Syllabus

1. Data about the program of study

1.1 Institution	Technical University of Cluj-Napoca
1.2 Faculty	Automation and Computer Science
1.3 Departament	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

2. Data about the subject

2.1 Subject name	**Knowledge-based Systems**				Discipline code	**35.20**
2.2 Course responsible/lecturer	Conf.dr.ing. Roxana Rusu-Both – roxana.both@aut.utcluj.ro					
2.3 Teachers in charge of applications	Conf.dr.ing. Roxana Rusu-Both – roxana.both@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	*DF – fundamental, DS – specialty, DC – complementary*					DS
	DOB – compulsory, DOP – elective, DFA – optional					DOP

3. Estimated total time

3.1 Number of hours per week	4	of which:	3.2 Course	2	3.3 Seminar	0	3.3 Laboratory	1	3.3 Project	1
3.4 Number of hours per semester	56	of which:	3.5 Course	28	3.6 Seminar	0	3.6 Laboratory	14	3.6 Project	14
3.7 Individual study										
(a) Manual, lecture material and notes, bibliography										28
(b) Supplementary study in the library, online and in the field										10
(c) Preparation for seminars/laboratory works, homework, reports, portfolios, essays										28
(d) Tutoring										-
(e) Exams and tests										3
(f) Other activities:										-

3.8 Total hours of individual study (sum of (3.3(a)...3.3(f)))	69
3.9 Total hours per semester (3.2+3.4)	125
3.10 Number of credit points	5

4. Pre-requisites (where appropriate)

4.1 Curriculum	• Basics in special mathematics for engineering • Basics in measurements and transducers
4.2 Competence	• Basic knowledge of data analysis and statistical concepts • Basic knowledge of process modeling

5. Requirements (where appropriate)

5.1. For the course	• Interactive lectures using multimedia technology (laptop, projector, blackboard) • Emphasis on practical examples and case studies from real industrial contexts (predictive maintenance, Industry 4.0) • Attendance at lectures is not mandatory, but is encouraged, recorded and rewarded
5.2. For the applications	• Labs and projects will be conducted using real data and case studies, in collaboration with industrial partners • Students will work with Python, MATLAB and other modern tools for data analysis, modeling and evaluation • Attendance at lab and project activities is mandatory • Preliminary preparation of the laboratory works is recommended

6. Specific competences

Professional competences	C2 Operation with fundamental concepts from computer science, information and communication technology. C2.2 Reasoned use of concepts from informatics and computer technology in solving well-defined problems in systems engineering and in applications that require the use of hardware and software in industrial systems or in computer systems. C3 Use of automation fundamentals, modeling, simulation, process identification and analysis methods, computer-aided design techniques. C3.1 Identification of the fundamental concepts of systems theory, automatic control engineering, basic principles of modeling and simulation, as well as process analysis methods, in order to explain the basic problems in the field. C3.2 Explaining and interpreting the automation problems of some types of processes by applying the fundamentals of automation, methods of modeling, identification, simulation and analysis of processes, as well as computer-aided design techniques. C3.3 Solving some types of control problems by: using modeling methods and principles, developing simulation scenarios, applying identification and analysis methods to processes (including technological processes) and systems.
Cross competences	CT2 Identifying roles and responsibilities in a multi-specialized team, making decisions and assigning tasks, applying interpersonal techniques and effective teamwork.

7. Expected learning outcomes

Knowledge	The student describes and explains the fundamental concepts of knowledge-based (data-driven) systems and of predictive modeling (machine learning, deep learning), with a focus on industrial data; The student identifies and summarizes the challenges related to data quality, data preprocessing, feature selection and model evaluation in industrial contexts; The student describes anomaly detection methods and models for multivariate time series, as well as their application to concrete problems (e.g. predictive maintenance).
Skills	The student acquires and processes industrial data, using suitable sensors, signal processing and data filtering techniques; The student applies criteria and methods for data quality assessment, using statistical and visualization techniques, including modern digital technologies; The student implements and validates predictive models (regression, classification, anomaly detection) for industrial applications, using Python, MATLAB and other modern software tools; The student interprets theoretical and experimental results and evaluates the performance of the developed models.
Responsibilities and autonomy	The student works effectively, independently and in teams, on data-centric industrial projects, from problem definition to solution; The student documents, presents and communicates clearly and concisely, verbally and in writing, the results and performance of the developed models, to technical and non-technical audiences; The student takes responsibility for the quality and ethical implications of data-driven solutions, respecting the ethics of the engineering profession.

8. Course objectives

General objective	The objective of this course is to provide students with theoretical and practical knowledge regarding the development of knowledge-based (data-driven) systems: processing industrial data and implementing predictive models for automation and optimization.
Specific objectives	• To familiarize students with data-driven workflows specific to industrial environments; • To develop skills in data acquisition, cleaning, transformation, and visualization; • To introduce predictive modeling methods (machine learning, deep learning) applicable to industrial systems; • To provide hands-on experience in model implementation, evaluation, validation and refinement, fostering analytical and critical thinking; • To enable students to analyze and interpret industrial data using modern software tools; • To expose students to real industrial case studies and best practices regarding data ethics and governance.

9. Contents

9.1 Lecture	No.hours	Teaching methods	Notes
Introduction to knowledge-based (data-driven) system development. Application domains and examples: predictive maintenance, Industry 4.0, intelligent systems.	2	. Teaching using laptop, projector and blackboard; Systematic exposure; Interactive course, debate; Case study.	On-site. In case of force majeure, activities will be held online on the Teams platform.
Data understanding 1: data acquisition, exploration (statistics) and visualization techniques.	2		
Data understanding 2: data quality analysis, time-frequency analysis.	2		
Data pre-processing 1: denoising (filtering techniques), dimensionality reduction.	2		
Data pre-processing 2: detrending, handling missing samples and outliers.	2		
Data pre-processing 3: feature extraction and feature selection.	2		
Modeling: introduction to predictive modeling techniques (machine learning, deep learning).	2		
Modeling: time-series segmentation and semantic labeling.	2		
Modeling: prediction models I – regression.	2		
Modeling: prediction models II – classification.	2		
Modeling: anomaly detection methods. Applications in predictive maintenance.	2		
Modeling: models for multivariate time series and forecasting.	2		
Evaluation and validation: methods and metrics. Model refinement and performance optimization.	2		
Industrial case studies and best practices. Ethical considerations and data governance.	2		

Bibliography

1. A.V. Oppenheim and A.S. Willsky, with S.H. Nawab, Signals and Systems, Prentice-Hall, Second Edition, 1997. (UTCN Library - 3 copies);
2. E.S. Gopi, Algorithm Collections for Digital Signal Processing Applications Using Matlab, Springer, 2007, ISBN 978-1-4020-6410-4 (UTCN Library - 1 copy);
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 al., Knowledge-based Systems, lecture/laboratory/project notes, available in electronic format.

9.2 Applications (laboratory)	No.hours	Teaching methods	Notes
Data acquisition – experimental.	2	Presentation of examples. Practical applications. Case study. Discussions.	On-site. Mandatory attendance.
Data understanding: descriptive statistics, visual analytics, correlation analysis, data quality check.	2		
Data pre-processing: filtering, principal component analysis.	2		
Predictive modeling I: regression.	2		
Predictive modeling II: classification.	2		
Anomaly detection on industrial data.	2		
Activity recognition.	2		
9.2.2 Applications (project)			
Topic assignment (real industrial data), experimental setup and data acquisition.	2		
Data analysis: visualization, quality analysis.	2		
Data pre-processing: denoising, detrending, etc.	2		
Data modeling: regression.	2		
Data modeling: classification.	2		
Model evaluation and refinement.	2		
Final presentation / final report.	2		
Bibliography			

- A.V. Oppenheim and A.S. Willsky, with S.H. Nawab, Signals and Systems, Prentice-Hall, Second Edition, 1997. (UTCN Library - 3 copies);
- E.S. Gopi, Algorithm Collections for Digital Signal Processing Applications Using Matlab, Springer, 2007, ISBN 978-1-4020-6410-4 (UTCN Library - 1 copy);
- D.S.G. Pollock, A Handbook of Time-Series Analysis, Signal Processing and Dynamics, Academic Press, 1999;
- Bisgaard, S., & Kulahci, M., Time Series Analysis and Forecasting by Example, John Wiley & Sons, 2011;
- Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006;
- 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;
- Roxana Rusu-Both et al., Knowledge-based Systems, laboratory and project notes, available in electronic format.

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

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	11.1 Assessment criteria	11.2 Assessment methods	11.3 Weight in the final grade
11.4 Course	Understanding of theoretical concepts, clarity in explanations, and ability to apply theory in practice.	Written exam / Online assessment on the Teams platform in case of force majeure	50%
11.5.1 laboratory	Laboratory: practical execution of data preprocessing, modeling, and evaluation tasks; troubleshooting and interpretation of results.	Laboratory: continuous in-lab evaluation + practical test	25%
11.5.2 project	Project: ability to design and complete a data-driven project, clarity of presentation and soundness of analysis.	Project: oral presentation + report	25%
11.6 Minimum performance standard • **Final exam grade ≥ 5** • **Lab grade ≥ 5** (mandatory condition to take the final exam) • **Project grade ≥ 5** (mandatory condition to take the final exam) • **Final grade = 50% Exam + 25% Laboratory + 25% Project ≥ 5**			

Date of filling in:		Title Firstname NAME	Signature
	Course	Conf.dr.ing. Roxana Rusu-Both	
10.07.2026	Aplications	Conf.dr.ing. Roxana Rusu-Both	

Date of approval by the Department Board	Head of Departament Prof.dr.ing. Honoriu VĂLEAN
Date of approval by the Faculty Council	Dean Prof.dr.ing. Vlad MUREȘAN