms, definitions, classifications, historical development, applications and examples of mobile robots. Mobile robots hardware, drive mechanisms, actuators. Mobile robots locomotion. Mobile robots kinematics. Proprioceptive and non-visual perceptive sensors for mobile robots. Visual perceptive sensors for mobile robots. Processing and interpretation of robots sensors signals. Measurement uncertainty. Multiple sensors information fusion in order to improve quality and robustness of robots navigation through space. Control and navigation system structures. Algorithms for global path planning of mobile robot in space. Algorithms for obstacle avoidance and global path following. Robots relative and absolute localization in space. Environment modeling: occupancy grid maps, geometrical properties maps, topological maps, hybrid maps. Introduction to self-learning mobile robots and human-robot communication. Basics of coordinated work of multiple autonomous mobile robots.
Grading System: Mid-term exams 10%+10%, Lab work 20%, Project 30%, Final exam 30%.
Literature:

1. Roland Siegwart, Illah R. Nourbakhsh, *Introduction to Autonomous Mobile Robots*, The MIT Press, 2004.
2. Thomas Bräunl, *Embedded Robotics: Mobile Robot Design and Applications with Embedded Systems*, Springer, 2008
3. Gerald Cook,.*Mobile Robots: Navigation, Control and Remote Rensing*, IEEE, 2011
4. John Holland, *Designing Autonomous Mobile Robots: Inside the Mind of an Intelligent Machine*, Newnes, 2004

5. Stefan Florczyk, Robot Vision: Video-based Indoor Exploration with Autonomous and Mobile Robots, Wiley-VCH, 2005

Course title: Neural network and fuzzy logic control (Elective, Sem III., 5 ECTS)
The goal: The aim of the course is to provide basic knowledge of neural and fuzzy methods for the modeling and control of nonlinear systems. The participants will have the opportunity to design and implement neuro and fuzzy controllers with rapid prototyping technique based on Matlab/Simulink/QuaRC system.
Learning outcomes: On successful completion of the course, students will be able to: 1. understand the basic neural networks and fuzzy logic paradigms; 2. understand the basic concepts of training in neural and fuzzy networks; 3. use neural and fuzzy networks for identification and control of the nonlinear processes; 4. design fuzzy and neural networks for successful applications; 5. design RBF and CMAC neural networks for control problems;6. design and implement combined fuzzy-PID controllers; 7. implement neural and fuzzy controllers on-line for process control.
Course content: Artificial neural systems, fundamental concepts, models, learning rules (Hebbian, perceptron, delta Widrow-Hoff learning rules). Single layer perceptron classification: classification model, features and decision regions, training and classification using discrete perceptions. Single layer continuous perceptron networks for linear separable classification. Multilayer neural networks, generalized delta learning rule, back propagation training, learning factors. Single layer feedback networks, Hopfield networks. Radial basis function NN, CMAC. Neural network in control system, neuro-control approaches. Training algorithm, evaluation through simulation. Self tuning neuro-control scheme, self tuning PID neural controller. Introduction of fuzzy control, introduction of fuzzy control from an industrial perspective, mathematics of fuzzy control, fuzzy sets, fuzzy relations. Non-linear fuzzy control, fuzzy-PID control. Fuzzy knowledge based controller.
Grading System: Mid-term exams 10%+10%, Lab work 20%, Project 30%, Final exam 30%.
Literature:

1. S. Haykin, *Neural Networks: A Comprehensive Foundation*, Macmillan College Publishing Company, 1994.
2. D. T. Pham, X. Liu, *Neural Networks for Identification, Prediction and Control*, Springer, 1995
3. John H. Lilly, *Fuzzy Control and Identification*, Wiley, 2010
4. F. L. Lewis, J. Campos, R. Selmic, *Neuro-Fuzzy Control of Industrial Systems with Actuator Nonlinearities*, Society for Industrial Mathematics, 2002
5. Lakhmi C. Jain, N.M. Martin, *Fusion of Neural Networks, Fuzzy Systems and Genetic Algorithms: Industrial Applications*, CRC Press, 1998

Course title: Machine vision (Elective, Sem III., 5 ECTS)
The goal: The major objective of course is to help students understand and apply image processing techniques and machine vision systems to solve engineering and scientific problems of their interest. Particular focus will be on industrial, robotic, and game interface systems through adequate examples and applications. However, the concepts learned in this class can be applied to solve wide range of problems in all disciplines of science, engineering and medicine.
Learning outcomes: On successful completion of the course, students will be able to: 1. understand the basics of image acquisition and processing techniques; 2. use specific, well known, machine vision methods, algorithms and results; 3. understand camera geometry and calibration; 4. use feature detection

and tracking algorithms; 5. extract 3-D information from single, two, and multiple views;6. estimate camera and object motion; 7. use Matlab and OpenCV for real-time vision applications.
Course content: Introduction to machine vision. Tools for machine vision, Matlab and toolboxes, OpenCV. Binary image processing. Morphology. Image acquisition. Image calibration, transformation, interpolation. Image enhancement. Spatial filtering. FFT and frequency domain filtering. Edge detection. Color and color image processing. Multi/hyper spectral image analysis. Texture and shape analysis. Segmentation. Feature extraction. Hough transform. Recognition. Classification. Motion/video processing. Tracking - Kalman filtering. 3D vision techniques and sensors, Kinect, stereo vision. 3D calibration, registration and transformation. 3D reconstruction. Soft computing techniques: neural network, fuzzy logic, genetic algorithm. Vision for control, visual feedback, robot vision, position and orientation from vision, visual navigation, depth perception.
Grading System: Mid-term exams 10%+10%, Lab work 20%, Project 30%, Final exam 30%.
Literature:

1. L. Shapiro and G. Stockman, *Computer Vision*, Prentice-Hall, 2001
2. Richard Hartley, Andrew Zisserman, *Multiple View Geometry in Computer Vision*, Cambridge University Press, 2003
3. Milan Sonka, Vaclav Hlavac, Roger Boyle, *Image Processing, Analysis, and Machine Vision*, Nelson Education Limited, 2008
4. Simon J. D. Prince, *Computer Vision: Models, Learning, and Inference*, Cambridge University Press, 2012
5. Berthold K.P. Horn, *Robot Vision*, MIT Pess, 1986

Course title: Control of Electrical Drives (Elective, Sem. III, 5 ECTS)
The goal: The course goal is to provide advance knowledge for control of electrical drives.
Learning outcomes: On successful completion of the course, students will know: 1. Electrical drives control principles, 2. Control of asynchronous motors, vector and scalar control, 3. ontrolMotorve synchronous control.
Course content: Introduction. Eelements of electrical drive system. Mechanical system. Electric supply. Controllers and convertors of energy. Dq modeling of induction machines –rotating systems in stator, rotor and system rotating with synchronous speed; equations with space vector, principles of control of electrical drives with induction machines, vector control, scalar control. Basic principles of control of synchronous motors.
Methods of teaching: 30 hours of lectures + 30 hours of auditorial exercises and seminars . Approximately 80 hours of personal study and exercise including seminars.
Grading System: Seminar 10%, Mid-term exams 30 %, Final Exam 60 %
Literature:

1. R Krishnan, Electric Motor Drives, PHI-2001.
2. D W Novotny and T A Lipo, Vector Control and Dynamics of AC Drives, Oxford University Press, 1996.
3. B K Bose, Modern Power Electronics and AC Drives, Pearson-2002.
4. Leonhard, Control of Electric Drives, Springer-2001.
5. Kazmierkowski, Krishnan, Blaabjerg, Control in Power Electronics-Selected Problems, Academic Press, 2002.

Course title: Master Thesis (Mandatory, Sem. IV, 30 ECTS)
The goal: Master thesis is the final scientific work that will prove the student capability to work on a scientific topic independently by using methodologically sound approaches.
Learning outcomes: At the end of this course, students will be capable to: 1. Read and understand state-of-the-art literature. 2. Independently specify, analyze and propose solutions. 3. Explain and discuss critically results. 4. Present and defend the thesis in a written and oral form.
Course content: The thesis could be proposed by the supervisor or can be chosen by the student, and should be in the accordance with the qualification profile. 1. Reading of the state of the art. 2. Understanding and specifying the problem. 3. Design and implement different solutions. 4. Analyze and discuss critically the results.
Methods of teaching:
Compliant with the actual regulation at the faculty level on how to conduct a master thesis.
Literature:

1. Jean-Luc LeBrun. Scientific Writing. World Scientific, 2007.
2. Depending on the topic covered in thesis, different bibliographic resources will be recommended by the teachers.