Department of Intelligent Transportation Systems
Chair of Applied Computing

UNIVERSITY OF ZAGREB
FACULTY OF TRANSPORT AND TRAFFIC SCIENCES

GRADUATE STUDY: TRANSPORT, ITS AND LOGISTICS

SEMESTER (II)

Syllabus

Academic year 2024/2025

Course:	**Artificial Intelligence**				
Head of course: Prof. **Edouard Ivanjko**, Ph.D.					
Co-lecturers: Asst. Prof. **Martin Gregurić**, Ph.D. **Mladen Miletić**, mag. ing. traff.					
Semester: **S**	Course code: **171845**	Lectures: **30**	Auditory exercises: **10**	Laboratory exercises: **20**	ECTS credits: **5**
Group for lectures: **30 students**			Group for auditory and laboratory exercises: **15 students**		

Objective of the course:

- To provide the knowledge and information necessary for a systematic understanding of the structure and behavior of technical systems based on artificial intelligence, and the application of methods and techniques from the domain of artificial intelligence in traffic engineering
- To train students to use Matlab software modules related to the application of artificial intelligence in traffic engineering (learning neural network systems, making fuzzy regulators and decision systems, optimizing systems using the genetic algorithm)
- Provide the basic knowledge needed to evaluate the possibilities of applying method from the domain of artificial intelligence within intelligent transport systems, and information and communication traffic systems

Learning outcomes:

After completing the course, students will be able to:

1. **Explain** basic concepts in the domain of artificial intelligence.
2. **Describe** the features of technical systems based on artificial intelligence.
3. **Model** the traffic problem for control or optimization using methods from the domain of artificial intelligence.
4. **Choose** a suitable method from the domain of artificial intelligence to solve a traffic problem.
5. **Solve** a traffic problem with appropriate methods from the domain of artificial intelligence.

6. **Develop** a solution using modules from the Matlab software package to create simple systems based on artificial intelligence.

LECTURES and EXERCISES

Week	Syllabus	Form of classes	Performed by	Lessons	Remark
1.	▪ Introductory lecture (introducing the content of the course, the way of work, the literature, the obligations for successful passage through the course) ▪ The subject of study and basic concepts, examples of the application of artificial intelligence in traffic engineering	L	Edouard Ivanjko	2	
	▪ Introductory auditory exercise (introducing the contents of auditory and laboratory exercises, computer laboratory, how to work on auditory and laboratory exercises) ▪ Introduction to the Matlab / Simulink software package ○ Theoretical basis ○ Syntax of statements ○ Working with matrices	AE	Martin Gregurić, Mladen Miletić	2	
2.	▪ Mathematical logic ○ Propositional logic ○ Predicate logic	L	Edouard Ivanjko	2	
	▪ Introduction to the Matlab / Simulink software package ○ Representation of data ○ Importing data ○ Processing data ○ Graphically displaying data	LE	Martin Gregurić, Mladen Miletić	2	
3.	▪ Knowledge-based systems ○ Frame based knowledge representation ○ Knowledge base ○ Expert systems ○ Rule based inference	L	Edouard Ivanjko	2	

	▪ Simulation of technical systems using the Matlab / Simulink software package ○ Theoretical basis ○ Making a simple Simulink model ○ Processing and presenting traffic data using a Simulink model	LE	Martin Gregurić, Mladen Miletić	2	
4.	▪ Processing of uncertain data ○ Characteristics of uncertain data ○ Bayes rule ○ Bayesian inference	L	Edouard Ivanjko	2	
	▪ Mathematical logic and Bayesian inference ○ Propositional logic ○ Predicate logic ○ Bayesian inference framework	AE	Martin Gregurić, Mladen Miletić	2	
5.	▪ Introduction to Fuzzy Logic ○ Fuzzy sets ○ Shapes of membership functions ○ Fuzzy variables	L	Edouard Ivanjko	2	
	▪ Fuzzy Logic Toolbox within the Matlab / Simulink software package ○ Example of a decision-making system to control the braking of a road vehicle using fuzzy logic ○ Using the Simulink blocks related to fuzzy inference systems	LE	Martin Gregurić, Mladen Miletić	2	
6.	▪ Inference based on Fuzzy Logic ○ Procedure for fuzzy inference ○ Methods for fuzzy inference	L	Edouard Ivanjko	2	
	▪ Example of using the Fuzzy Logic toolbox ○ Creating a fuzzy decision-making system for planning of the train's movement regime	AE	Martin Gregurić ,Mladen Miletić	2	
7.	▪ Machine learning ○ Need for machine learning ○ Machine learning concepts ○ Approaches to machine learning ○ Naive Bayes classifier	L	Edouard Ivanjko	2	Announcement of the first midterm exam

	▪ Preparing for the first midterm exam ○ Inductive and deductive reasoning, propositional logic ○ Numerical examples of Fuzzy Logic	AE	Martin Gregurić, Mladen Miletić	2	
8.	▪ Genetic algorithm ○ Optimization problems ○ Principle of evolution ○ Concept of the genetic algorithm ○ Solution coding ○ Genetic operators	L	Edouard Ivanjko	2	
	▪ Genetic Algorithm within the Matlab / Simulink software package ○ Getting familiar with the Optimization toolbox ○ Calculating the minimum of a simple function with constrains using the genetic algorithm in the Optimization toolbox	LE	Martin Gregurić, Mladen Miletić	2	First midterm exam
9.	▪ Introduction to Neural Networks ○ Model of an artificial neuron ○ Activation functions ○ Neural network structures ○ Artificial intelligence and Neural Networks	L	Edouard Ivanjko	2	
	▪ Genetic algorithm within the Matlab / Simulink program package ○ Solving the traveling salesman problem using the genetic algorithm	LE	Martin Gregurić, Mladen Miletić	2	
10.	▪ Learning Neural Networks ○ Kolmogorov theorem ○ Types of learning ○ Learning of the ADALINE Neural Network ○ Backpropagation algorithm	L	Edouard Ivanjko	2	
	▪ Neural Network Toolbox within the Matlab / Simulink software package ○ Basics of the Neural Network toolbox ○ Creating the structure of an artificial Neural Network ○ Data preparation for learning Neural Networks	LE	Martin Gregurić, Mladen Miletić	2	

11.	▪ Associative and Self-Organizing Neural Networks ○ Associative Neural Networks ○ Self-Organizing Neural Networks ○ Kohonen Neural Network	L	Edouard Ivanjko	2	
	▪ Neural Network Toolbox within the Matlab / Simulink software package ○ Learning Neural Networks to predict traffic parameters ○ Evaluation of quality of the learned Neural Networks	LE	Martin Gregurić, Mladen Miletić	2	
12.	▪ Computer vision in transport and traffic ○ Image processing in a computer ○ Traffic parameters ○ Incident situations ○ Driver assistance systems	L	Edouard Ivanjko	2	
	▪ Computer Vision Toolbox within the Matlab / Simulink software package ○ Basics of the Computer vision toolbox ○ Creating a simple program for detection of road vehicles ▪ Analysis of the accuracy of an algorithm for vehicle detection in a parking lot ○ Processing of data obtained using computer vision toolbox within the Matlab / Simulink software system ○ Creating a simple vehicle detection program based on processing of false and positive vehicle detection cases	LE	Martin Gregurić, Mladen Miletić	2	
13.	▪ Hybrid Intelligent Systems ○ Neuro-expert systems ○ Neuro-fuzzy systems ○ Genetic algorithm and Fuzzy Logic ○ Genetic algorithm and Neural Networks	L	Edouard Ivanjko	2	

	▪ Preparing for the writing of the second midterm exam ○ Numerical examples of genetic algorithm problem solving ○ Numerical examples of learning Neural Networks	AE	Martin Gregurić, Mladen Miletić	2	
14.	▪ Intelligent Agents ○ Agents ○ Reinforcement learning	L	Edouard Ivanjko	2	Announcement of the second midterm exam
	▪ Reinforcement learning ○ Defining the basic functional elements of the Q-learning algorithm ○ Implementing a routing example in a simple state space using Q-learning	LE	Martin Gregurić, Mladen Miletić	2	
15.	▪ Deep learning ○ Architectures of deep learning ○ Convolutional neural networks ○ Enhancing generalization ○ Deep reinforcement learning ○ Application in traffic processes	L	Martin Gregurić	2	
	▪ Deep learning ○ Methodology for creating convolutional networks within the Matlab / Simulink software system using the Deep Learning toolbox ○ Implementation of a simple convolutional network for the classification of images with numbers with the possibility of application for license plate detection	LE	Martin Gregurić, Mladen Miletić	2	Second midterm exam

L = Lectures; **AE** = Auditory Exercises; **LE** = Laboratory Exercises; S = Seminars

STUDENT OBLIGATIONS AND EXAMS

Conditions for obtaining signatures:

Regular attendance of lectures and laboratory exercises. The student should attend at least 60% (10 out of 15) lectures and 100% (15 out of 15) auditory and laboratory exercises. In the case of auditory

and laboratory exercises, there are possibilities for reimbursement periods during the semester and in the last week of the semester.

Written knowledge assessment:

There are two ways of passing the exam:

a) **In two parts through midterm exams**: are held at about the middle and the end of the semester. The number of points a student can earn in a single midterm exam is 100, and the total number of points is counted as the mean value of the points with two midterm exams. Students who achieve a mid-point score less than 50 have not passed the midterm exams or written exams, and points for the written knowledge assessment will be awarded on a written final exam. Students who achieve a mid-point score of less than 50 through midterm exams are required to access the written part of the exam. All students can access both midterm exams.

b) **In one part through a written final exam**: 100 points can be awarded on a written exam. Students who score less than 50 have not passed the written part of the exam. All those students who did not collect enough points individually on the midterm exams or are not satisfied with the points collected at the exams or who did not attend the written check of knowledge through the midterm exams are all on the written part of the exam.

Oral exam: To attend the oral exam, an average of at least 50 points should be obtained either through the midterm exams or the final written exam.

Additional points: A student can accumulate additional points by engaging in interactive lectures with an analysis of the application of the methods from the domain of artificial intelligence in intelligent transport systems or information-communication traffic, by developing additional teaching materials and by presenting them in front of the students.

LITERATURE

a) Obligatory literature:

1. Gold, H., Ivanjko, E., Gregurić, M.: **Authorized lectures** (merlin.srce.hr)
2. Ivanjko, E., Buntić, M., Gregurić, M., Miletić, M.: **Authorized instructions for Laboratory excersizes** (merlin.srce.hr)
3. Sandro Skansi, **Introduction to Deep Learning: From Logical Calculus to Artificial Intelligence**, Springer, 2018
4. Charu C. Aggarwal, **Neural Networks and Deep Learning: A Textbook**, Springer, 2018
5. Driscoll, T.A.: **Learning Matlab,** University of Delaware, SIAM, 2009
6. Luger, G.F.: **Artificial Intelligence,** Addison Wesley, 2005

b) Recommended literature:

1. Russell, S., Norvig, P.: **Artificial Intelligence: A Modern Approach**, Prentice Hall, 2003.
2. http://www.mathworks.com/
3. https://octave-online.net/
4. https://www.gnu.org/software/octave/

METHODOLOGY OF THE IMPLEMENTATION OF THE COURSE PLAN

1. LECTURES

Lectures accompany the subject in the authorized lectures (presentations and scripts) listed in the mandatory literature and are mostly performed using PowerPoint presentations and whiteboard for sketches. The lecture focuses on the discussion of the problem that is being examined. Especially by linking the artificial intelligence method to traffic problems and the possibilities of their solution and application within intelligent transport systems and information and communication traffic.

2. AUDITORY/LABORATORY EXERCISES

Auditory and laboratory exercises are performed in a computer lab in a way that addresses the traffic problems (conclusion of the recommendation of the driving mode, predicting traffic parameters, control of autonomous vehicle) using available software packages (Matlab / Simulink, AMORsim - autonomous vehicle simulator for Matlab). Performing of the exercises is organized in a way that students are enabled to use the aforementioned program packages, adopt the methodology for creating concepts of management and decision-making based on artificial intelligence methods for application in intelligent transport systems and information and communication traffic. The exercises consist of two units, the first includes theoretical preparation for the use of the above-mentioned program packages and mentoring students in the preparation of their student tasks, and the other includes the application of the learned knowledge in the use of above-mentioned software packages and simulators. During the semester there are also special auditory exercises related to solving numerical examples for the purpose of preparing the students for the midterm exams.

3. DOCUMENTATION

Evidence is being taken of student presence in all lectures, auditory and laboratory exercises, participation in interactive lectures and attended midterm exams.

4. SCORING SYSTEM

The final grade is based on the sum of the scores obtained on the written and verbal part of the exam. The student activity on the course can increase the final score for a total of 10 points.

Table 1 The scoring system for the monitoring of students and explained credit values in ECTS credits

no	Segment:	Required credits to be achieved:		Remark:	ECTS credits
		Min.	Max.		
1.	Presence to lectures:	10	15	Presence ≥ 60%, mandatory for obtaining the course signature and not included in the overall number of points for the final grade	**1**
2.	Presence to exercises:	15	15	Presence 100%, mandatory for obtaining the course signature and not included in the overall number of points for the final grade	**1**
4.	First midterm exam	50	100	Cumulative number of points is averaged	**1**
5.	Second midterm exam	50	100		**1**
6.	Written exam (terms)	50	100	Replaces items 4 and 5	**2**
7.	Oral exam	15	30		**1**
Σ	Overall point	**Σ 65**	**Σ 130**	Overall ETCS points*:*	**Σ 5**

Table 2 - Explanation of the credit values in evaluations

CREDITS:	Estimate based on attendance and two midterm exams (or written exam) - [4 ECTS]:	The final score [5 ECTS]:
65 - 83	Sufficient (2)	Exemption from the written part of the exam, the final score after the oral exam
83 - 102	Good (3)	
102 - 117	Very good (4)	
117 - 130	Excellent (5)	Exemption from verbal part of the exam

Information for students (scoring system, implementation plan, learning outcomes, syllabus, literature, consulting teachers, the announcement of results of examinations or colloquium, and all other information):

- **https://moodle.srce.hr/2024-2025/**
- **http://www.fpz.unizg.hr**

Student assistants: Additional individual work with the students through individual consultations for assignments from auditory exercises and/or research designs from laboratory exercises, for

optional homework, as well as for insight into the negatively written part of the exam including midterm exams.