SYLLABUS
Academic year 2025-2026

Dean,
Prof. dr. eng. Vasile-Ion Manta

1. Program data

1.1 Higher education institution	"Gheorghe Asachi" Technical University of Iași
1.2 Faculty	Automatic Control and Computer Engineering
1.3 Department	Computers
1.4 Field of studies	Computers and Information Technology
1.5 The cycle of studies[1]	Master
1.6 Study program	Artificial Intelligence

2. Subject data

2.1 Name of the subject / Code				**Probabilistic Reasoning (**Raționament probabilistic) / **AI.102**			
2.2 Course coordinator				Lect. dr. eng. Tiberius Dumitriu			
2.3 Application instructor				Lect. dr. eng. Tiberius Dumitriu			
2.4 Year of study[2]	1	2.5 Semester[3]	1	2.6 Type of assessment[4]	exam	2.7 Type of subject[5]	DS

3. Estimated total time of daily activities (hours per semester)

3.1 Number of hours per week	4	3.2 lectures	2	3.3a sem.		3.3b laboratory	2	3.3c project	
3.4 Total hours in curriculum[6]	56	3.5 lectures	28	3.6a sem.		3.6b laboratory	28	3.6c project	

Distribution of the time fund[7]	No. hours
Study by textbook, course support, bibliography and notes	25
Additional documentation in the library, on specialist electronic platforms and in the field	20
Preparation of seminars/labs/projects, assignments, reports and portfolios	20
Tutorial[8]	
Examinations[9]	4
Other activities:	

3.7 Total hours of individual study[10]	69
3.8 Total hours per semester[11]	125
3.9 Number of credits	5

4. Prerequisites (where applicable)

4.1 curriculum[12]	
4.2 competences	

5. Conditions (where applicable)

5.1 conducting the lectures[13]	• Blackboard, video projector
5.2 conducting the seminar / laboratory / project[14]	• Laboratory room with computers and Internet access • The Visual Studio programming environment (academic license)

6. Specific competences accumulated[15]

		Number of credits assigned to the subject[16]: **5**	Distribution of credits per competences[17]
Professional competences	CP1	Knowledge of advanced concepts of computer science and information technology and the ability to work with these concepts.	0.7
	CP2	Scientific and practical research in the field of artificial intelligence.	1
	CP3	Problem solving using probabilistic reasoning methods and techniques.	1
	CP4	Design and development of Bayesian Network.	1
	CP5	Utilization of specific tools and technologies.	0.8
	CP6		
	CPS1		
	CPS2		
Transversal competences	CT1	Legislation compliant application of the intellectual property rights and of the principles, norms and values of the professional ethics code within their own strategies for rigorous, effective and responsible work.	0.1
	CT2	Application of communication techniques and effective group work; developing empathic interpersonal communication skills and assuming leadership roles/functions in a multi-specialized team.	0.2

	CT3	Creating opportunities for continuous training and the effective utilization of learning resources and techniques for personal development.	0.2
	CTS		

7. Objectives of the subject (resulting from the grid of specific competences accumulated)

7.1 General objective of the subject	Understanding and possibility of practical application of knowledge specific to probabilistic reasoning
7.2 Specific objectives	• The goal of this course is to introduce the general concepts for probabilistic reasoning, Bayesian Network, Inference Algorithms. • Provide a clear understanding of fundamentals and key concepts, as well as the importance of probabilistic reasoning. • Study computational models for different types of Bayesian Network

8. Contents

8.1 Course[18]	Teaching methods[19]	Remarks
1. Introduction to the field of probabilistic reasoning (2h) Definitions; Key concepts; Fundamentals; Applications of probabilistic reasoning; Overview of the course ***2. Probability Theory (2h)*** Mathematical foundations. Probabilities. Axioms. Conditional probability and independence. ***3. Bayes' Theorem (2h)*** Bayes' Theorem. The application of Bayes' theorem. The notion of MAP (Maximum A posteriori Probability) hypotheses. The computation of expected values for discrete random variables. ***4. Bayesian Networks (Static) (3h)*** What is a Baesyan Network. Representation of Bayesian Networks. Joint probability dstribution, factorization of probability distributions, construction of Bayesian Networks. ***5. Inference Algorithms (Exact) (3h)*** Introduction. Variable elimination. Clique Tree propagation. Junction Tree Algorithm. ***6. Inference Algorithms (Approximate) (2h)*** Monte Carlo sampling. Variational inference. Markov chain Monte Carlo. ***7. Dynamic Bayesian Networks (2h)*** Introduction. Temporal independence. Inference in Dynamic Bayesian Networks ***8. Causal Networks (4h)*** Causal Networks: correlation AI vs. causal AI. Causal inference. Do calculus. Interventional probabilities. ***9. Bayesian Networks with Latent Variables (2h)*** Latent variables. Hidden Markov models. ***10. Machine Learning and Probabilistic Reasoning (2h)*** Introduction. Gaussian mixture models. Expectation maximization. ***11. Decision Making and Utility (2h)*** Utility functions. Expected utility maximization. ***12. Advanced Topics in Probabilistic Reasoning (2h)*** Particle filtering. Approximate bayesian computation.	Lectures with Powerpoint presentations, explanations and answers to questions	

Course references:

1. Richard E. Neapolitan, *Learning Bayesian Networks*, Pearson, ISBN-13 : 978-0130125347, 2019
2. Kevin Patrick Murphy, *Dynamic Bayesian Networks Representation, Inference and Learning*, Berleley Unibersity, Fall 2002
3. Judea Pearl and Dana Mackenzie, *The book of why : the new science of cause and effect*, Basic Books, ISBNs: 978-0-465-09760-9 , 2018
4. Dani Gamerman, Hedibert F. Lopes, *Markov Chain Monte Carlo*, Chapman & Hall/CRC Texts in Statistical Science, 2nd Edition, ISBN-10 : 1584885874, ISBN-13 : 978-1584885870, 2006
5. Steve Brooks, Andrew Gelman, Galin Jones, Xiao-Li Meng, *Handbook of Markov Chain Monte Carlo*, Chapman & Hall/CRC Handbooks of Modern Statistical Methods 1st Edition, ISBN-13 : 978-1420079418, 2011
6. Daphne Koller, Nir Friedman, *Probabilistic Graphical Models: Principles and Techniques*, Adaptive Computation and Machine Learning series, 1st Edition, 2009

7. Adnan Darwiche, *Modeling and Reasoning with Bayesian Networks*, Cambridge University Press, ISBN-13 978-0-521-88438-9, 2009

8.2a Seminar	Teaching methods[20]	Remarks

8.2b Laboratory	Teaching methods[21]	Remarks
Week 1. Fundamentals of probabilistic reasoning (2h) Definitions and general concepts. Examples. Applications. ***Week 2. Probability Theory (2h)*** Mathematical foundations. Solving some practical problems. Applications. ***Week 3. Application of Bayes' Theorem (2h)*** ***Week 4-5. Bayesian Networks (Static) (4h)*** Representation of Bayesian Networks. A simple implementation of a Bayesian Networks. Using a Bayesian Networks to solve a specific issue, ***Week 6-7. Inference Algorithms (4h)*** Implement and using of Markov chain Monte Carlo method in order to solve a specific task. ***Week 8. Inference in Dynamic Bayesian Networks (2h)*** ***Week 9. Do calculus application (2h)*** ***Week 10. Hidden Markov models (2h)*** ***Week 11-12. Implement an application using Expectation maximization method (4h)*** ***Week 13-14. Implement an application using Expected utility maximization method (4h)***	General and individual explanations, individual computer work	
8.2c Project	Teaching methods[22]	Remarks

Applications (laboratory) references:

1. Liviu Ciortuz, Alina Munteanu, Elena Bădărău, *Exerciţii de învăţare automată*, 3st Edition ISBN: 978-973-0-33148-6, 2020
2. T. Mitchell, *Machine Learning*, McGRAW Hill, 1997
3. Eric Xing, *HW*, CMU, Fall, 2008
4. C. Manning & H.Schutze, *Foundations of Statistical NLP*, MIT Press, 2002

9. Corroboration of the contents of the subject with the expectations of representatives of the epistemic community, professional associations and representative employers in the field related to the program[23]

- The course content was created in accordance with the syllabuses of related courses from prestigious international universities.
- The curriculum aims to train students in the field of artificial intelligence. The discipline, first the theoretical and the practical part, fits perfectly into this objective, given the increased interest in probabilistic reasoning methods and techniques.
- The course content aims to prepare the students for research-advanced design projects and was drafted to be up to date with the relevant open problems in recent research.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods		10.3 Weight in the final grade
10.4a Exam	Acquired theoretical and practical knowledge (quantity, correctness, accuracy)	Periodic tests[24]:		50% (minimum 5)
		Homework:		
		Other activities[25]:		
		Final evaluation:	100%	
10.4b Seminar	Frequency/relevance of interventions or responses	Record of interventions, portfolio of works (references, scientific summaries)		
10.4c Laboratory	Knowledge of equipment, how to use specific tools; evaluation of tools or achievements, processing and interpretation of results	• Practical demonstrations • Oral answers • Written questionnaires • Self-assessment, presentation and/or defence of the work		50% (minimum 5)
10.4d Project	The quality of the completed project, the correctness of the project documentation, the justification of the chosen solutions	• Critical evaluation of a project		
10.5 Minimum performance standard[26]: grade 5 in the exam and applications (the average between laboratory and project)				

Date of completion,
4 December 2023

Signature of course coordinator,
Lect. dr. eng. Tiberius Dumitriu

Signature of application instructor,
Lect. dr. eng. Tiberius Dumitriu

Date of approval in the department,
7 December 2023

Director of department,
Assoc. prof. dr. eng. Andrei Stan

[1] *Bachelor / Master*
[2] *1-4 for Bachelor's, 1-2 for Master's*
[3] *1-8 for Bachelors, 1-3 for Masters*
[4] *Exam, colloquium or VP A/R – from the curriculum*
[5] *DF - fundamental subject, DID - subject in the field, DS - specialized subject or DC - complementary subject - from the education plan*
[6] *It is equal to 14 weeksx number of hours from point 3.1 (similar for 3.5, 3.6abc)*
[7] *The lines below refer to the individual study; the total is completed at point 3.7.*
[8] *Between 7 and 14 hours*
[9] *Between 2 and 6 hours*
[10] *The sum of the values on the previous lines, which refer to the individual study.*
[11] *The sum of the number of hours of direct teaching activity (3.4) and the number of hours of individual study (3.7); must be equal to the number of credits allocated to the subject (point 3.9)x 24 hours per credit.*
[12] *Mention the subjects that must be passed previously or equivalent*
[13] *Blackboard, video projector, flipchart, specific teaching materials, etc.*
[14] *Computing technique, software packages, experimental stands, etc.*
[15] *Competencies from the G1 and G1bis Grids of the study program, adapted to the specifics of the subject, for which credits are allocated (www.rncis.ro or the faculty website)*
[16] *From the education plan*
[17] *The credits allocated to the subject are distributed on professional and transversal competences according to the specifics of the subject*
[18] *Chapter and paragraph headings*
[19] *Exposition, lecture, blackboard presentation of the studied issue, use of video projector, discussions with students (for each chapter, if applicable)*
[20] *Discussions, debates, presentation and/or analysis of papers, solving exercises and problems*
[21] *Practical demonstration, exercise, experiment*
[22] *Case study, demonstration, exercise, error analysis, etc.*
[23] *The connection with other subjects, the usefulness of the subject on the labor market*
[24] *The number of tests and the weeks in which they will be held will be specified.*
[25] *Scientific circles, professional competitions, etc.*
[26] *The minimum performance standard from the competences grid of the study program is customized to the specifics of the subject, if applicable.*