# SYLLABUS

## 1. Program Information

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|---|---|
| 1.1 Higher education institution | Technical University of Cluj-Napoca |
| 1.2 Faculty | Faculty of Automation and Computer Science |
| 1.3 Department | Department of Automation |
| 1.4 Field of study | Automation, Applied Informatics and Intelligent Systems |
| 1.5 Cycle of studies | Bachelor |
| 1.6 Study Programme/Qualification | Intelligent Automation Systems (dual, in English language) |
| 1.7 Form of education | IF – full-time education |
| 1.8 Course code | 51.10 |

## 2. Course information

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|---|---|---|---|---|---|---|
| 2.1 Course title | | | | | **Applied Machine Learning for Industrial Automation** | |
| 2.2 Course lecturer | | | | | *Conf.Dr.Ing Roxana Rusu-Both – roxana.both@aut.utcluj.ro* | |
| 2.3 Seminar / Laboratory / Project Lecturer | | | | | *Drd. Ing. Eliza Olariu (Emerson)* | |
| 2.4 Year of study | 4 | 2.5 Semester | 1 | 2.6 Type of assessment | | E |
| 2.7 Course status | Formative category *(DF, DS, DC)* | | | | | DS |
| | Optionality *(DOB, DOP, DFac)* | | | | | DOP |

## 3.Total estimated time

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.1 Number of hours per week | 5 | of which: | HEI | Lecture | 2 | Seminar | 0 | Laboratory | 1 | Project | 0 |
| | | | CO | | 0 | | 0 | | 0 | | 2 |
| 3.2 Number of hours per semester | 70 | of which: | HEI | Lecture | 28 | Seminar | 0 | Laboratory | 14 | Project | 0 |
| | | | CO | | 0 | | 0 | | 0 | | 28 |

| 3.3 Distribution of time allocation (hours per semester) for: | HEI | CO |
|---|---|---|
| (a) Study based on textbook, course support, bibliography, and notes | | |
| (b) Additional documentation in library, specialized electronic platforms, and fieldwork | 5 | 7 |
| (c) Preparation of seminars/laboratories, assignments, papers, portfolios and essays | | 7 |
| (d) Tutoring | | 4 |
| (e) Examinations | 3 | 4 |
| (f) Other activities: | | |
| 3.4 Total individual study hours (sum (3.3(a)... 3.3(f))) | 8 | 22 |
| 3.5 Total hours per semester (3.2+3.4) | 50 | 50 |
| 3.6 Number of credits per semester | 2 | 2 |

*(HEI = Higher Education Institution, CO = Company)*

## 4. **Prerequisites** (where applicable)

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| 4.1 Curriculum Prerequisites | • Statistics and Numerical Calculus,<br>• Measurements and transducers.<br>• Process Modeling<br>• Signal Processing |
| 4.2 Competency Prerequisites | • Basic knowledge of data analysis and statistical concepts.<br>• Basic knowledge of process modeling. |

## 5. **Conditions** (where applicable)

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| 5.1. Course Organization Conditions | • Interactive lectures using multimedia technology (laptop, projector, blackboard)<br>• Emphasis on practical examples and case studies from industrial contexts<br>• Attendance at lectures is not mandatory, but is encouraged and recorded |

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| 5.2. Seminar / Laboratory / Project organization conditions | • Laboratory and project activities will be carried out in collaboration with company partners (Emerson), offering real industrial data and case studies<br>• Students will work with MATLAB, Python, and other relevant tools for data analysis, modeling and evaluation.<br>• Activities will be supervised by both instructors and industry engineers, providing real-world insights and best practices.<br>• Attendance at labs and project activities is mandatory |

**6. Specific Competencies Acquired**

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| Professional Competencies | • PC02 Analyse test data<br>• PC05 Conduct quality control analysis<br>• PC08 Design automation components<br>• PC12 Gather technical information<br>• PC19 Prepare production prototypes<br>• PC26 Use information technology tools<br>• PC27 Execute analytical mathematical calculations<br>• PC30 Design control systems<br>• PC32 Perform data analysis |
| Transversal Competencies | • TC01 Apply knowledge of science, technology and engineering<br>• TC02 Think analytically<br>• TC05 Interpret mathematical information |

**7. Learning outcomes**

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| Knowledge: | • The student will be able to **describe and explain** fundamental machine learning techniques, with a focus on industrial data.<br>• The student will be able to **identify the challenges** in data preprocessing, feature selection, and model evaluation in industrial contexts. |
| Skills: | • The student will be able to implement and validate machine learning models for prediction and anomaly detection in industrial applications.<br>• The student will be able to conduct data acquisition, analysis, and quality assessment using statistical and visualization techniques. |
| Responsibility and autonomy: | • The student will be able to work independently and collaboratively to address practical problems using machine learning in industrial environments on data-centric industrial projects.<br>• The student will be able to document, interpret, and communicate model performance and results, respecting professional and ethical guidelines. |

**8. Course Objectives**

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| 8.1 General objective of the course | • To provide students with **foundational and applied knowledge** in machine learning techniques for industrial automation, including data preparation, modeling, and evaluation. |
| 8.2 Specific objectives | • To familiarize students with the **process of data-driven system development** in industrial contexts.<br>• To develop practical skills in **data acquisition, cleaning, and preprocessing** for time-series and industrial data.<br>• To introduce various **machine learning algorithms and approaches** for prediction, anomaly detection, and activity recognition. |

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| | • To provide hands-on experience in **model implementation and evaluation**, fostering analytical and critical thinking.<br>• To expose students to **current tools and software** used in industrial data science applications. |

**9. Contents**

| 9.1 Lectures | No. of hours | Teaching methods | Obs. |
|---|---|---|---|
| Introduction to data driven system development. Application domains and examples. | 2 | Teaching using laptop, projector and blackboard; Systematic exposure; Interactive course, debate; Case Study. | |
| Data understanding: aquisition, exploration (statistics), visualization techiques | 2 | | |
| Data understanding: data quality analysis, time-frequency analysis | 2 | | |
| Data pre-processing: denoising (filtering techniques), dimensionality reduction | 2 | | |
| Data pre-processing: detrending , interpolation of missing samples, outlier removal | 2 | | |
| Data pre-processing: feature extraction, feature selection | 2 | | |
| Modeling: modeling techniques | 2 | | |
| Modeling: time-series segmentation and semantic labeling | 2 | | |
| Modeling: prediction models I | 2 | | |
| Modeling: prediction models II | 2 | | |
| Modeling: anomaly detection methods | 2 | | |
| Modeling: models for multivariate time series | 2 | | |
| Evaluation and validation: methods and metrics | 2 | | |
| Evaluation and validation: model validation framework | 2 | | |

Bibliography


1. A.V. Oppenheim and A.S. Willsky, with S.H. Nawab, Signals and Systems, Prentice-Hall, Second Edition, 1997. (Biblioteca UTCN - 3 exemplare);
2. E.S. Gopi. Algorithm Collections for Digital Signal Processing Applications Using Matlab, Springer, 2007, ISBN 978- 1-4020-6410-4 (Biblioteca UTCN - 1 exemplar);
3. D.S.G. POLLOCK, A Handbook of Time-Series Analysis, Signal Processing and Dynamics, Academic Press, 1999,
4. Bisgaard, S., & Kulahci, M, Time series analysis and forecasting by example, John Wiley & Sons., 2011
5. Christopher M.Bishop, Pattern Recognition And Machine Learning, Springer, 2006
6. John D. Kelleher, Brian Mac Namee, Aoife D'Arcy, Fundamentals of Machine Learning for Predictive Data Analytics: Algorithms, Worked Examples, and Case Studies, MIT Press, 2015
7. Roxana Rusu-Both et all. Knowledge-based systems, Laboratory notes, available in electronic format


| 9.2.1 Laboratory | Hours HEI | Hours CO | Teaching methods | Obs. |
|---|---|---|---|---|
| Data aquisition - experimental | 2 | | Presentation of examples. Practical application. Case Study. Discussions. | |
| Data understanding: descriptive statistics, visual analytics, correlation analysis, data quality check | 2 | | | |
| Data pre-processing: filtering, principal component analysis | 2 | | | |
| Predictive modeling I | 2 | | | |
| Predictive modeling II | 2 | | | |
| Anomaly detection | 2 | | | |
| Activity recognition | 2 | | | |

Bibliography


1. A.V. Oppenheim and A.S. Willsky, with S.H. Nawab, Signals and Systems, Prentice-Hall, Second Edition, 1997. (Biblioteca UTCN - 3 exemplare);
2. E.S. Gopi. Algorithm Collections for Digital Signal Processing Applications Using Matlab, Springer, 2007, ISBN 978- 1-4020-6410-4 (Biblioteca UTCN - 1 exemplar);
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6. John D. Kelleher, Brian Mac Namee, Aoife D'Arcy, Fundamentals of Machine Learning for Predictive Data Analytics: Algorithms, Worked Examples, and Case Studies, MIT Press, 2015
7. Roxana Rusu-Both et all. Knowledge-based systems, Laboratory notes, available in electronic format


| 9.2.2 Project | Hours HEI | Hours CO | Teaching methods | Obs. |
|---|---|---|---|---|
| Topic assignment: industrial data | | 4 | Presentation of examples. Practical application. Case Study. Discussions. | |
| Data analysis: vizualization, quality analysis | | 4 | | |
| Data preprocessing: denoising, detrending, etc. | | 4 | | |
| Data modeling | | 4 | | |
| Data modeling | | 4 | | |
| Model evaluation | | 4 | | |
| Final Presentation/ Final Report | | 4 | | |

Bibliography


1. A.V. Oppenheim and A.S. Willsky, with S.H. Nawab, Signals and Systems, Prentice-Hall, Second Edition, 1997. (Biblioteca UTCN - 3 exemplare);
2. E.S. Gopi. Algorithm Collections for Digital Signal Processing Applications Using Matlab, Springer, 2007, ISBN 978- 1-4020-6410-4 (Biblioteca UTCN - 1 exemplar);
3. D.S.G. POLLOCK, A Handbook of Time-Series Analysis, Signal Processing and Dynamics, Academic Press, 1999,
4. Bisgaard, S., & Kulahci, M, Time series analysis and forecasting by example, John Wiley & Sons., 2011
5. Christopher M.Bishop, Pattern Recognition And Machine Learning, Springer, 2006
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**10. Correlation of course content with the expectations of the epistemic community representatives, professional associations, and major employers in the field related to the program**

The content of this course is designed to align with the current and future needs of the industrial automation sector, ensuring that students are prepared to tackle real-world challenges in industrial systems by emphasizing practical data analysis, predictive maintenance, and system optimization techniques. It ensures that students acquire competencies in handling real-world industrial data and developing predictive solutions, highly valued by employers and recognized in engineering education standards (ARACIS).

The content of the discipline, together with the acquired skills and abilities, was discussed with other universities and important companies from Romania. It also ensures the adoption of ethical standards appropriate to engineering practice.

**11. Evaluation**

| Activity Type | Evaluation criteria | Evaluation methods | Weight in final grade |
|---|---|---|---|
| 11.1 Lecture | Understanding of theoretical concepts, clarity in explanations, and ability to apply theory in practice | Written exam | 40% |
| 11.2.1 Laboratory | Practical execution of data preprocessing, modeling, and evaluation tasks; troubleshooting and interpretation | Continuous in-lab evaluation + final report | 20% |
| 11.2.2 Project | Ability to design and complete a data-driven project, clarity of presentation, and soundness of analysis | Oral presentation + report | 40% |
| 11.3 Minimum Performance Standard<br>• Final exam >=5<br>• Lab grade>=5 mandatory to be able to take the final exam<br>• Project grade>=5 mandatory to be able to take the final exam<br>**40% Final exam + 20% Lab Grade + 40% Project grade > 5** | | | |

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| Date of completion: | Lecturers | | Signature |
| | Course | Conf.Dr.Ing. Roxana Rusu-Both | |
| | Applications | | |
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| Date of approval by the Department of Automation Council<br>24.11.2025<br><br>Date of approval by the Faculty of Automation and Computer Science Council<br>28.11.2025 | Director of the Department of Automation<br>Prof.dr.ing. Honoriu VĂLEAN<br><br>Dean<br>Prof.dr.ing. Vlad MUREȘAN |