„POLITEHNICA" UNIVERSITY OF TIMIŞOARA

SYLLABUS
for the discipline:

"DYNAMIC SYSTEMS AND STABILITY IN AUTOMOTIVE CONTROL"

FACULTY OF AUTOMATION AND COMPUTERS
DOMAIN/SPECIALIZATION: MASTER AUTOMOTIVE EMBEDDED SOFTWARE

Year of studies: I

Semester: 2

Course instructor: *Prof.dr.ing. Radu-Emil Precup*
Applications instructor: *Prof.dr.ing. Radu-Emil Precup*

Number of hours/week/Evaluation/Credits					
Course	**Seminar**	**Laboratory**	**Project**	**Evaluation**	**Credits**
2	0	1	1	E	7

A. COURSE OBJECTIVES

The course involves the following objectives: (1) the study of dynamical properties and stability of control systems in automotive applications, (2) gaining an understanding of the functional operation of a variety of techniques specific to intelligent systems and intelligent control systems, (3) the study of their control-theoretic foundations, (4) learning analytical approaches to study properties, (5) gaining experience in computer-aided design of intelligent systems in automotive embedded systems, and (6) acquiring competence and knowledge in the development of hardware and software applications for automotive systems using actual informatics technologies. The aim will be to gain a "hands-on" working knowledge of several of the main techniques in intelligent control systems and an introduction to some promising research directions in automotive embedded systems. The course contributes to the skills 1 (15 %), 2 (15 %), 3 (50%), and 4 (20%) from the skills table.

B. COURSE SUBJECTS (Total 28 hours)

Dynamics, Stability and Control Problems in Automotive Embedded Systems (AESs) Including Motion Control: *Dynamic models; Stability analysis; Engine control systems employing lambda control, idle speed control and knock control; Driveline control, driveline speed control and driveline control for gear-shifting; Vehicle control systems employing ABS control systems and control of the yaw dynamics; Longitudinal and lateral control in terms of hybrid driver model – 2 hours.*
Introduction to Soft Computing: *Soft computing constituents and conventional artificial intelligence; Neuro-fuzzy and soft computing characteristics; Soft computing in intelligent systems and intelligent control systems – 2 hours.*
Fuzzy Sets and Fuzzy Information Processing: *Basic definitions and terminology; Set-theoretic operators; Membership function formulation and parameterization; Fuzzy inference mechanisms and rule bases; Defuzzification – 2 hours.*
Structures of Fuzzy Control Systems and Fuzzy Inference Systems: *Mamdani fuzzy controllers; Takagi-Sugeno fuzzy controllers; Mathematical characterizations; Measures to modify the input-output maps of fuzzy controllers – 2 hours.*
Typical and Special Fuzzy Controllers: *Fuzzy controllers without and with dynamics; Mamdani fuzzy controllers; Takagi-Sugeno fuzzy controllers; Tsukamoto fuzzy models; Classes of PD-, PI- and PID-fuzzy controllers; Design methods dedicated to fuzzy controllers; Stability and sensitivity analysis of fuzzy control systems; Applications to AESs – 4 hours.*
Basics of Neural Networks. Architectures: *Dynamics; Learning and adaptation; Training neural networks and fuzzy systems with least squares and gradient methods; Hybrid learning rules; Supervised and unsupervised learning neural networks – 4 hours.*
Neuro-fuzzy Systems: *Adaptive hybrid neuro-fuzzy control systems; Adaptive neuro-fuzzy inference systems; ANFIS as universal approximator; Data clustering algorithms; Applications to AESs – 6 hours.*
Derivative-free Optimization in Intelligent Control Systems: *Genetic algorithms; Simulated annealing; Random search; Downhill Simplex search; Intelligent control systems involving fuzzy, neural and genetic techniques. Applications to AESs – 6 hours.*

C. APPLICATIONS SUBJECTS (laboratory, seminar, project) (Total 28 hours)

Laboratory topics list – total 14 hours:

1. Computer-aided design of intelligent control systems in Matlab & Simulink. Fuzzy Logic Toolbox, Neural Network Toolbox, genetic algorithms toolboxes – 4 hours.
2. PI-, PD- and PID-fuzzy controlled systems designs for AESs – 2 hours.
3. ANFIS applications in AESs – 2 hours.
4. Genetic algorithm-based system optimization applied to AESs – 2 hours.
5. Intelligent control system design for a motion control system involving a laboratory plant in one of the following versions: ABS system, 3D crane system, inverted pendulum system, air-stream and temperature control system, servos and electrical drives, three- or multi-tank system. General characteristics, hardware and software structure, controller design for several regimes, simulations and real-time experiments, study of parameter modification effects on control system behaviours – 4 hours.

Project topics – total 14 hours

The project topics concern the development of intelligent control systems for specific AESs:

- problem setting – 2 hours;
- analysis of control system structures – 2 hours;
- design – 4 hours;
- implementation of control system structures – 4 hour;
- analysis of the effect of several structures and parameters on the control system performance indices – 2 hours.

ABS control systems and driveline control for gear-shifting are involved because the laboratory equipment in the Intelligent Control Systems Laboratory permits real-time implementations and serious experiments. The intelligent control systems make use of all techniques studied in the framework of the lecture meetings and ensure their merge from the point of view of automation and computer science and engineering: modeling; identification; structure analysis; computer-aided design; implementation of several intelligent control systems; performance analysis of different structure versions.

The activities are organized in the spirit of team-working. 3 students in a team are preferred.

D. REFERENCES

1. R.-E. Precup, S. Preitl, *Fuzzy Controllers*; Editura Orizonturi Universitare; Timisoara, 1999.
2. J.-S. R. Jang, C.-T. Sun, E. Mizutani, *Neuro-Fuzzy and Soft Computing. A Computational Approach to Learning and Machine Intelligence*; Prentice Hall; Upper Saddle River, NJ, 1997.
3. U. Kienke, L. Nielsen, *Automotive Control Systems*; Springer-Verlag; Berlin, Heidelberg, New York, 2000.
4. K.-H. Dietsche, M. Klingebiel, *Automotive Handbook*; Robert Bosch GmbH, Plochingen, 2007.
5. T. Munakata, *Fundamentals of the New Artificial Intelligence*; Second ed., Springer-Verlag, Berlin, Heidelberg, New York, 2008.

E. EVALUATION PROCEDURE

Distributed evaluation with two examiners, two questions at the final oral assessment, the students have access to the graphics material taught during the course. Grading policy: laboratory with 33 % weighting in the final grade, project with 33 % weighting in the final grade, the course efforts and the final oral assessment with 33 % weighting in the final grade. Conditions to obtain grade 5: passing both course efforts and final assessment. Conditions to obtain grade 10: according to the algorithm employed in our university to calculate the final grade using 34 % weighting for course efforts and final assessment and 66 % for the laboratory and project. The classroom for final assessment is assigned by Dean's Office. Conditions to recognize the progressive knowledge gaining: course efforts assessment with 34 % weighting in the final grade, laboratory and project assessment during each meeting and finally in terms of defending the project, the grades are recognized until the promotion using teachers' files.

F. INTERNATIONAL COMPATIBILITY

1. Theory and Design of Intelligent Control Systems, Purdue University, Purdue, West Lafayette, IN, SUA
(https://engineering.purdue.edu/ProEd/courses/credit_courses?course=GRAD590R&semyr=SU2008).
2. Robotics and Intelligent Systems, Princeton University, Princeton, NJ, SUA
(http://www.princeton.edu/~stengel/MAE345.html).
3. Intelligent Control, Dalarna University, Falun, Suedia (http://www.du.se/Templates/SyllabusPage____199.aspx?epslanguage=EN&kod=ET3004).

Date: 25.09.2008

HEAD OF DEPARTMENT,	**COURSE INSTRUCTOR,**
Prof.dr.ing. Ioan Silea	Prof.dr.ing. Radu-Emil Precup