I. FORM FOR DESCRIPTION OF LIFELONG EDUCATION PROGRAM

NOTE: Some fields in the forms are marked with symbols [a, b, c, d, e] . These fields are not mandatory for all programs. They need to be filled in only if the corresponding program is applied according to the Type of *program field* in Form I - part of *General information* . Fields that are not specifically marked are mandatory for everyone.

GENERAL INFORMATION	
Name of the program	**A short-cycle program to acquire basic skills in artificial intelligence and data science**
The host of the program	**prof. dr. sc. Zlatan Car**
Program manager	
Program type	a) Different programs in the process of acquiring an academic title b) Programs for acquiring knowledge, skills and competences within the framework of an accredited study program[1] c) Training programs with ECTS credits **d) Training programs without ECTS credits** e) Programs of authorized bodies

1. INTRODUCTION
1.1. Reasons for starting the program
The program is launched as part of the Erasmus+ project Introduction of joint short-cycle ICT courses for better employability of students and graduates (WICT) (ref. 2021-1-HR01-KA220-HED-000031177). The goal of the program is to increase the capacity of students of higher institutions in the field of data science and artificial intelligence, in order to increase the employability of students from areas that are not directly related to the aforementioned elements. With this program, students can acquire skills in the field of data analysis.
1.2. Assessment of expediency with regard to the needs of the labor market in the public and private sector [a, b, c, e]
1.2.1. Connection with the local community (economy, entrepreneurship, civil society) [a, b, c, e]
1.2.2. Compliance with the requirements of professional associations (recommendations) [a, b, c, e]
1.2.3. List possible partners outside the higher education system who have expressed interest in the program
1.3. Institutional strategy for the development of lifelong learning programs (compliance with the institution's strategy)

[1] For this program, a special form for the description of the program must be filled out .

1.4. Other important information - according to the opinion of the proponent

2. GENERAL PART

2.1. Name of the lifelong education program

A short-cycle program to acquire basic skills in artificial intelligence and data science

2.1.1. Program type

a) Different programs in the process of acquiring an academic title
b) Programs for acquiring knowledge, skills and competences within the framework of an accredited study program
c) Training programs with ECTS credits
d) Training programs without ECTS credits
e) Programs of authorized bodies

2.1.2. Level of study program (if applicable) [a, b]

2.1.3. Field of the program (scientific/artistic) - state the name [a, b, c]

2.2. Program holder/s

prof. dr. sc. Zlatan Car

2.3. Program performer/s

Zlatan Car
Nikola Anđelić
András Horváth
Anna Gelencsér-Horváth
Kálmán Tornai
Zoran Kalinić
Vladimir Ranković
Tijana Geroski
Naoum Mylonas
Themis Exarchos
Pawel Lula
Katarzyna Wójcik

2.4. Program duration

2 semesters

2.4.1. ECTS points – the minimum number of points required for the participant to complete the program [a, b, c]

2.5. Conditions for enrolling in the program
Enrolled or completed university studies, regardless of field. Completed high-school studies.
2.6. Learning outcomes of the program (competencies that the participant acquires at the end of the program)
2.7. When applying for the program, state the study programs of the proposer or other institutions in the Republic of Croatia from which it is possible to enroll in the proposed program (if applicable) [and]

3. DESCRIPTION OF THE PROGRAM
1.
3.1. The structure of the program, the rhythm of attendance and the obligations of the participants
3.2. List of courses and/or modules (if they exist) with the number of hours of active teaching required for their implementation (and the number of ECTS points for program types a, b, or c) (attachment: Table 1)
Computer Programming for Data Science and Artificial Intelligence **Introduction to Data Science and Artificial Intelligence** **Data Storage and Management** **Data Visualization** **Fundamentals of Mathematics for Machine Learning** **Social Aspects of Artificial Intelligence** **Problem Solving and Decision Making with Artificial Intelligence and Machine Learning Methods and Tools** **BIg Data** **Supervised and Unsupervised Learning** **Statistical Data Analysis** **Practical AI Applications** **Practical Data Collection and Analytics** **Introduction to High Performance Computing**
3.3. Description of each subject (if any) (attachment: Table 2)
Computer Programming for Data Science and Artificial Intelligence - aims to provide students with the knowledge necessary to apply artificial intelligence methods in appropriate programming languages.

Introduction to Data Science and Artificial Intelligence - teaches the basics of various popular techniques in the area of data science and artificial intelligence
Data Storage and Management - information on storing and managing large amounts of data necessary for the application of data science and AI techniques
Data Visualization - provides knowledge on proper manner of visualizing various types of data points
Fundamentals of Mathematics for Machine Learning - aims to provide students with the knowledge necessary to understand the underlying mathematics and statistics behind machine learning methods
Social Aspects of Artificial Intelligence - analysis of the impact artificial intelligence has on the society and vice-versa
Problem Solving and Decision Making with Artificial Intelligence and Machine Learning Methods and Tools - aims to provide information on the application of data science and artificial intelligence in the context of business analytics
Big Data - provides knowledge on the big data concepts and handling of extremely large amounts of structured or unstructured data points
Supervised and Unsupervised Learning - describes the approaches of supervised and unsupervised machine learning and their applications
Statistical Data Analysis - in depth analysis of statistical properties of data
Practical AI Applications - covers applications of AI in various fields (medicine, technology, biology, economics…) allowing students to receive an overview of various techniques that are applied as state-of-the-art in different fields
Practical Data Collection and Analytics - analyses the procedures of data collection and initial analytics
Introduction to High Performance Computing - defines and teaches the basics of high performance computer systems

3.3.1. Requirements for enrollment in the next semester or trimester (title of course) (if applicable) [a]

3.4. List of courses and/or modules that can be taught in a foreign language (specify which language)

Introduction to Data Science (English)
Computer Programming for Data Science and Artificial Intelligence (English)
Introduction to Data Science and Artificial Intelligence (English)
Data Storage and Management (English)
Data Visualization (English)
Fundamentals of Mathematics for Machine Learning (English)
Social Aspects of Artificial Intelligence (English)
Problem Solving and Decision Making with Artificial Intelligence and Machine Learning Methods and Tools (English)
BIg Data (English)
Supervised and Unsupervised Learning (English)
Statistical Data Analysis (English)
Practical AI Applications (English)
Practical Data Collection and Analytics (English)
Introduction to High Performance Computing (English)

3.5. Method of executing the program [2](it is possible to foresee several methods of executing the program)

☐ direct teaching
☐ distance learning (a) synchronous, b) asynchronous)[3]

[2] If more than one execution method is approved, explain each one.
[3]Distance learning refers to the way the program is carried out, but not to the way of knowledge verification that can be provided through one of the distance learning systems or knowledge verification (exam) in direct contact.

☒ hybrid teaching
3.5.1. Explain the purpose of conducting the program/module online or hybridly **The analysis of interests carried out within the project determined interest in the possibility of holding hybrid classes. This is most likely caused by the desire of participants who are studying or have completed their studies, and are interested in additional education in the field of data science and artificial intelligence.**
3.5.2. Justify the existence of the conditions for carrying out the program through distance or hybrid teaching (availability of the system for *distance learning, infrastructure, etc.)*
3. 6. Language of performance
☐ Croatian language ☒ English language ☐ second: _____
3.7. Explain the multidisciplinarity of the program
The multidisciplinarity of the program stems from the fact that the goal of the program is to bring advanced data analysis techniques closer to those participants who work or study in other scientific fields in order to enable them to apply them in their current and future work.
3.8. Method of completing the program
The student completes the program by fulfilling all obligations at the study, i.e. by passing all subjects through appropriate exams.

Table 1.

3.1. List of courses and/or modules (if they exist) with the number of hours of active teaching required for their implementation and the number of ECTS credits

LIST OF MODULES / COURSES						
Semester [a]:						
MODULE	CASE	COURSE INSTRUCTOR	P	V	S	ECTS [a, b, c]
1	Computer Programming for Data Science and Artificial Intelligence	Naoum Mylonas, Themis Exarchos	5	5	0	-
	Introduction to Data Science and Artificial Intelligence	Kálmán Tornai, András Horváth, Anna Gelencsér-Horváth, András Attila Sulyok	10	0	0	-
	Data storage and management	Zlatan Car, Nikola Anđelić	10	0	0	-
	Data Visualization	Vladimir Ranković, Andrija Djonić	2	6	2	-

	Fundamentals of mathematics for machine learning	Paweł Lula, Katarzyna Wójcik	5	5	0	-
	Social Aspects of AI	Zlatan Car, Nikola Anđelić	5	0	5	-
	Problem Solving and Decision Making with Artificial Intelligence and Machine Learning Methods and Tools	Paweł Lula, Katarzyna Wójcik	5	5	0	-
	Big Data	Zlatan Car, Nikola Anđelić	8	2	0	-
	Supervised and Unsupervised Learning	Kálmán Tornai, András Horváth, Anna Gelencsér-Horváth, András Attila Sulyok	5	5	0	-
	Statistical Data Analysis	Paweł Lula, Katarzyna Wójcik	5	5	0	-
	Practical AI Applications	Zoran Kalinic, Aristeidis Vrahatis, Themis Exarchos	5	5	0	-
	Practical Data Collection and Analytics	Zlatan Car, Nikola Anđelić	5	3	2	-
	Introduction to High Performance Computing	Tijana Georski	7	3	0	-

Table 2.

3.2.1. Description of the course / lecture

NOTE: If there are no subjects in the program (eg short courses), fill in the fields that are relevant to the program

GENERAL INFORMATION		
Subject holder	**Naoum Mylonas, Themis Exarchos**	
Name of the object	**Computer Programming for Data Science and Artificial Intelligence**	
Semester [a]		
Point value and method of teaching	ECTS student load factor [a, b, c]	

1. SUBJECT DESCRIPTION
1.1. Objectives of the course
This course is designed to equip students with fundamental programming skills required for Data Science and Artificial Intelligence. It covers key programming concepts, data structures, algorithms, and relevant libraries used for data analysis, machine learning, and AI implementation. The course aims to help students apply these skills to solve problems in social sciences.
1.2. Conditions for course enrollment (if applicable)
No conditions.
1.3. Expected learning outcomes for the subject
● **Understand and apply basic computer programming concepts.** ● **Use programming languages such as Python or R for data analysis and visualization.** ● **Implement data structures and algorithms for Data Science and AI.** ● **Use libraries such as Pandas, NumPy, Scikit-Learn, and TensorFlow for data analysis, machine learning, and AI.** ● **Develop, test, and debug programs for Data Science and AI applications.** ● **Apply programming skills to solve real-world problems in social sciences.**
1.4. Subject content
Introduction to Programming for Data Science and AI. Basics of Programming. Programming for Data Analysis. Programming for Machine Learning. Programming for Artificial Intelligence. Debugging, Testing, and Documentation. **1. Basics of algorithms** **a. Problem analysis and algorithmic design** **b. Time and memory complexity (examples)** **2. Basics of programming** **a. Basics of Python (variables, control statements, functions, classes, modules)** **b. Basics of R (variables, control statements, functions, classes, modules)** **c. Basic data types** **3. Scientific libraries for Python** **a. Numpy data types, operations** **b. Numpy data processing functions**

c. **Scikit**
d. **TensorFlow**
e. **Pandas**

4. **Data visualization**
5. **Script debugging**
    a. **Code analysis (breakpoints, watches)**
6. **GitHub Copilot**

1.5. Intended way of teaching/subject/module/program
☐ direct teaching
☐ distance learning (a) synchronous, b) asynchronous)
☒ hybrid teaching

Teaching performance (direct teaching)	☐ lectures ☒ seminars and workshops ☒ exercises ☒ field teaching	☐ independent tasks ☐ multimedia and network ☐ laboratory ☒ mentoring work ☒ other _____
Teaching performance (distance learning)	☐ lectures ☒ seminars and workshops ☒ exercises	☐ independent tasks ☐ multimedia and network ☐ mentoring work ☐ other _____
Teaching performance (hybrid)	Direct teaching: ☒ lectures ☐ seminars and workshops ☒ exercises ☐ field teaching ☒ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work ☐ other	Distance learning: ☒ lectures ☐ seminars and workshops ☒ exercises ☒ independent tasks ☐ multimedia and network ☐ mentoring work

1.6. Additional explanation

1.7 Obligations of participants

Class attendance, class activity, tests, exams

Monitoring the work of [4abc] trainees

Attending classes	X	Activities in class		Seminar work		Experimental work	X
Written exam	X	Oral exam		Essay		Research	
Project	X	Continuous verification of knowledge		Report	X	Practical work	X
Portfolio							

[4] **IMPORTANT** : For each method of monitoring the student's work, enter the corresponding share in ECTS points of individual activities so that the total number of ECTS points corresponds to the point value of the course. Use empty fields for additional activities.

1.9. Assessment and evaluation of the work of [abc participants]

Evaluation Components: 1. Examination, 2. Group Work, 3. Individual Work

1.10. Mandatory literature (at the time of application of the program proposal) [abc]

•Grus, J. (2019). Data Science from Scratch: First Principles with Python (2nd Edition). O'Reilly Media.

•VanderPlas, J. (2016). Python Data Science Handbook: Essential Tools for Working with Data. O'Reilly Media.

1.11. Supplementary literature (at the time of application of the program proposal) [abc]

1.12. The number of copies of compulsory literature in relation to the number of participants who are currently attending classes at
to the subject [ab]

title	Number of copies	Number of participants

1.13. Quality monitoring methods that ensure the acquisition of output knowledge, skills and competencies

Table 3.

3.2.2. Description of the course / lecture

GENERAL INFORMATION		
Subject holder	**Kálmán Tornai, András Horváth, Anna Gelencsér-Horváth**	
Name of the object	**Introduction to Data Science and Artificial Intelligence**	
Semester [a]		
Point value and method of teaching	ECTS student load factor [a, b, c]	

1. SUBJECT DESCRIPTION
1.1. Objectives of the course
Acquisition of theoretical and practical knowledge on the basics of Data Science and the application of core algorithms of artificial intelligence.
1.2. Conditions for course enrollment (if applicable)
No conditions.
1.3. Expected learning outcomes for the subject
Define and correctly interpret the fundamental concepts of data science. Familiarity with the tools for processing large amounts of data. Define the terms artificial intelligence and machine learning. Analyze the manner in which AI can be applied to solve problems. Explain knowledge-based systems. Perform basic data preprocessing. Define the basic tasks of machine learning. Define and analyze algorithms of artificial neural networks, support vector machines, k-nearest neighbors. Apply tools for developing artificial intelligence algorithms and training machine learning models. Analyze and apply existing generative models.
1.4. Subject content
Basic concepts of data science. Loading and manipulating data. Definition of artificial intelligence. Historical overview of artificial intelligence. Problem solving methodology. Knowledge and reasoning: a knowledge-based information system. Artificial neural networks. Fuzzy logic. Support vector machines. Expert systems. Machine learning: learning from observations, learning with neural and belief networks, reinforcement learning, knowledge in learning. Application of artificial intelligence, optimization and planning of real problems, learning systems, visual recognition systems. Generative systems based on artificial intelligence.
1.5. Intended way of teaching/subject/module/program ☐ direct teaching ☐ distance learning (a) synchronous, b) asynchronous) ☒ hybrid teaching

Teaching performance (direct teaching)	☐ lectures ☐ seminars and workshops ☐ exercises ☐ field teaching	☐ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work ☐ other _____
Teaching performance (distance learning)	☐ lectures ☐ seminars and workshops	☐ independent tasks ☐ multimedia and network

	☐ exercises	☐ mentoring work ☐ other _____
Teaching performance (hybrid)	Direct teaching: ☒ lectures ☐ seminars and workshops ☒ exercises ☐ field teaching ☒ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work ☐ other	Distance learning: ☒ lectures ☐ seminars and workshops ☒ exercises ☒ independent tasks ☐ multimedia and network ☐ mentoring work

1.6. Additional explanation

1.7 Obligations of participants

Class attendance, class activity, tests, exams

Monitoring the work of [5abc] trainees

Attending classes		Activities in class		Seminar work		Experimental work	
Written exam		Oral exam		Essay		Research	
Project		Continuous verification of knowledge		Report		Practical work	
Portfolio							

1.9. Assessment and evaluation of the work of [abc participants]

1.10. Mandatory literature (at the time of application of the program proposal) [abc]

1.11. Supplementary literature (at the time of application of the program proposal) [abc]

1.12. The number of copies of compulsory literature in relation to the number of participants who are currently attending classes at
to the subject [ab]

title	Number of copies	Number of participants

1.13. Quality monitoring methods that ensure the acquisition of output knowledge, skills and competencies

[5] **IMPORTANT** : For each method of monitoring the student's work, enter the corresponding share in ECTS points of individual activities so that the total number of ECTS points corresponds to the point value of the course. Use empty fields for additional activities.

Table 4.

3.2.3. Description of the course / lecture

GENERAL INFORMATION		
Subject holder	**Zlatan Car, Nikola Anđelić**	
Name of the object	**Data storage and management**	
Semester [a]		
Point value and method of teaching	ECTS student load factor [a, b, c]	

1. SUBJECT DESCRIPTION
1.1. Objectives of the course
Acquisition of basic knowledge and skills in the field of data storage and management.
1.2. Conditions for course enrollment (if applicable)
No conditions.
1.3. Expected learning outcomes for the subject
Use the basics of programming and query languages necessary for processing large amounts of data. Define the terms redundancy and chot/old storage. Understand different ways of storing large amounts of data such as relational databases, data warehouses and data lakes. Distinguish between structured and unstructured data storage types. Knowledge of available services for processing large amounts of data in the cloud.
1.4. Subject content
Basic concepts of data storage and management. Basics of programming languages Python and R for large data processing. Basics of SQL. Loading and storing local data. Redundancy. Cold storage. Loading and storing data from remote servers. Basics of file systems. Structured and unstructured data. Data mapping. Relational databases. SQL databases. Data lakes. Data warehouses. Data mining. MapReduce algorithm. Microsoft Azure. Amazon AWS.
1.5. Intended way of teaching/subject/module/program ☐ direct teaching ☐ distance learning (a) synchronous, b) asynchronous) ☒ hybrid teaching

Teaching performance (direct teaching)	☐ lectures ☐ seminars and workshops ☐ exercises ☐ field teaching	☐ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work ☐ other _____
Teaching performance (distance learning)	☐ lectures ☐ seminars and workshops ☐ exercises	☐ independent tasks ☐ multimedia and network ☐ mentoring work ☐ other _____
Teaching performance	Direct teaching:	Distance learning:

(hybrid)	☒ lectures ☐ seminars and workshops ☒ exercises ☐ field teaching ☒ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work ☐ other	☒ lectures ☐ seminars and workshops ☒ exercises ☒ independent tasks ☐ multimedia and network ☐ mentoring work

1.6. Additional explanation

1.7 Obligations of participants

Class attendance, class activity, tests, exams

Monitoring the work of [6abc] trainees

Attending classes		Activities in class		Seminar work		Experimental work	
Written exam		Oral exam		Essay		Research	
Project		Continuous verification of knowledge		Report		Practical work	
Portfolio							

1.9. Assessment and evaluation of the work of [abc participants]

1.10. Mandatory literature (at the time of application of the program proposal) [abc]

1.11. Supplementary literature (at the time of application of the program proposal) [abc]

1.12. The number of copies of compulsory literature in relation to the number of participants who are currently attending classes at
to the subject [ab]

title	Number of copies	Number of participants

1.13. Quality monitoring methods that ensure the acquisition of output knowledge, skills and competencies

[6] **IMPORTANT** : For each method of monitoring the student's work, enter the corresponding share in ECTS points of individual activities so that the total number of ECTS points corresponds to the point value of the course. Use empty fields for additional activities.

Table 5.

3.2.4. Description of the course / lecture

GENERAL INFORMATION		
Subject holder	**Vladimir Ranković**	
Name of the object	**Data visualization**	
Semester [a]		
Point value and method of teaching	ECTS student load factor [a, b, c]	

1. SUBJECT DESCRIPTION		
Objectives of the course		
Acquisition of theoretical and practical knowledge about data visualization.		
1.2. Conditions for course enrollment (if applicable)		
No conditions.		
1.3. Expected learning outcomes for the subject		
Define and correctly interpret basic terms and principles of data visualization. Be familiar with visualization types and application areas. Understand the specificity and fundamental characteristics of the data being visualized. Understand and apply the appropriate type of visualization according to the type of data. Conduct data analysis using visualization. Draw conclusions about the data based on the performed visualization. Know how to create effective data visualization using appropriate tools.		
1.4. Subject content		
Purpose and principles of data visualization. Basics of visualization technique. Visualization of numerical data. Visualization of categorical data. Visualization of univariate, bivariate and multivariate data. Data analysis using visualization.		
1.5. Intended way of teaching/subject/module/program ☐ direct teaching ☐ distance learning (a) synchronous, b) asynchronous) ☒ hybrid teaching		
Teaching performance (direct teaching)	☐ lectures ☐ seminars and workshops ☐ exercises ☐ field teaching	☐ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work ☐ other _____
Teaching performance (distance learning)	☐ lectures ☐ seminars and workshops ☐ exercises	☐ independent tasks ☐ multimedia and network ☐ mentoring work ☐ other _____
Teaching performance (hybrid)	Direct teaching: ☒ lectures	Distance learning: ☒ lectures

	☐ seminars and workshops ☒ exercises ☐ field teaching ☒ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work ☐ other	☐ seminars and workshops ☒ exercises ☒ independent tasks ☐ multimedia and network ☐ mentoring work

1.6. Additional explanation

1.7 Obligations of participants

Monitoring the work of [7abc] trainees

Attending classes	X	Activities in class		Seminar work		Experimental work	
Written exam		Oral exam		Essay		Research	
Project	X	Continuous verification of knowledge		Report		Practical work	X
Portfolio							

1.9. Assessment and evaluation of the work of [abc participants]

Evaluation Components: 1. Examination, 2. Individual Work

1.10. Mandatory literature (at the time of application of the program proposal) [abc]

Daniel Nelson, Data Visualization in Python. Explore and Manipulate Data and Create Engaging Interactive Plots with 9 Python Libraries, StackAbuse, 2020-2021
John Hunter, Darren Dale, Eric Firing, Michael Droettboom. Matplotlib documentation. 2017

1.11. Supplementary literature (at the time of application of the program proposal) [abc]

Waskom, M. L., (2021). Seaborn tutorial. https://seaborn.pydata.org/tutorial.html

1.12. The number of copies of compulsory literature in relation to the number of participants who are currently attending classes at
to the subject [ab]

title	Number of copies	Number of participants

1.13. Quality monitoring methods that ensure the acquisition of output knowledge, skills and competencies

[7] **IMPORTANT** : For each method of monitoring the student's work, enter the corresponding share in ECTS points of individual activities so that the total number of ECTS points corresponds to the point value of the course. Use empty fields for additional activities.

Table 6.

3.2.5. Description of the course / lecture

GENERAL INFORMATION		
Subject holder	**Paweł Lula, Katarzyna Wójcik**	
Name of the object	**Fundamentals of mathematics for machine learning**	
Semester [a]		
Point value and method of teaching	ECTS student load factor [a, b, c]	

1. SUBJECT DESCRIPTION
Objectives of the course
Acquisition of basic knowledge and skills in the field of mathematics for application in the domain of machine learning.
1.2. Conditions for course enrollment (if applicable)
No conditions.
1.3. Expected learning outcomes for the subject
● **knows the foundations of discrete mathematics** ● **knows basic concepts of linear algebra: matrix, vector, matrix operations, orthogonality** ● **knows the idea of vector space and linear transformations** ● **understands the idea of eigenvalues and eigenvectors and its applications** ● **understands the idea of singular value decomposition and knows how to use it** ● **understands main concepts of mathematical analysis: functions, sequences, series, difference quotient, derivative, differentiation, partial differentiation, gradients and integration and is able to use them to solve practical problems** ● **knows linear programming approach** ● **knows quadratic programming** ● **knows gradient-based optimization approach and is able to use it** ● **knows basic concepts of probability: probability, conditional probability, random variable, distribution, Bayes' rule** ● **knows typical discrete and continuous distributions** ● **understand the concept of multivariate random variables** ● **is able to generate uni- and multivariable random data**
1.4. Subject content
1. Discrete mathematics **1.1. Logic** **1.2. Set theory** **1.3. Combinatorics** **1.4. Graph theory** **2. Linear algebra** **2.1. Vectors and matrices** **2.2. Matrix operations** **2.3. Linear equations**

- **2.4. Vector space**
- **2.5. Orthogonality**
- **2.6. Linear independence**
- **2.7. Linear transformations**
- **2.8. Eigenvalues and eigenvectors**
- **2.9. Singular value decomposition**
- **2.10. Matrix decomposition**
- **2.11. Linear algebra applications**

3. Introduction to mathematical analysis

- **3.1. Functions ($R \rightarrow R$, $R^n \rightarrow R$, $R^n \rightarrow R^m$)**
- **3.2. Sequences**
- **3.3. Series**
- **3.4. Limits**
- **3.5. Difference quotient and derivative concept**
- **3.6. Differentiation**
- **3.7. Partial differentiation and gradients**
- **3.8. Integration**

4. Optimization

- **4.1. Linear programming**
- **4.2. Quadratic programming**
- **4.3. Gradient-based optimization**

5. Probability

- **5.1. Foundations**
  - **5.1.1. Sample space and probability concept**
  - **5.1.2. Conditional probability**
  - **5.1.3. Bayes' rule**
  - **5.1.4. Random variables**
  - **5.1.5. Independence and correlation**
- **5.2. Discrete random variables**
  - **5.2.1. Definition**
  - **5.2.2. Probability mass function**
  - **5.2.3. Discrete uniform distribution**
  - **5.2.4. Bernoulli distribution**
  - **5.2.5. Binomial distribution**
  - **5.2.6. Poisson distribution**
- **5.3. Continuous random variables**
  - **5.3.1. Definition**
  - **5.3.2. Probability density function**
  - **5.3.3. Continuous uniform distribution**
  - **5.3.4. Normal distribution**
  - **5.3.5. Exponential distribution**
- **5.4. Multivariate random variables**
  - **5.4.1. Discrete multivariate random variables**
    - **5.4.1.1. Joint probability mass function (joint pmf)**
    - **5.4.1.2. Marginal and conditional pmf**
    - **5.4.1.3. Multinomial distribution**
    - **5.4.1.4. Dirichlet-multinomial distribution**
  - **5.4.2. Continuous multivariate random variables**
    - **5.4.2.1. Joint probability density function (joint pdf)**
    - **5.4.2.2. Marginal and conditional pdf**
    - **5.4.2.3. Multivariate uniform distribution**
    - **5.4.2.4. Multivariate normal distribution**

5.4.2.5. Dirichlet distribution

1.5. Intended way of teaching/subject/module/program
☐ direct teaching
☐ distance learning (a) synchronous, b) asynchronous)
☒ hybrid teaching

Teaching performance (direct teaching)	☐ lectures ☐ seminars and workshops ☐ exercises ☐ field teaching	☐ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work ☐ other _____
Teaching performance (distance learning)	☐ lectures ☐ seminars and workshops ☐ exercises	☐ independent tasks ☐ multimedia and network ☐ mentoring work ☐ other _____
Teaching performance (hybrid)	Direct teaching: ☒ lectures ☐ seminars and workshops ☒ exercises ☐ field teaching ☒ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work ☐ other	Distance learning: ☒ lectures ☐ seminars and workshops ☒ exercises ☒ independent tasks ☐ multimedia and network ☐ mentoring work

1.6. Additional explanation

1.7 Obligations of participants

Class attendance, class activity, tests.

Monitoring the work of [8abc] trainees

Attending classes		Activities in class		Seminar work		Experimental work	
Written exam		Oral exam		Essay		Research	
Project		Continuous verification of knowledge		Report		Practical work	
Portfolio							

1.9. Assessment and evaluation of the work of [abc participants]

1.10. Mandatory literature (at the time of application of the program proposal) [abc]

[8] **IMPORTANT** : For each method of monitoring the student's work, enter the corresponding share in ECTS points of individual activities so that the total number of ECTS points corresponds to the point value of the course. Use empty fields for additional activities.

1.11. Supplementary literature (at the time of application of the program proposal) [abc]		
1.12. The number of copies of compulsory literature in relation to the number of participants who are currently attending classes at to the subject [ab]		
title	Number of copies	Number of participants
1.13. Quality monitoring methods that ensure the acquisition of output knowledge, skills and competencies		

Table 7.

3.2.6. Description of the course / lecture

GENERAL INFORMATION		
Subject holder	**Zlatan Car, Nikola Anđelić**	
Name of the object	**Social Aspects of AI**	
Semester [a]		
Point value and method of teaching	ECTS student load factor [a, b, c]	

1. SUBJECT DESCRIPTION		
Objectives of the course		
Address the mutual impact of societal factor and artificial intelligence.		
1.2. Conditions for course enrollment (if applicable)		
None		
1.3. Expected learning outcomes for the subject		
Define and explain key concepts and principles of Artificial Intelligence. Describe the role and potential applications of AI in society. Evaluate the ethical, privacy, and societal issues related to the use of AI in society. Propose and develop AI-based solutions to real-world social problems. Critically analyze and interpret results from AI models.		
1.4. Subject content		
Overview of artificial intelligence in society. History of artificial intelligence use in public. Turing test. Wozniak test. Student test. Ethics of data collection. Expert support systems. Ethics of AI-driven decision making. Application of AI in the public sector. Application of AI in medical services. AI applications in daily functioning of society.		
1.5. Intended way of teaching/subject/module/program ☐ direct teaching ☐ distance learning (a) synchronous, b) asynchronous) ☒ hybrid teaching		
Teaching performance (direct teaching)	☐ lectures ☐ seminars and workshops ☐ exercises ☐ field teaching	☐ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work ☐ other _____
Teaching performance (distance learning)	☐ lectures ☐ seminars and workshops ☐ exercises	☐ independent tasks ☐ multimedia and network ☐ mentoring work ☐ other _____
Teaching performance (hybrid)	Direct teaching: ☒ lectures	Distance learning: ☒ lectures

	☐ seminars and workshops ☒ exercises ☐ field teaching ☒ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work ☐ other	☐ seminars and workshops ☒ exercises ☒ independent tasks ☐ multimedia and network ☐ mentoring work

1.6. Additional explanation

1.7 Obligations of participants

Class attendance, class activity, control assignments, tests

Monitoring the work of [9abc] trainees

Attending classes		Activities in class		Seminar work		Experimental work	
Written exam		Oral exam		Essay		Research	
Project		Continuous verification of knowledge		Report		Practical work	
Portfolio							

1.9. Assessment and evaluation of the work of [abc participants]

1.10. Mandatory literature (at the time of application of the program proposal) [abc]

1.11. Supplementary literature (at the time of application of the program proposal) [abc]

1.12. The number of copies of compulsory literature in relation to the number of participants who are currently attending classes at
to the subject [ab]

title	Number of copies	Number of participants

1.13. Quality monitoring methods that ensure the acquisition of output knowledge, skills and competencies

[9] **IMPORTANT** : For each method of monitoring the student's work, enter the corresponding share in ECTS points of individual activities so that the total number of ECTS points corresponds to the point value of the course. Use empty fields for additional activities.

Table 8.

3.2.7. Description of the course / lecture

GENERAL INFORMATION		
Subject holder	**Paweł Lula, Katarzyna Wójcik**	
Name of the object	**Problem Solving and Decision Making with Artificial Intelligence and Machine Learning Methods and Tools**	
Semester [a]	**2**	
Point value and method of teaching	ECTS student load factor [a, b, c]	

1. SUBJECT DESCRIPTION
Objectives of the course
Providing the skills necessary to implement decision making processes based on AI and ML
1.2. Conditions for course enrollment (if applicable)
No conditions.
1.3. Expected learning outcomes for the subject
● **understands crucial elements of system theory (system, types of systems, synergy, connections)** ● **understands concepts of "problem" and "decision" and relationships between them** ● **understands the role of time in system development** ● **is able to evaluate information availability in the context of system behavior** ● **knows methods of system's modeling** ● **knows main stages of decision-making process** ● **knows AI and ML methods supporting decision-making processes** ● **knows methods and tools for description, modeling and evaluation of system behavior** ● **is able to design proper solutions for solving problems typical for various types of managerial systems**
1.4. Subject content
1. The theoretical framework **1.1. The definition and the „system" concept in the system theory** **1.2. Classification of systems** **1.2.1. Closed** **1.2.2. Complex** **1.2.3. Opened** **1.3. Problem solving as the process of making corrective actions to meet system's objectives** **1.4. Classification of problems (from the perspective of system approach)** **1.4.1. problems related to system identification, modeling and evaluation** **1.4.2. problems related to system control** **1.4.3. problems related to system (re)designing** **1.5. Dynamic systems** **1.6. The evaluation of information availability**

- **1.6.1. Certainty**
- **1.6.2. Uncertainty**
- **1.6.3. Risk**
- **1.7. Decision making**
- **1.8. Problem solving vs. decision making**

2. System modeling

- **2.1. The scope of the system (boundaries, inputs, outputs)**
- **2.2. Modeling of system's elements (components)**
- **2.3. Modeling of system's structure (organization)**
- **2.4. Modeling of system's behavior**

3. Decision-making support

- **3.1. Choice as a crucial element of decision-making processes**
- **3.2. Stages of decision making-process**
- **3.3. Artificial intelligence and machine learning models supporting decision-making processes**
  - **3.3.1. Identification and modeling of decision-makers behavior**
    - **3.3.1.1. Rules-based approach**
    - **3.3.1.2. Decision tree models**
  - **3.3.2. Community-based decision making**
    - **3.3.2.1. Recommendation systems and apriori algorithm**
    - **3.3.2.2. Opinion mining**
  - **3.3.3. Decisions typical for tree and graph models**
    - **3.3.3.1. Optimal paths**
    - **3.3.3.2. Optimal flow**
  - **3.3.4. Reinforcement learning**
  - **3.3.5. Evolutionary algorithms in decision-making processes**
  - **3.3.6. AI and ML in multicriteria analysis**

4. Methods and tools useful for solving problems related to system behavior

- **4.1. Mathematical programming**
- **4.2. Constraint programming**
- **4.3. Control systems**
- **4.4. Methods of system (re)design**

5. AI and ML tools in solving problems related to domain systems

- **5.1. Project management**
- **5.2. Human resources management system**
- **5.3. Logistics**
- **5.4. Supply chain optimization**
- **5.5. Fraud detection and cybersecurity**
- **5.6. Marketing communication**
- **5.7. Retail and wholesale trade**

1.5. Intended way of teaching/subject/module/program

☐ direct teaching

☐ distance learning (a) synchronous, b) asynchronous)

☒ hybrid teaching

Teaching performance (direct teaching)	☐ lectures ☐ seminars and workshops ☐ exercises ☐ field teaching	☐ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work ☐ other _____
Teaching performance (distance learning)	☐ lectures ☐ seminars and workshops ☐ exercises	☐ independent tasks ☐ multimedia and network ☐ mentoring work ☐ other _____
Teaching performance (hybrid)	Direct teaching: ☒ lectures ☐ seminars and workshops ☒ exercises ☐ field teaching ☒ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work ☐ other	Distance learning: ☒ lectures ☐ seminars and workshops ☒ exercises ☒ independent tasks ☐ multimedia and network ☐ mentoring work

1.6. Additional explanation

1.7 Obligations of participants

Class attendance, class activity, control assignments, tests

Monitoring the work of [10abc] trainees

Attending classes		Activities in class		Seminar work		Experimental work	
Written exam		Oral exam		Essay		Research	
Project		Continuous verification of knowledge		Report		Practical work	
Portfolio							

1.9. Assessment and evaluation of the work of [abc participants]

1.10. Mandatory literature (at the time of application of the program proposal) [abc]

1.11. Supplementary literature (at the time of application of the program proposal) [abc]

1.12. The number of copies of compulsory literature in relation to the number of participants who are currently attending classes at
to the subject [ab]

[10] **IMPORTANT** : For each method of monitoring the student's work, enter the corresponding share in ECTS points of individual activities so that the total number of ECTS points corresponds to the point value of the course. Use empty fields for additional activities.

title	Number of copies	Number of participants
1.13. Quality monitoring methods that ensure the acquisition of output knowledge, skills and competencies		

Table 9.

3.2.8. Description of the course / lecture

GENERAL INFORMATION		
Subject holder	**Zlatan Car, Nikola Anđelić**	
Name of the object	**Big data**	
Semester [a]		
Point value and method of teaching	ECTS student load factor [a, b, c]	

1. SUBJECT DESCRIPTION		
Objectives of the course		
Introduce students to the concept and meaning of Big Data and the basic approach to related problems.		
1.2. Conditions for course enrollment (if applicable)		
None		
1.3. Expected learning outcomes for the subject		
Define Big Data. Define different uses of Big Data. Differentiate between structured and unstructured data. Differentiate between various types of big data processing. Familiarity with the basics of big data storage and management. Familiarity with algorithms in Big Data storage and processing.		
1.4. Subject content		
Big data definitions and historical overview. Applications and collection of Big Data. Types of Big Data. Structured and Unstructured data. Big Data access and processing. File systems for Big Data. Data warehouses and lakes. Apache Hadoop. MapReduce.		
1.5. Intended way of teaching/subject/module/program ☐ direct teaching ☐ distance learning (a) synchronous, b) asynchronous) ☒ hybrid teaching		
Teaching performance (direct teaching)	☐ lectures ☐ seminars and workshops ☐ exercises ☐ field teaching	☐ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work ☐ other _____
Teaching performance (distance learning)	☐ lectures ☐ seminars and workshops ☐ exercises	☐ independent tasks ☐ multimedia and network ☐ mentoring work ☐ other _____
Teaching performance (hybrid)	Direct teaching: ☒ lectures ☐ seminars and workshops ☒ exercises	Distance learning: ☒ lectures ☐ seminars and workshops ☒ exercises

	☐ field teaching ☒ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work ☐ other	☒ independent tasks ☐ multimedia and network ☐ mentoring work

1.6. Additional explanation

1.7 Obligations of participants

Class attendance, class activity, control assignments, tests

Monitoring the work of [11abc] trainees

Attending classes		Activities in class		Seminar work		Experimental work	
Written exam		Oral exam		Essay		Research	
Project		Continuous verification of knowledge		Report		Practical work	
Portfolio							

1.9. Assessment and evaluation of the work of [abc participants]

1.10. Mandatory literature (at the time of application of the program proposal) [abc]

1.11. Supplementary literature (at the time of application of the program proposal) [abc]

1.12. The number of copies of compulsory literature in relation to the number of participants who are currently attending classes at
to the subject [ab]

title	Number of copies	Number of participants

1.13. Quality monitoring methods that ensure the acquisition of output knowledge, skills and competencies

[11] **IMPORTANT** : For each method of monitoring the student's work, enter the corresponding share in ECTS points of individual activities so that the total number of ECTS points corresponds to the point value of the course. Use empty fields for additional activities.

Table 10.

3.2.9. Description of the course / lecture

GENERAL INFORMATION		
Subject holder	**Kálmán Tornai, András Horváth, Anna Gelencsér-Horváth**	
Name of the object	**Supervised and Unsupervised Learning**	
Semester [a]		
Point value and method of teaching	ECTS student load factor [a, b, c]	

1. SUBJECT DESCRIPTION
Objectives of the course
This course provides a comprehensive understanding of the core principles and techniques of Supervised and Unsupervised Learning. Students will develop practical skills to implement, evaluate, and interpret machine learning models for data-driven supervised machine learning in the field of regression and classification and unsupervised machine learning in the field of clustering.
1.2. Conditions for course enrollment (if applicable)
No conditions.
1.3. Expected learning outcomes for the subject
Define the basic concepts of machine learning. Understand key concepts of machine learning (theoretical assumptions, mathematical foundations, advantages and disadvantages of supervised and unsupervised machine learning algorithms). Apply model selection and statistical evaluation of the learned model. Apply various classification algorithms, inclusive generative, discriminative, and nonparametric ones. Apply clustering algorithms and cluster validation. Design and implement a machine learning method for classification/regression/clustering and carry out its evaluation. Assess the suitability of a machine learning algorithm for a given task.
1.4. Subject content
Introduction to Machine Learning, Areas of application. Types of machine learning. **Supervised learning. Setting supervised learning problems. Tree-based models. Training decision trees. Pruning decision trees. Representation of decision trees in the form of rules. Random Forest. Probabilistic models. Naive Bayesian classifier. Artificial neural networks. Perceptron. Gradient descent. Artificial neural networks with advance propagation. Activation functions. Linear models for regression and classification. Linear regression. Multiple linear regression. Logistic regression. Multinomial logistic regression. Unsupervised learning. Clustering. Evaluation and model selection. Confusion matrix. Sensitivity and specificity. ROC curve. Area below ROC curve (AUC). Hands-on Machine Learning.**
1.5. Intended way of teaching/subject/module/program ☐ direct teaching ☐ distance learning (a) synchronous, b) asynchronous) ☒ hybrid teaching

Teaching performance (direct teaching)	☐ lectures ☐ seminars and workshops ☐ exercises ☐ field teaching	☐ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work

		☐ other _____
Teaching performance (distance learning)	☐ lectures ☐ seminars and workshops ☐ exercises	☐ independent tasks ☐ multimedia and network ☐ mentoring work ☐ other _____
Teaching performance (hybrid)	Direct teaching: ☒ lectures ☐ seminars and workshops ☒ exercises ☐ field teaching ☒ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work ☐ other	Distance learning: ☒ lectures ☐ seminars and workshops ☒ exercises ☒ independent tasks ☐ multimedia and network ☐ mentoring work

1.6. Additional explanation

1.7 Obligations of participants

Class attendance, class activity, control assignments, tests

Monitoring the work of [12abc] trainees

Attending classes	X	Activities in class		Seminar work		Experimental work	
Written exam	X	Oral exam		Essay		Research	
Project	X	Continuous verification of knowledge		Report		Practical work	X
Portfolio							

1.9. Assessment and evaluation of the work of [abc participants]

1.10. Mandatory literature (at the time of application of the program proposal) [abc]

1. **Joshi, A. V. (2020). Machine learning and artificial intelligence.**
2. **Müller, A. C., & Guido, S. (2016). Introduction to machine learning with Python: a guide for data scientists. " O'Reilly Media, Inc.".**
3. **Géron, A. (2022). Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow. " O'Reilly Media, Inc.".**

1.11. Supplementary literature (at the time of application of the program proposal) [abc]

1. **Coelho, L. P., Richert, W., & Brucher, M. (2018). Building Machine Learning Systems with Python: Explore machine learning and deep learning techniques for building intelligent systems using scikit-learn and TensorFlow. Packt Publishing Ltd.**
2. **Raschka, S., & Mirjalili, V. (2017). Python machine learning: Machine learning and deep learning with python. Scikit-Learn, and TensorFlow. Second edition ed, 3.**

[12] **IMPORTANT** : For each method of monitoring the student's work, enter the corresponding share in ECTS points of individual activities so that the total number of ECTS points corresponds to the point value of the course. Use empty fields for additional activities.

1.12. The number of copies of compulsory literature in relation to the number of participants who are currently attending classes at to the subject [ab]		
title	Number of copies	Number of participants
1.13. Quality monitoring methods that ensure the acquisition of output knowledge, skills and competencies		

Table 11.

3.2.10. Description of the course / lecture

GENERAL INFORMATION		
Subject holder	**Paweł Lula, Katarzyna Wójcik**	
Name of the object	**Statistical Data Analysis**	
Semester [a]		
Point value and method of teaching	ECTS student load factor [a, b, c]	

1. SUBJECT DESCRIPTION
Objectives of the course
Acquisition of basic knowledge and skills in the field of Statistical Data Analysis.
1.2. Conditions for course enrollment (if applicable)
Participation in the course "Fundamentals of mathematics for machine learning"
1.3. Expected learning outcomes for the subject
● **understands scales of measurement and knows how to use them** ● **understands the role of descriptive statistics and knows how to apply it** ● **knows the idea of inferential statistics** ● **understands the concept of population and sample** ● **understand the idea of statistical tests** ● **is able to use statistical tests to verify typical research problems** ● **knows the concept of statistical estimation** ● **knows how to design and conduct estimation process** ● **knows regression models and is able how to build and use them** ● **knows the idea of Bayesian estimation**
1.4. Subject content
1. Scales of measurement **1.1. Nominal** **1.2. Ordinal** **1.3. Interval** **1.4. Ratio** **2. Descriptive statistics** **2.1. Central tendency** **2.1.1. Mode** **2.1.2. Median** **2.1.3. Means** **2.2. Variability** **2.2.1. Range** **2.2.2. Standard deviation** **2.2.3. Variance**

- **2.3. Skewness**
- **2.4. Kurtosis**
- **2.5. Frequency distribution**
- **2.6. Correlation**
- **2.7. Partial correlation**

3. Inferential statistics

- **3.1. Sample and population**
  - **3.1.1. Sampling methods**
  - **3.1.2. Degree of freedom**
  - **3.1.3. Central limit theorem**
  - **3.1.4. Sample statistics vs. population parameters**
- **3.2. Hypothesis testing**
  - **3.2.1. Null and alternative hypothesis**
  - **3.2.2. Performing a statistical test**
  - **3.2.3. Statistical significance and p-value**
  - **3.2.4. Type I and Type II errors**
  - **3.2.5. Statistical power of hypothesis tests**
  - **3.2.6. Criteria for choosing choice a proper statistical test**
    - **3.2.6.1. Scale of measurement**
    - **3.2.6.2. Type of research problem**
      - **3.2.6.2.1. Nature of data**
      - **3.2.6.2.2. Comparison of samples**
        - **3.2.6.2.2.1. Number of samples**
        - **3.2.6.2.2.2. Relations between samples: paired vs. unpaired samples**
      - **3.2.6.2.3. Existence of relationship / independence test**
  - **3.2.7. Common statistical tests**
    - **3.2.7.1. Comparison tests**
      - **3.2.7.1.1. z-test**
      - **3.2.7.1.2. Independent sample t-test**
      - **3.2.7.1.3. Mann-Whitney U test**
      - **3.2.7.1.4. Paired t-test**
      - **3.2.7.1.5. Wilcoxon Signed Rank Test**
      - **3.2.7.1.6. ANOVA**
      - **3.2.7.1.7. Kruskal-Wallis H test**
      - **3.2.7.1.8. ANOVA for repeated measures**
      - **3.2.7.1.9. Pearson correlation**
      - **3.2.7.1.10. Spearman correlation**
      - **3.2.7.1.11. Chi-square test**
      - **3.2.7.1.12. Friedman's test**
      - **3.2.7.1.13. Normality tests**
- **3.3. Estimation theory**
  - **3.3.1. Estimating population parameters from sample statistics**
  - **3.3.2. Properties of estimator**
    - **3.3.2.1. Unbiasedness**
    - **3.3.2.2. Consistency**
    - **3.3.2.3. Efficiency**
    - **3.3.2.4. Sufficiency**
  - **3.3.3. Standard error vs. standard deviation**
  - **3.3.4. Point estimation**
  - **3.3.5. Interval estimation**
  - **3.3.6. Estimation methods**
  - **3.3.7. Methods of moments**

3.3.8. Maximum likelihood estimation
3.3.9. Least square estimation
3.3.10. Bayesian estimation
3.3.10.1. Parameters as random variables
3.3.10.2. Prior and posterior distribution
3.3.10.3. Bayesian inference
3.3.10.4. Maximum a posteriori estimation
3.3.10.5. Conjugacy
3.3.10.6. Bayesian approach to point estimation
3.3.10.7. Bayesian confidence interval

4. Regression analysis
4.1. Linear regression
4.1.1. Assumption of linear regression model
4.1.2. Building regression models
4.1.3. Evaluation of regression model
4.2. Other types of linear regression
4.2.1. Logistic regression
4.2.2. Ordinal regression
4.2.3. Multinomial regression
4.2.4. Discriminant analysis

5. Cluster analysis
5.1. Classification vs. clustering
5.2. Measurement of proximity
5.2.1. Dissimilarity and distance for continuous data
5.2.2. Similarity measures for categorical data
5.2.3. Hierarchical clustering
5.2.4. Optimization methods
5.2.5. Model-based clustering (mixture models)
5.2.6. Density-based clustering

1.5. Intended way of teaching/subject/module/program
☐ direct teaching
☐ distance learning (a) synchronous, b) asynchronous)
☒ hybrid teaching

Teaching performance (direct teaching)	☐ lectures ☐ seminars and workshops ☐ exercises ☐ field teaching	☐ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work ☐ other _____
Teaching performance (distance learning)	☐ lectures ☐ seminars and workshops ☐ exercises	☐ independent tasks ☐ multimedia and network ☐ mentoring work ☐ other _____
Teaching performance	Direct teaching:	Distance learning:

(hybrid)	☒ lectures ☐ seminars and workshops ☒ exercises ☐ field teaching ☒ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work ☐ other	☒ lectures ☐ seminars and workshops ☒ exercises ☒ independent tasks ☐ multimedia and network ☐ mentoring work

1.6. Additional explanation

1.7 Obligations of participants

Class attendance, class activity, control assignments, tests

Monitoring the work of [13abc] trainees

Attending classes	3	Activities in class		Seminar work		Experimental work	
Written exam	1	Oral exam		Essay		Research	
Project	2	Continuous verification of knowledge	1	Report		Practical work	
Portfolio							

1.9. Assessment and evaluation of the work of [abc participants]

1.10. Mandatory literature (at the time of application of the program proposal) [abc]

1.11. Supplementary literature (at the time of application of the program proposal) [abc]

1.12. The number of copies of compulsory literature in relation to the number of participants who are currently attending classes at
to the subject [ab]

title	Number of copies	Number of participants

1.13. Quality monitoring methods that ensure the acquisition of output knowledge, skills and competencies

[13] **IMPORTANT** : For each method of monitoring the student's work, enter the corresponding share in ECTS points of individual activities so that the total number of ECTS points corresponds to the point value of the course. Use empty fields for additional activities.

Table 12.

3.2.11. Description of the course / lecture

GENERAL INFORMATION		
Subject holder	**Zoran Kalinic, Themis Exarchos**	
Name of the object	**Practical AI Applications**	
Semester [a]		
Point value and method of teaching	ECTS student load factor [a, b, c]	

1. SUBJECT DESCRIPTION
Objectives of the course
Application of Artificial Intelligence methods to real-world problems in economics and healthcare. This course is designed to provide students with a comprehensive understanding of the practical applications of Artificial Intelligence (AI) in the healthcare sector. It encompasses the study of AI techniques, tools, and methodologies that are applied to improve healthcare delivery, diagnostics, patient care, and medical research. Key topics include computational analysis of biomedical data, development of predictive models, image and signal processing, natural language processing for medical records, and the integration of AI in clinical decision support systems. The course aims to enable students to leverage AI to solve real-world healthcare problems, enhance decision-making processes, and contribute to the advancement of medical technology.
1.2. Conditions for course enrollment (if applicable)
No conditions.
1.3. Expected learning outcomes for the subject
Define methods and algorithms from the field of artificial intelligence. Demonstrate ideas behind different algorithms and their use. Select methods for specific problems. Determine and demonstrate potential challenges in real-world problem tasks. Recognise problems adequate for artificial intelligence approaches. Solve real-world problems with artificial intelligence methods. Understand and apply fundamental concepts of Artificial Intelligence in healthcare. Utilize programming languages such as Python or R for computational analysis of biomedical data. Implement machine learning algorithms and models specific to healthcare applications. Use libraries such as Pandas, NumPy, Scikit-Learn, TensorFlow, and specialized healthcare libraries for data analysis, machine learning, and AI in healthcare. Develop, test, and deploy AI-driven solutions for healthcare diagnostics, treatment planning, and patient care. Analyze and interpret biomedical data, including medical imaging and electronic health records. Apply AI techniques to solve real-world healthcare problems and improve clinical decision-making processes.
1.4. Subject content
Artificial Intelligence methods and algorithms and its use cases. Challenges of applying artificial intelligence algorithms to real world problems. Real world problem formulation. Identification solutions based on artificial intelligence. Solving real world problem with artificial intelligence. Interpretation of obtained results. Introduction to AI in Healthcare. Basics of AI and Machine Learning. Data Analysis and Visualization in Healthcare. AI Techniques for Biomedical Data. AI Applications in Diagnostics and Treatment. Ethical Considerations in AI for Healthcare.
1.5. Intended way of teaching/subject/module/program ☐ direct teaching

☐ distance learning (a) synchronous, b) asynchronous) ☒ hybrid teaching		
Teaching performance (direct teaching)	☐ lectures ☐ seminars and workshops ☐ exercises ☐ field teaching	☐ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work ☐ other _____
Teaching performance (distance learning)	☐ lectures ☐ seminars and workshops ☐ exercises	☐ independent tasks ☐ multimedia and network ☐ mentoring work ☐ other _____
Teaching performance (hybrid)	Direct teaching: ☒ lectures ☐ seminars and workshops ☒ exercises ☐ field teaching ☒ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work ☐ other	Distance learning: ☒ lectures ☐ seminars and workshops ☒ exercises ☒ independent tasks ☐ multimedia and network ☐ mentoring work

1.6. Additional explanation

1.7 Obligations of participants

Class attendance, class activity, control assignments, tests

Monitoring the work of [14abc] trainees

Attending classes	3	Activities in class		Seminar work		Experimental work	
Written exam	1	Oral exam		Essay		Research	
Project	2	Continuous verification of knowledge	1	Report		Practical work	
Portfolio							

1.9. Assessment and evaluation of the work of [abc participants]

1.10. Mandatory literature (at the time of application of the program proposal) [abc]

1.11. Supplementary literature (at the time of application of the program proposal) [abc]

[14] **IMPORTANT** : For each method of monitoring the student's work, enter the corresponding share in ECTS points of individual activities so that the total number of ECTS points corresponds to the point value of the course. Use empty fields for additional activities.

1.12. The number of copies of compulsory literature in relation to the number of participants who are currently attending classes at to the subject [ab]		
title	Number of copies	Number of participants
1.13. Quality monitoring methods that ensure the acquisition of output knowledge, skills and competencies		

Table 13.

3.2.12. Description of the course / lecture

GENERAL INFORMATION		
Subject holder	**Zlatan Car, Nikola Anđelić**	
Name of the object	**Practical data collection and analytics**	
Semester [a]		
Point value and method of teaching	ECTS student load factor [a, b, c]	

1. SUBJECT DESCRIPTION
Objectives of the course
Teach the basic concepts and principles of data collection and initial analytics.
1.2. Conditions for course enrollment (if applicable)
None.
1.3. Expected learning outcomes for the subject
Be capable of identifying and distinguishing between different data methods. Analyze the data needs of the study. Familiarity with possible biases in data which may be introduced during the collection process. Fundamentals of securing and transporting data. Knowledge of basic data processing and statistical analysis to be performed in the course of data collection.
1.4. Subject content
Data collection methods. Scrapping. Identification of data vectors. Basics of data storage. Data transport. Data transfer. Operational Security. Symmetric and asymmetric encryption. Biases. Generation of descriptive statistics. Outlier identification. Normality analysis.
1.5. Intended way of teaching/subject/module/program ☐ direct teaching ☐ distance learning (a) synchronous, b) asynchronous) ☒ hybrid teaching

Teaching performance (direct teaching)	☐ lectures ☐ seminars and workshops ☐ exercises ☐ field teaching	☐ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work ☐ other _____
Teaching performance (distance learning)	☐ lectures ☐ seminars and workshops ☐ exercises	☐ independent tasks ☐ multimedia and network ☐ mentoring work ☐ other _____
Teaching performance (hybrid)	Direct teaching: ☒ lectures ☐ seminars and workshops	Distance learning: ☒ lectures ☐ seminars and workshops

	☒ exercises ☐ field teaching ☒ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work ☐ other	☒ exercises ☒ independent tasks ☐ multimedia and network ☐ mentoring work

1.6. Additional explanation

1.7 Obligations of participants

Class attendance, class activity, control assignments, tests

Monitoring the work of [15abc] trainees

Attending classes		Activities in class		Seminar work		Experimental work	
Written exam		Oral exam		Essay		Research	
Project		Continuous verification of knowledge		Report		Practical work	
Portfolio							

1.9. Assessment and evaluation of the work of [abc participants]

1.10. Mandatory literature (at the time of application of the program proposal) [abc]

1.11. Supplementary literature (at the time of application of the program proposal) [abc]

1.12. The number of copies of compulsory literature in relation to the number of participants who are currently attending classes at
to the subject [ab]

title	Number of copies	Number of participants
Python Machine Learning	1	

1.13. Quality monitoring methods that ensure the acquisition of output knowledge, skills and competencies

Table 14.

[15] **IMPORTANT** : For each method of monitoring the student's work, enter the corresponding share in ECTS points of individual activities so that the total number of ECTS points corresponds to the point value of the course. Use empty fields for additional activities.

3.2.13. Description of the course / lecture

GENERAL INFORMATION		
Subject holder	**Tijana Georski**	
Name of the object	**Introduction to High Performance Computing**	
Semester [a]		
Point value and method of teaching	ECTS student load factor [a, b, c]	

1. SUBJECT DESCRIPTION
Objectives of the course
This course provides understanding of the basic principles of the High Performance Computing, including parallel processing, distributed systems, and cluster architectures.
1.2. Conditions for course enrollment (if applicable)
No conditions.
1.3. Expected learning outcomes for the subject
Upon successful completion of this course, participants can expect to achieve the following learning outcomes: Knowledge of the foundational principles underlying High Performance Computing, including parallel processing, distributed systems, and cluster architectures. Usage of Python libraries for HPC tasks, including Dask and Numba, understanding their functionalities and selecting appropriate tools for specific computational needs. Develop the skills to write parallel code in Python, enabling the usage of multi-core processors and distributed computing environments for enhanced computational efficiency. Apply HPC concepts to real-world social science challenges.
1.4. Subject content
HIgh performance computing basics. Hardware used in high performance computing systems. Architecture of the high performance computing systems. Applications of high performance computing. Parallel programming in Python using Numba and Dask. Batching and distribution systems such as PBS.
1.5. Intended way of teaching/subject/module/program ☐ direct teaching ☐ distance learning (a) synchronous, b) asynchronous) ☒ hybrid teaching

Teaching performance (direct teaching)	☐ lectures ☐ seminars and workshops ☐ exercises ☐ field teaching	☐ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work ☐ other _____
Teaching performance (distance learning)	☐ lectures ☐ seminars and workshops ☐ exercises	☐ independent tasks ☐ multimedia and network ☐ mentoring work ☐ other _____

Teaching performance (hybrid)	Direct teaching: ☒ lectures ☐ seminars and workshops ☒ exercises ☐ field teaching ☒ independent tasks ☐ multimedia and network ☐ laboratory ☐ mentoring work ☐ other	Distance learning: ☒ lectures ☐ seminars and workshops ☒ exercises ☒ independent tasks ☐ multimedia and network ☐ mentoring work

1.6. Additional explanation

1.7 Obligations of participants

Class attendance, class activity, control assignments, tests

Monitoring the work of [16abc] trainees

Attending classes	x	Activities in class		Seminar work		Experimental work	
Written exam		Oral exam		Essay		Research	
Project	x	Continuous verification of knowledge		Report		Practical work	x
Portfolio							

1.9. Assessment and evaluation of the work of [abc participants]

Evaluation Components: 1. Examination, 2. Individual Work

1.10. Mandatory literature (at the time of application of the program proposal) [abc]

Matthew Rocklin, Matthew Powers, Richard Pelgrim, Dask: The Definitive Guide, O'Reilly Media Inc, 2023.
Tiago Rodrigues Antao, Fast Python: High performance techniques for large datasets, Manning Publications, 2023.

1.11. Supplementary literature (at the time of application of the program proposal) [abc]

High Performance Computing Carpentry. "HPC with Python." Carpentries. URL: https://www.hpc-carpentry.org/hpc-python/. 2023

1.12. The number of copies of compulsory literature in relation to the number of participants who are currently attending classes at
to the subject [ab]

title	Number of copies	Number of participants

1.13. Quality monitoring methods that ensure the acquisition of output knowledge, skills and competencies

[16] **IMPORTANT** : For each method of monitoring the student's work, enter the corresponding share in ECTS points of individual activities so that the total number of ECTS points corresponds to the point value of the course. Use empty fields for additional activities.