

Syllabus

1. Data about the program of study

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| 1.1 Institution | Technical University of Cluj-Napoca |
| 1.2 Faculty | Automation and Computer Science |
| 1.3 Department | Automation |
| 1.4 Field of study | Systems Engineering |
| 1.5 Cycle of study | Bachelor of Science |
| 1.6 Program of study/Qualification | Automation and Applied Informatics (English) |
| 1.7 Form of education | Full time |
| 1.8 Subject code | 34.00 |

2. Data about the subject

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|--|--|--------------|---|------------------------|--------|
| 2.1 Subject name | System identification | | | | |
| 2.2 Course responsible/lecturer | Prof. dr. ing. Lucian Busoniu – Lucian.Busoniu@aut.utcluj.ro | | | | |
| 2.3 Teachers in charge of applications | Prof. dr. ing. Lucian Busoniu – Lucian.Busoniu@aut.utcluj.ro | | | | |
| 2.4 Year of study | 3 | 2.5 Semester | 1 | 2.6 Assessment (E/C/V) | E |
| 2.7 Type of subject | <i>DF – fundamental, DID – in the field, DS – specialty, DC – complementary</i> | | | | DD, DI |
| | <i>DOB – compulsory, DOP – elective, FAC – optional</i> | | | | DOB |

3. Estimated total time

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|--|----|-----------|--------|----|---------|---|------------|----|---------|----|
| 3.1 Number of hours per week | 5 | of which: | Course | 2 | Seminar | 0 | Laboratory | 2 | Project | 1 |
| 3.2 Number of hours per semester | 70 | of which: | course | 28 | Seminar | 0 | Laboratory | 28 | Project | 14 |
| 3.3 Individual study | | | | | | | | | | |
| (a) Manual, lecture material and notes, bibliography | | | | | | | | | | 20 |
| (b) Supplementary study in the library, online and in the field | | | | | | | | | | 10 |
| (c) Preparation for seminars/laboratory works, homework, reports, portfolios, essays | | | | | | | | | | 10 |
| (d) Tutoring | | | | | | | | | | 2 |
| (e) Exams and tests | | | | | | | | | | 3 |
| (f) Other activities: | | | | | | | | | | 10 |
| 3.4 Total hours of individual study (sum of (3.3(a)...3.3(f))) | | | | | 55 | | | | | |
| 3.5 Total hours per semester (3.2+3.4) | | | | | 125 | | | | | |
| 3.6 Number of credit points | | | | | 5 | | | | | |

4. Pre-requisites (where appropriate)

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| 4.1 Curriculum | Physics; Electrotechnics; Basics of electronic circuits; Mechanics; Mathematical analysis; Process modeling; System theory |
| 4.2 Competence | Special mathematics; Linear algebra and analytical geometry; Numerical calculus; Programming and experimental competencies, Analytical spirit |

5. Requirements (where appropriate)

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| 5.1. For the course | Exposition, questions, discussions |
| 5.2. For the applications | Solving the laboratory assignments is mandatory |

6. Specific competences

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| 6.1 Professional competences | C3. Fundamental usage of automation, modeling, simulation, identification and analysis of systems; of computer-assisted design techniques C3.1 Identification of fundamental concepts of systems theory, of control engineering, of basic principles of modeling and simulation, as well as system analysis techniques, with the goal of explaining the fundamental problems in the field. |
| 6.2 Cross competences | |

7. Course objectives

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| 7.1 General objective | The student will be formed to choose and apply system identification methods in MATLAB, given an unknown system |
| 7.2 Specific objectives | The student will have the following skills: <ul style="list-style-type: none"> - use the concept of dynamical model for control - choose the experiment and input signal - choose model type and order - identify model parameters from experimental data - validate the model and select the best model among several alternatives |

8. Contents

| 8.1 Lecture | No.hours | Teaching methods | Notes |
|--|----------|---|-------|
| 1. Foundations of system identification (dynamical models for control) | 2 | - Exposition using the videoprojector and the board - Interactive questions and exercises - Discussions with students - Optional lecture quizzes | |
| 2. Identification of first and second order systems from the step response (zero and non-zero initial conditions) | 2 | | |
| 2. Identification of first and second order systems from the impulse response (zero and non-zero initial conditions) | 2 | | |
| 4. Mathematical foundations: Linear regression and statistics | 2 | | |
| 5. Identification of higher order systems, e.g. using correlation analysis | 2 | | |
| 6. Prediction error methods: ARX identification | 2 | | |
| 7. Input signals (PRBS, multisine) | 2 | | |
| 8. Prediction error methods: model structures and identification procedure | 2 | | |
| 9. Prediction error methods: identification procedure; optimization | 2 | | |
| 10. Instrumental variable methods | 2 | | |
| 11. Advanced identification techniques: state-space or closed-loop identification | 2 | | |
| 12. Recursive identification | 2 | | |
| 13. Model validation | 2 | | |
| 14. Practical considerations and case study | 2 | | |
| Bibliography (<i>minimal bibliography of the subject containing at least one bibliographical reference work of the subject, which is available to students in an appropriate number of copies</i>) | | | |
| 1.Eykhoff P. System Identification: Parameter and State Estimation. John Wiley, London, 1974. | | | |
| 2.Goodwin G.C., Payne R.L. Dynamic System Identification: Experiment Design and Data Analysis. Academic Press, New York, 1984. | | | |
| 4.Isermann R. Special Issue on System Identification. Automatica, 17(1), 1981. | | | |
| 5.Söderström T., Stoica P. System Identification. Prentice Hall Inc., Hertfordshire, 1989. Disponibilă online: http://user.it.uu.se/~ts/bookinfo.html | | | |
| 6.Ljung L. System Identification - Theory for the User. Prentice Hall, New York, 2006. | | | |
| 7.Landau I.D. Adaptive Control - The Model Reference Approach. Dekker, New York, 1979. | | | |
| 8.Ljung L., Söderström T. Theory and Practice of Recursive Identification. MIT Press, Cambridge, Massachusetts, 1983. | | | |
| 9.Landau I.D. Lecture Notes on Adaptive Control. University of California, Continuing Education in Engineering, Berkeley, California, 1983. | | | |
| 10.Goodwin G.C., Sin K.S. Adaptive Filtering Prediction and Control. Prentice Hall, New Jersey, 1984. | | | |
| 11.Landau I.D. A Feedback System Approach to Adaptive Filtering. IEEE Trans. on Information Theory, April, 1984. | | | |
| 8.2 Applications (seminar/laboratory/project) | No.hours | Teaching methods | Notes |
| Using MATLAB/SCILAB for identification experiments | 2 | - Lab quizzes - Matlab/Simulink implementation - Testing/validation with the help of physical systems - Verification and | |
| Identification of first and second order systems from the step response | 2 | | |
| Identification of first and second order systems from the impulse response | 2 | | |
| Mathematical foundations | 2 | | |
| Identification of higher order systems using e.g. correlation | 2 | | |

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| analysis | | discussions of solutions with students | |
| The ARX method | 2 | | |
| Input generation and analysis for identification of parametric patterns (pseudo binary random signal) | 2 | | |
| Pre-processing of experimental data to identify parametric models | 2 | | |
| Identification of output error models with the Gauss-Newton method | 2 | | |
| The instrumental variables method | 2 | | |
| Identification in state space or closed loop | 2 | | |
| The recursive least squares method | 2 | | |
| Identification of dead time systems and validation of models | 2 | | |
| Practical considerations and parameter estimation in a case study | 2 | | |
| Project: Identify the corresponding dynamic model of a nonlinear system (and the necessary regression fundamentals), an electrical circuit, or a brushless DC motor driven in-plane positioning system (control signal generation, data acquisition, model structure determination, parameter estimation and model validation) | 14 | | |
| Bibliography (<i>minimal bibliography of the subject containing at least one bibliographical reference work of the subject, which is available to students in an appropriate number of copies</i>) | | | |
| 1.Ljung L. System Identification - Theory for the User. Prentice Hall, New York, 2006. | | | |
| 2.Söderström T., Stoica P. System Identification. Prentice Hall Inc., Hertfordshire, 1989. Disponibilă online: http://user.it.uu.se/~ts/bookinfo.html | | | |
| 3.Landau I.D. Adaptive Control - The Model Reference Approach. Dekker, New York, 1979. | | | |
| 4.Ljung L., Söderström T. Theory and Practice of Recursive Identification. MIT Press, Cambridge, Massachusetts, 1983. | | | |

9. Bridging course contents with the expectations of the representatives of the community, professional associations and employers in the field

Laboratory work focused in the fields of interest of companies active in the local/regional market. Identification methods are a prerequisite for the application of automation: system analysis, controller design, state feedback controllers, etc. These considerations apply to both industry and R&D.

10. Evaluation

| Activity type | Assessment criteria | Assessment methods | Weight in the final grade |
|--|--|---|---------------------------|
| Course | Correct solution of proposed problems | A combination of the following: written exam, online exam, online quiz, lecture homework | 30-60% |
| Seminar | N/A | N/A | N/A |
| Laboratory | Using Matlab/Scilab for identification | A combination of the following: lab activity, validated lab solutions; anti-plagiarism check; lab test; lab quizzes | 20-40% |
| Project | Practical experience | Project report and/or presentation | 20-30% |
| Minimum standard of performance: labs and project solved correctly and originally, rounded combined grade at exam, lab tests, and project at least 5 | | | |

| Date of filling in: | | Title Firstname NAME | Signature |
|---------------------|--------------|-------------------------------|-----------|
| 12.06.2024 | Course | Prof. dr. eng. Lucian Busoniu | |
| | Applications | Prof. dr. eng. Lucian Busoniu | |

Date of approval by the Department Board Automation

Head of Department of Automation
Prof.dr.ing. Honoriu VĂLEAN

Date of approval by the Faculty Council
Automation and Computer Science

Dean of the Faculty of Automation and
Computer Science
Prof.dr.ing. Mihaela DINSOREANU