

Study programme: MAS AI			
Course name: Theoretical Foundations of Artificial Intelligence			
Lecturer / Lecturers: Tatjana Stojanović			
No. of ECTS: 10			
Precondition: Enrolment in the appropriate semester			
Course objectives To gain knowledge about methods and techniques of artificial intelligence. To enable students to solve demanding real problems and research problems using artificial intelligence methods.			
Course outcomes Students will be able to apply artificial intelligence methods in solving specific real problems in various fields. Students will be competent to apply methods and techniques of artificial intelligence in research they conduct on projects within other courses of master academic studies, and in research related to the preparation of a master's thesis. Students will be able to apply critical thinking skills regarding possibilities and limitations of artificial intelligence from a scientific point of view.			
Course content <i>Theoretical classes</i> Problem solving and searching. Advanced heuristic search methods. Real time search. Constraint satisfaction problems. Inference in constraint satisfaction problems. Planning. Classical planning techniques. Forward and backward search planning. Heuristics in planning. Planning and agent action in a real environment. Probabilistic reasoning. Uncertain knowledge representation. Markov models. Learning. Supervised learning. Probabilistic models. Kernel methods. Clustering methods. Reinforcement learning. Unsupervised learning. Model selection and validation. <i>Practical classes</i> Implementation of artificial intelligence methods learned in theoretical classes in the programming language Python.			
Literature 1. Stuart Russell, Peter Norvig, Veštačka inteligencija, savremeni pristup, CET, Београд 2011. 2. George Luger, Artificial intelligence – Structures and Strategies for Complex Problem Solving, Fifth Edition, Addison-Wesely, 2005. 3. Tom Mitchell, Machine Learning. New York: Mc Graw-Hill, 1997. 4. Patrick Henry Winston, Artificial Intelligence (3rd Edition), Pearson, 1992.			
Number of active teaching classes	Theoretical classes: 30	Practical classes: 45	
Teaching methods Problem-oriented teaching, practical teaching, independent work of students, consultations. Combination of classical teaching with e-learning with the use of appropriate literature. Practical classes are conducted in the form of laboratory exercises in computer classrooms, where students solve real problems in the field of artificial intelligence independently or with the help of assistants.			
Knowledge assessment (maximum no. of points 100)			
Pre-exam obligations	70 points	Final exam	30 points
In class activity	4	Oral exam	30
Practical classes			
Seminar(s)	20		
Colloquium(s)	20+26		

Study program: MAS Artificial Intelligence			
Course title: INTERNSHIP			
Teacher (s): All teachers in the study program			
Course status: Mandatory			
No. of ECTS: 5			
Prerequisites: enrolled in an adequate semester			
Course objective: Introducing students to the conditions and modes of work in economic organizations, institutions, and establishments in which work is performed in the field of computer science and information technology. Students should understand the global organization and the way of functioning of organizations, the place, and role of computer centers, tasks, and their solution, as well as take part in their solution.			
Course learning outcomes: The students can engage themselves efficiently and successfully in activities within the scope of work that hosting organizations perform, to improve the level of practical knowledge, build capacities to handle new conditions, and improve their communication level.			
Course contents: <i>A student will be introduced to:</i> • <i>organization, tasks, and manner of functioning of the organization</i> • <i>organization and functioning of computer centers</i> • <i>information flows, their creation and handling</i> • <i>the hardware and software platform used</i> • <i>built information system, current tasks, and jobs</i> • <i>and receives specific tasks to complete independently</i>			
Literature -			
No. of active teaching hours	Lectures:	Practice:	
Teaching methods The internship is realized in the business, scientific and educational institutions, through individual work. A mentor from the hosting organization staff is assigned to each student. Studying the process and activities through insight into documentation and practical work on certain tasks. At the end of the internship, the mentor from the organization assesses the success of the internship, which is one of the elements in evaluating the success of the internship. After the internship, the student submits a report on his / her work and activities in the form of a seminar paper and then presents it.			
Examination (maximum number of points 100)			
Exam prerequisites	70 points	Final exam	30 points
Student’s participation during lectures		oral exam	30
Practice		written exam	
Test/s			
Seminar/s			
Project - based exercises	70		
Other			

Study programme: MAS Artificial Intelligence		
Course title: ADVANCED DATABASES		
Lecturers: Erić Milan, Đorđević Aleksandar		
Course status: Elective		
No. of ECTS: 6		
Prerequisites: /		
Course objectives Providing a foundation for understanding large-scale distributed systems used to store and process large amounts of data		
Course learning outcomes After mastering the programme, candidates will be able to design, create and maintain databases. After completing the course, the student will be able to explain the architecture and properties of computer systems required for storage, search and index a large amount of data; use various computer machines to design and implement non-trivial analytics over massive data; explain different models for allocating and allocating computational task resources on large computer clusters; develop trade-offs when designing efficient algorithms for massive data processing in a distributed computing environment.		
Course contents <i>Lectures</i> This course covers the following topics: Introductory considerations (Classical data processing and its shortcomings; Definition and basic concepts of databases). Basic concepts (Information, data, entity, attribute, domain, logical record, file, file sets, databases, data banks, automatic data processing, information system). Data models (Conceptual modeling, structures and constraints, hierarchical, network, relational model, E-R data model, object-oriented data model). Database types (Database Management Systems). Relational databases (Relational algebra, relational calculus, design of relational databases, the concept of data normalization, translation of E-R models into relational models, types of relations). NoSQL database (key repository value, Oracle NoSQL, Document Oriented Database, MongoDB). Scalable messaging systems (Apache Kafka). Engines for executing big data. High-level queries and interactive stream and chart processing. <i>Practice</i> Practical teaching through exercises and independent work. The student realizes individual work through a project task. The project task as well as the necessary instructions are related to the design of the logical data model and the physical database model of a specific real system. <i>Project</i> Project development in a team or individual work. The project will be developed as part of a student internship at Comtrade. The company is a leading expert in the field of software engineering and employs young staff in its offices. In cooperation with the professional teams of this company, students will work on improving their acquired knowledge and application through practice.		
Literature: 1. Лазаревић Б.: Базе података, ФОН Београд, Београд 2003. 2. Павловић-Лажетић Г.: Основе релационих база података, Математички факултет, Београд, 2000. 3. R. Elmasri, S. Navathe, Fundamentals of Database Systems, Addison-Wesley, Boston, 2003.		
No. of active teaching hours	Lectures: 30	Practice: 30

Teaching methods

Lectures, laboratory exercises, individual student research and problem-solving based on the given tasks (consultations in project assignment production and independent student work through studying and production of project assignment)

Examination (maximum number of points 100)

Exam prerequisites	70 points	Final exam	30 points
In class activity	5	oral exam	30
Practice	5	written exam	
Test(s)	30		
Seminar/s			
Project	30		

Study program: MAS Artificial Intelligence			
Course title: ADVANCED MACHINE LEARNING			
Teacher(s): Vladimir M. Milovanović			
Lecturer from a foreign University: Zoran Bosnić, Zlatan Car			
Course status: Elective			
No. of ECTS: 10			
Prerequisites: /			
Course objective: Introduction to advanced methods as well as understanding of basic theoretical concepts of machine learning and statistical pattern recognition.			
Course learning outcomes: Mastering the knowledge and skills necessary for designing systems based on machine learning as well as the ability to apply modern techniques of statistical pattern recognition in solving specific engineering tasks and problems.			
Course contents: <i>Lectures</i> Introduction. Basic terms. Supervised learning. Linear regression of one or more variables. Classification. Logistic regression. Regularization. Naive Bayesian classifiers. Supporting vector method. Compromise between displacement and dispersion. HF theory. Perceptron. Artificial neural networks. Recurrent and convolutional neural networks. Deep learning. Unsupervised learning. The k-means method. Main components method. Independent component method. Detection of anomalies. Recommendation systems. Markov's decision-making process. Supportive learning. <i>Practice</i> A brief review of linear algebra and numerical analysis. Examples of the application of machine learning in robot control, autonomous vehicles, bioinformatics, speech and text recognition or translation, as well as in deep analysis and processing of Internet data. Machine learning tools and libraries. <i>Project-based exercises</i> Search of available literature. In cooperation with the company NGO Novi Sad Artificial Intelligence, the students will have the opportunity to practice and actively participate in current projects to improve knowledge in the field of machine learning. With its many years of experience in working on projects, NGO Novi Sad Artificial Intelligence will provide students with the opportunity to respond to the real demands of the industry.			
Literature: 1. T. Hastie, R. Tibshirani, J. Friedman, "The Elements of Statistical Learning", 2nd edition, Springer, 2016. 2. S. Shalev-Shwartz, S. Ben-David, "Understanding Machine Learning: From Theory to Algorithms", Cambridge University Press, 2014. 3. R. Duda, P. Hart, D. Stork, "Pattern Classification", 2nd edition, Wiley-Interscience, 2000. 4. R. Sutton, A. Barto, "Reinforcement Learning: An Introduction", A Bradford Book, 1998. 5. T. Mitchell, "Machine Learning", McGraw-Hill Education, 1997.			
No. of active teaching hours:		Lectures: 30	Practice: 30
Teaching methods Lectures, auditory exercises, laboratory exercises, independent work.			
Examination (maximum number of points 100)			
Exam prerequisites		70 points	Final exam
Student's participation during		oral exam	30 points
			20

lectures			
practical exercises	10+10	written exam	10
test(s)			
seminar(s)			
project	50		
other			

Study program: MAS Artificial Intelligence		
Course title: ARTIFICIAL INTELLIGENCE AND LAW		
Teacher(s): Sonja Lučić, Nikola Milosavljević		
Course status: Elective		
No. of ECTS: 10		
Prerequisites: /		
Course objective: Artificial intelligence represents the cutting edge of information technology, which is increasingly considered to be the 4th industrial revolution. The possibility of development of the software that learns, thinks and concludes on its own, possesses new challenges to the law in terms of the consequences of the operation of this software. The aim of this course is the scientific processing and presentation of existing legal regulations in relevant areas, as well as opening a discussion on future legal solutions in this area.		
Course learning outcomes: Students will have the opportunity to get acquainted with the basics of legal regulations in relevant areas of civil law, criminal law and intellectual property rights related to artificial intelligence. In addition, in the conversation and analysis, students, as future bearers of the development of this field, will be able to give their views and suggestions for the development of the law in the field of artificial intelligence.		
Course contents: <i>Lectures</i> ARTIFICIAL INTELLIGENCE AND HUMAN RIGHTS. A challenge to the classical conception of human rights. Protection of human dignity vs. artificial intelligence. Protection against discrimination vs. artificial intelligence. Privacy protection vs. artificial intelligence. LEGAL SUBJECTIVITY OF ARTIFICIAL INTELLIGENCE. Is artificial intelligence a subject or an object of the law? Possibility of conscious action. Legal capacity. Business ability. ARTIFICIAL INTELLIGENCE AND COPYRIGHT. Computer generated works as a subject of copyright protection. The problem of determining the copyright holder in computer-generated works. Copyright infringement by artificially-intelligent entities. ARTIFICIAL INTELLIGENCE AND PATENT LAW. Invention, patents and inventor. The possibility of creating an invention by an artificially intelligent machine. (Un) Fulfilment of conditions for granting a patent to computer-generated inventions. ARTIFICIAL INTELLIGENCE AND LIABILITY FOR DAMAGE. Consequences of civil law offenses caused by the artificial intelligence system. Debtor damages. Types of liability for injury. ARTIFICIAL INTELLIGENCE AND CRIMINAL LAW. The system of artificial intelligence as a perpetrator of a crime. Problems of criminal responsibility in connection with the use of artificial intelligence. <i>Practice</i> Discussion and proposing new solutions.		
Literature: 1. Marković, S., Popović, Intellectual property right, Belgrade, 2017. (Марковић, С., Поповић, Д., Право интелектуалне својине, Београд, 2017.) 2. Victor M. Palace, What is Artificial Intelligence wrote this? Artificial Intelligence and Copyright. 3. Matthieu Dhenne, Artificial Intelligence: Back to the Future of Patent Law, 2021. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3787526		
No. of active teaching hours:	Lectures: 30	Practice: 30
Teaching methods Lectures, exercises, independent work		
Examination (maximum number of points 100)		

Exam prerequisites	points	Final exam	points
student's participation during lectures	15	oral	70
practical exercises	15	written	
test(s)			
seminar(s)			
project			
other			

Study program: MAS Artificial Intelligence			
Course title: ARTIFICIAL INTELLIGENCE AND ROBOTICS			
Teacher/s: Vesna Ranković			
Course status: Elective			
No. of ECTS: 6			
Prerequisites: /			
Course objective: The main goal of the course is to provide students with basic knowledge in the field of robotics and mechatronics with an understanding of the design, programming, and management of industrial robots. It covers the mechanics of mobile robots and manipulators, robot hardware and software, as well as artificial intelligence algorithms in robotics and methods for kinematics, control, navigation, and planning. It serves to give a general understanding of robotics as a field of study and provides the basis for further study of the various topics involved deeper in other, more specialized courses.			
Course learning outcomes: After mastering the program and passing the exam, a student will acquire basic knowledge of the fundamental principles of movement planning, programming, and robot control. After completing the course with a passing grade, a student should be able to use basic theoretical tools in robotics to describe and calculate kinematics and dynamics for robotic systems with several degrees of freedom; calculate and apply algorithms to generate path plans, apply algorithms to solve problems on high level, apply mapping algorithms, consider different methods of navigation and localization, use modern software architectures to develop robotic applications, and understand the role that artificial intelligence has in robotics and its algorithms.			
Course contents: <i>Lectures</i> Basic configurations of industrial robots. Kinematic model of industrial robots. The direct and inverse problem of kinematics. Movement planning. Defining the trajectory via internal and external coordinates. Static and dynamic robot analysis. Basic subsystems and components of industrial robots. Terminating devices. Control of industrial robots. Robot programming. Methods of programming and types of programming languages. Environmental models and task descriptions. Typical examples of robot applications. Characteristics of tasks in which robots are used. Calibration. <i>Exercises</i> Making assignments. As part of the study research work, students will be trained for basic research in the subject field. <i>Project-based practice</i> Through one major or several smaller projects, students will be able to work with real robots, implement artificial intelligence algorithms in the design, modeling, and analysis of problems with robot functioning.			
Literature: 1. The Mechatronics Handbook, ed. Robert H. Bishop, CRC Press 2002. 2. Govers, Francis X. Artificial intelligence for robotics: Build intelligent robots that perform human tasks using AI techniques. Packt Publishing Ltd, 2018. 3. Borovac B., Đorđević, G., Rašić M., Andrić D., Zbirka zadataka iz robotike, 2002. https://www.etf.ues.rs.ba/~slubura/robotika/ZibrkaIzRobotike.pdf			
No. of active teaching hours:	Lectures: 30	Practice: 30	
Teaching methods Lectures, auditory exercises, laboratory exercises, independent work.			
Examination (maximum number of points 100)			
Exam prerequisites	70 points	Final exam	30 points
student's participation during lectures		oral exam	20
practice		written exam	10
test/s	40		
seminar/s			
project	30		
other			

Study program: MAS Artificial Intelligence		
Course title: ARIFICIAL INTELLIGENCE IN MEDICINE		
Teacher(s): Arso Vukićević		
Lecturer from a foreign university: Jelene Škorućak		
Course status: Elective		
No. of ECTS: 10		
Prerequisites: /		
Course objective: Machine learning (ML) methods have proven to be very valuable in medical research and clinical practice, and their application in the medical field has become increasingly popular in recent years. ML provides approaches to large analyses in scientific research that were not possible before, while in the clinical environment it can serve as an aid to physicians. Students will be introduced to different applications of ML algorithms in medical research and clinical practice, after acquiring basic knowledge of ML algorithms (supervised and unsupervised learning, different classification algorithms, etc.).		
Course learning outcomes: Students will master the applications of machine learning algorithms in medical research and clinical practice, become independent in project execution and problem analysis, as well as solve complex practical tasks.		
Course contents: <i>Lectures</i> At the beginning of the course, machine learning algorithms that are mostly used in preclinical and clinical practice will be presented. Supervised and unsupervised learning techniques will be covered, such as classification and regression models, feature selection and data pre-processing, as well as state-of-the-art deep learning methods. After the introduction of basic methodologies, the most relevant applications of machine learning in medicine will be discussed. Processing of time series data and medical images will be covered in this course. <i>Practice</i> Joint conception and elaboration of the topic and content of the project. Reference to concepts, tools and literature. Research work, review of available papers. Development and solution of simpler problems of application of artificial intelligence in medicine - processing of biomedical signals, processing of medical images, etc. <i>Project-based exercises</i> Independent realization of projects with the aim of applying the acquired knowledge to real problems in practice. Presenting project results to the public. Monitoring and discussion of solutions and results during project work and its documentation. The development of the project would be realized in cooperation with the NGO Novi Sad Artificial Intelligence and would include the processing of EEG signals and medical images (classification problems for the purpose of medical diagnostics).		
Literature: 1. George Luger, Artificial intelligence – Structures and Strategies for Complex Problem Solving, Fifth Edition, Addison-Wesely, 2005. 2. Cleophas, Ton J., and Aeilko H. Zwinderman. Machine Learning in Medicine-a Complete Overview. Springer International Publishing, 2015. 3. Wu, Guorong, Dinggang Shen, and Mert Sabuncu, eds. Machine learning and medical imaging. Academic Press, 2016 4. . DuBois, Kelly N. "DEEP MEDICINE: How Artificial Intelligence Can Make Healthcare Human Again." Perspectives on Science and Christian Faith 71.3 (2019): 199-201.		
No. of active teaching hours:	Lectures: 30	Practice: 30
Teaching methods Lectures, auditory exercises, laboratory exercises, independent work.		
Examination (maximum number of points 100)		

Exam prerequisites	60 points	Final exam	40 points
student's participation during lectures	10	oral	40
practical exercises		written	
test(s)			
seminar(s)			
project	50		
other			

Study program: MAS Artificial Intelligence				
Course title: BIG DATA ANALYSIS				
Teacher(s): Ana M. Kaplarević-Mališić, Miloš Ivanović				
Visiting professor: Dimitrios Fotiadis				
Course status: Elective				
No. of ECTS: 10				
Prerequisites: Enrolled in the appropriate semester				
Course objective: Introduction to the basics of storage, processing and analysis of large amounts of data using solid mathematical foundations and current software tools.				
Course learning outcomes: The student knows and understands the mathematical base, standards and technologies that deal with the storage, processing and analysis of mass data. He/She is able to independently create a decision support application that uses a large amount of data as input.				
Course contents: <i>Lectures</i> Mathematical basics. Connection with classic parallel programming of shared and distributed memory. Scientific and business applications that involve the processing of large amounts of data. MapReduce concept, its advantages and limitations. Scaling in NoSQL databases such as MongoDB, Cassandra and Neo4j. Optimizations and heuristics over a large amount of data. Cluster computing using Apache Hadoop, Apache Spark and Hive tools. Advanced application of Apache Spark using MLib and SparkSQL libraries. Streaming applications using message lines, as well as Apache Kafka. Concepts of virtualization and containerization. <i>Practice</i> Creating illustrative applications using current Big Data technologies. Independent development and creation of cluster applications using the basic RDD approach in Spark, as well as calling routines from libraries. Scripting using Python and R programming languages. Measuring and optimizing the performance of MapReduce applications. Streaming applications using message lines and Apache Kafka boxes. Creating a scaling plan. Cluster Administration, Containerization, Docker and Kubernetes. <i>Project-based exercises</i> Application of acquired knowledge to a specific problem and realization of projects in current technologies for processing large amounts of data and in programming languages Python, R, etc. Project development will be organized in cooperation with Steinbeis Advanced Risk Technologies Institute doo, Kragujevac, where students will be able to work on projects and face real problems in practice, applying the acquired theoretical knowledge in the field of processing large amounts of data.				
Literature: 1. Chodorow, Kristina, MongoDB: The Definitive Guide: Powerful and Scalable Data Storage, O'Reilly Media, Inc., 2013. 2. White, Tom, Hadoop: The definitive guide, O'Reilly Media, Inc., 2012. 3. Spark, Apache, Apache Spark: Lightning-fast cluster computing. URL http://spark.apache.org (2016).				
No. of active teaching hours:		Lectures: 30	Practice: 15+15	
Teaching methods Active teaching / learning methods of are used. In addition to ex-cathedra lectures and laboratory exercises, interactive methods of learning in the classroom are applied, as well as individual and team independent activities of students outside the classroom (in the computer centre, library, home). Interactive learning is applied in the form of individual independent work, cooperative and collaborative learning, problem-based learning, teamwork and the development of group or team projects (seminars).				
Examination (maximum number of points 100)				
Exam prerequisites		70 points	Final exam	30 points
student's participation during lectures			oral exam	30

practical exercises	4		
test(s)			
seminar(s)	18+18		
project	30		
Note: A 6-node Hadoop / HPC cluster is available for teaching of the course, as follows: 1 x Fujitsu PRIMERGY RX2540 M1 , 2 Intel(R) Xeon(R) CPU E5-2620 v3 @ 2.40GHz, 32 GB, 8 TB 5 x HP ProLiant DL165 G7, 2 X AMD Opteron(TM) Processor 6272, 16 GB, 300GB			

Study program: MAS Artificial Intelligence
Course title: BIOENGINEERING AND BIOINFORMATICS
Teacher(s): Nenad D. Filipović, Milica Nikolić Lecturer from a foreign university: Sašo Džeroski
Course status: Elective
No. of ECTS: 10
Prerequisites: /
Course objective: The aim of the course is to acquaint students with the possible application of bioengineering and bioinformatics in the field of modelling of cardiovascular systems, coupling of heart work with muscle contraction, connecting micro and macro scales, combination of biochemical reactions and use of databases for searching in bioinformatics. Introducing students to the concepts and techniques of bioinformatics. DNA, RNA sequencing and work with protein structures.
Course learning outcomes: After mastering the program and passing the exam in the subject Bioengineering and Bioinformatics, candidates will be able to engage in scientific research in this very popular and interdisciplinary field. The knowledge that candidates acquire relates to basic concepts from cardiovascular biomechanics, circulatory mechanisms, muscle contraction, basics of bioinformatics, parallel systems and the use of bioinformatics' databases in modelling and simulation of coupled problems of cardiovascular systems. Upon completion of the course, students will be able to work with DNA and RNA sequences, three-dimensional protein structures, individual protein sequences. Students will acquire the knowledge necessary for further scientific-research work in the field of bioinformatics.
Course contents: <i>Lectures</i> Fundamentals of bioinformatics. Parallel systems in bioinformatics. Application of bioinformatics in medicine. Machine learning in bioinformatics. Use of nucleotide sequence databases. Use of protein databases and specialized sequences. Working with a unique DNA sequence. Working with a single protein sequence. Search for similarities in the sequence database. Comparison of two sequences. Alignment of multiple sequences. Edit alignment. Working with three-dimensional protein structures. Work with RNA. Construction of phylogenetic trees. <i>Practice</i> Application of artificial intelligence in the field of bioengineering and bioinformatics. Practical exercises are performed in a computer classroom. Creating a project with a practical and specific problem. Introduction to the basics of storage, processing and analysis of large amounts of data using solid mathematical foundations and current software tools. Creating illustrative applications using current Big Data technologies. <i>Project-based exercises</i> Creating projects in the field of bioinformatics, with the possibility of choosing a topic. The project includes the application of acquired knowledge in lectures and exercises and the implementation of a complex application. Independent development and creation of cluster applications using the basic RDD approach in Spark, as well as applying library routines. Scripting using Python and R programming languages. All of this will be accomplished in collaboration with NVS Strategy, a leading biomedical data company specializing in software and data analytics to conduct public and private health research. Their specialization will enable students to find connections between genomic and clinical data with direct access to more public datasets and bioinformatics tools than in any other company.
Literature: 1. M. Rocha and P. G. Ferreira: Bioinformatics Algorithms: Design and Implementation in Python, First Edition, Academic Press, 2018) (ISBN 978-0128125205) 2. P. M. Selzer, R. J. Marhöfer, O. Koch: Applied Bioinformatics: An Introduction, Second Edition, Springer, 2018. (ISBN 978-3319682990)

3. L. Baker: Bioinformatics: Tools and Techniques, CALLISTO REFERENCE, 2018. (ISBN 978-1641160032)			
4. R. Elder: Building Bioinformatics Solutions, Createspace Independent Publishing Platform, 2017. (ISBN 978-1975792152)			
5. C. Malkoff: Bioinformatics, Proteomics and Genomics, CALLISTO REFERENCE, 2017. (ISBN 978-1632398048)			
No. of active teaching hours:		Lectures: 30	Practice: 30
Teaching methods			
Active teaching / teaching methods are used in teaching / learning the subject. In addition to ex-cathedra lectures and laboratory exercises, interactive methods of learning in the classroom are applied, as well as individual and team independent activities of students outside the classroom (in the computer centre, library, home). Interactive learning is applied in the form of individual independent work, cooperative and collaborative learning, problem-based learning, teamwork and the development of group or team projects (seminars).			
Examination (maximum number of points 100)			
Exam prerequisites	70 points	Final exam	30 points
Student's participation during lectures		oral	20
practical exercises	5+5	written	10
test(s)	10		
seminar(s)			
project	50		
other			

Study program: MAS Artificial Intelligence			
Course title: BIOLOGICALLY INSPIRED COMPUTING			
Teacher(s): Nenad Filipović			
Course status: Elective			
No. of ECTS: 10			
Prerequisites: /			
Course objective: Introducing students to the concepts and techniques of biological computing, selected examples from the field of application of evolutionary computation, neural networks, cellular automata and genetic algorithms.			
Course learning outcomes: Upon completion of the course, students will be able to solve the problems of biologically inspired computing using an evolutionary computing approach and genetic algorithms. Students will have an overview of algorithms that can be used to autonomously design and customize intelligent systems. They will gain insight into biologically inspired machine learning as well as traditional machine learning methods for search, optimization and classification. They will learn about advantages and disadvantages of different methods. They will acquire knowledge of using methods for real applications.			
Course contents: <i>Lectures</i> An evolutionary algorithm. Genetic algorithms. Evolutionary strategies. Neural networks. Hybridization with other techniques, mathematical algorithms. Classification, search and optimization schemes based on biological computing. Coevolution, interactive evolution. Introduction to bio-inspired computer topics: genetic algorithms (biological inspiration is evolution), cellular automata (biological inspiration are cells), neural networks (biological inspiration are human neurons), etc. <i>Practice</i> Exercises are performed in a computer classroom. Practical tasks with gained experience both using tools and coding own algorithms. <i>Project-based exercises</i> Application of acquired knowledge to a specific problem and implementation of projects with a possible topic in the field of genetic algorithms, neural networks, genetic bee colony algorithms (GBC Algorithm), fish school algorithm (Fish Swarm Algorithm (FSA)), Artificial Algae Algorithm (AAA), etc. Realization of the project in programming languages Python, R, etc. Project development will be organized in cooperation with Steinbeis Advanced Risk Technologies Institute doo, Kragujevac, where students will be able to work on projects and problems from practice, discuss the complexity and complexity of algorithms, as well as accelerate them.			
Literature: 1. A.E. Eiben and J.E. Smith: Introduction to Evolutionary Computing, Second Edition, Springer, 2015. (ISBN 978-3-662-44873-1) 2. S. Haykin: Neural networks and learning machines, Third Edition, Pearson, 2008. (ISBN 978-0-13-147139-9) 3. A. Brabazon: Natural computing algorithms, Springer, 2015. (ISBN 9783662436318)			
No. of active teaching hours:		Lectures: 30	Practice: 30
Teaching methods Lectures, auditory exercises, laboratory exercises, independent work, project.			
Examination (maximum number of points 100)			
Exam prerequisites		70 points	Final exam
student's participation during lectures		oral	30 points
			20

practical exercises		written	10
test(s)	10+10		
seminar(s)			
project	50		
other			

Study program: MAS Artificial intelligence
Course title: BUSINESS MANAGEMENT
Teacher(s): Marija D. Gačić Teacher from the foreign university:
Course status: Elective
Number of ECTS: 10
Prerequisites: /
Course objective: Introducing students to the basics of entrepreneurship, business management, marketing and finance, to stimulate them to develop entrepreneurial mindset and enable them to start and run their own business in the field of artificial intelligence, as well as to present their business idea to potential corporate buyers and investors.
Course learning outcomes: By acquiring basic knowledge in the field of entrepreneurship, management, finance, project management and marketing, the student is trained to launch his own idea for a product or service based on artificial intelligence on the market. The student is also trained to start his/her own business in this field, organize a work team and manage the business and create a business model adapted to the field of artificial intelligence, as well as to present and valorize his idea within the corporation.
Course content: <i>Theory</i> • Basics of entrepreneurship, development of creative ideas, basic concepts of innovation, creating a business plan. • Fundamentals of management, leadership and team management • Project management • Financing and financial management • Development of a business model in the field of artificial intelligence <i>Practice</i> The exercises are of the auditory type and include the development and presentation of an individual or team project that represents the development of a business idea in the field of artificial intelligence. <i>Project-based exercises</i> Application of acquired knowledge in solving a specific problem and realization of projects with a focus on business management. Cooperation related to the launching of student's own idea for a product or service based on artificial intelligence will be organized with the company NVS Strategy. In cooperation with the professional teams of the company, students will be able to ask practical questions related to the development of business models, financing and financial management and development of a business plan.
Literature: 1. Jordi Canals, Franz Heukamp, <i>The Future of Management in an AI World: Redefining Purpose and Strategy in the Fourth Industrial Revolution</i>, IESE Business Collection, Springer Nature, 2019 ISBN 3030206807, 9783030206802 2. Rashed Haq, <i>Enterprise Artificial Intelligence Transformation</i>, John Wiley & Sons, 2020, ISBN 1119665930, 9781119665939 3. Jonathan P. Allen, <i>Digital Entrepreneurship</i>, Routledge, 2019, ISBN 1138583693, 9781138583696 4. Hosu, Ioan, Iancu, Ioana, <i>Digital Entrepreneurship and Global Innovation Advances in Business Strategy</i>

and Competitive Advantage, IGI Global, 2016, ISBN 1522509542, 9781522509547.

No. of active teaching hours	Lectures: 30	Practice: 30	
Teaching methods			
Lectures, auditory exercises, laboratory exercises, independent work.			
Examination (maximum number of points 100)			
Exam prerequisites	70 points	Final exam	30 points
Student’s participation during lectures	10	Oral exam	30
Practical exercises			
Tests	30		
Seminars			
Projects	30		
Other			

Study program: MAS Artificial Intelligence
Course title: COMPUTER GRAPHICS
Teacher(s): Igor Saveljić, Saša Ćuković Lecturer from industry: Nataša Vujnović Sedlar
Course status: Elective
No. of ECTS: 10
Prerequisites: /
Course objective: The aim of the course is to acquaint students with the basics of computer graphics such as visual signal processing, edge detection and line extraction, texture processing, presentation of scene characteristics, movement, stereovision and various image processing methods. The goal is also for students to be able to do a complex project in computer graphics on their own.
Course learning outcomes: After mastering the program and passing the exam in the subject of computer graphics, candidates will be able to engage in research and scientific work in this new field. They will be trained to process visual signals, use image processing methods, and form a three-dimensional image in computed tomography, as well as use Fuzzy logic in image processing. Candidates will be able to apply this knowledge in the software industry in the field of educational software development, film animations, commercials, military industry, automotive industry, biomedical industry, etc.
Course contents: <i>Lectures</i> Computer graphics and geometry as computing disciplines. Structure of input-output devices. Graphic hardware. Raster graphics. Ray-tracing algorithms. Mathematical apparatus (trigonometry, analytical geometry and linear algebra). Coordinate systems. Graphics in space. Basic objects in space. Transformations in space. Linear transformations (scaling, shifting, rotation, reflection). Composition and decomposition transformation. Translation and affine transformations. Inverse transformations. Transformation of coordinate systems. Views. Types of displays (wire structure, shading, hidden lines). View transformations. Camera transformations, projections and viewport transformations. Orthographic projection. Perspective. Graphic tube. Clipping. Z-buffer algorithm. Precision. Data structures. Representation of points, polygons and bodies. Graph scenes. Spatial data structures. <i>Practice</i> Drawing basic objects with attributes (dashed lines, line thickness). Incremental algorithm for drawing circles and ellipses. Polygons, filling the interior of the polygon and orientation of the polygon. Wire model of a polyhedron. Polygonal mesh. Development of spatial models. Model and view transformations. Partial transformations of scene elements. Animated display. Using the Unity platform to develop 3D applications. <i>Project-based exercises</i> Creating a more complex project in the form of game development that will apply the acquired knowledge – analysis by parts, texture, presentation of the scene characteristics, movement, stereovision, Image fusion. Possibility to select software and libraries for project development - OpenGL, Unity... Project development will be organized in cooperation with NVS Strategy and will be possible in a team or individually, including all steps of game development, from analysis of the presented problem, through game development, to game modification and adaptation based on users' comments.
Literature: 1. Shreiner D., Woo M., Jackie N.: OpenGL programmers' guide, Computer Library Čačak, 2007 (OpenGL водич за програмере, Компјутер библиотека Чачак, 2007), ISBN 978- 86-7310-362-4

2. Angel E.: Interactive Computer Graphic A Top-Down Approach with OpenGL, 6-th edition, ADDISONWESLEY, 2011, ISBN 978-0132545235 3. Dragan Cvetković, Computer Graphics, SET Belgrade, 2006 (Драган Цветковић. Рачунарска графика, CET Београд, 2006). 4. P. Shirley, S. Marschner. Fundamentals of Computer Graphics, CRC Press, 2009. 5. J. Kessenich, G. Sellers, D. Shreiner. OpenGL Programming Guide, Pearson Education, 2013. (www.opengl-redbook.com) 6. https://unity.com/			
No. of active teaching hours:	Lectures: 30	Practice: 30	
Teaching methods			
Lectures, auditory exercises, laboratory exercises, independent work.			
Examination (maximum number of points 100)			
Exam prerequisites	70 points	Final exam	30 points
student's participation during lectures		oral	20
practical exercises		written	10
test(s)	10+10		
seminar(s)			
project	50		
other			

Study programme : MAS Artificial intelligence
Course title: COMPUTER VISION
Lecturers: Igor Saveljić, Bogdan Milićević
Course status: Elective
No. of ECTS: 6
Prerequisites: /
Course objectives Overview of goals and methods for image analysis, image processing and computer vision. Orientation on biological vision and visual perception. Features of forming a perspective image. Basic image analysis: theoretical signal methods, filtering, image enhancement, image reconstruction, segmentation, classification, representation. Basic computer type: multiscale representation, edge detection and other distinctive features. Stereo and multi-camera systems. Object recognition, morphology.
Course learning outcomes Након завршеног курса студент треба да буде у стању да идентификује основне концепте, ерминологију, моделе и методе у компјутерском виду и обради слике, систематски развије и анализира низ основних метода рачунарског вида - методе за обраду слика који се односе на филтрирање слике, побољшање слике, сегментацију, класификацију и представљање, може да одлучи како основне могућности и ограничења утичу на избор метода обраде слике и рачунарског вида за специфичне примене, самостално буде у стању да имплементира, анализира и процени једноставне методе за рачунарски вид и обраду слике, буде оспособљен претражује стручну литературу из области.
Course contents <i>Lectures</i> Basic image operations to enhance and extract information from digital images. Examples are gray level transformations, filtering techniques, and detection of characteristics such as angles, edges, and regions (segmentation). Methods for deriving three-dimensional information about the outside world based on visual information, using signs such as texture, shading, stereo and movement. Methods for object recognition. <i>Practice</i> Application of the Python software tool to create the application of the described methods. Practice involves the application of acquired knowledge in order to develop computer vision algorithms. Algorithm Implementation: Image Classification / Recognition, Introduction to PyTorch. Object detection. Dense predictive problems. Representative learning through self-supervision. 3D computer vision. Introduction to 3D data. <i>Project</i> Project development in team or individually. The project is designed to be developed as part of a student internship at Comtrade, which is a leading expert in the field of software engineering and employs young staff in its offices. In cooperation with the professional teams of this company, students will work on improving their acquired knowledge and application through the implementation of various algorithms.
Literature: 1. http://d2l.ai/ - Aston Zhang and Zachary C. Lipton and Mu Li and Alexander J. Smola "Dive into Deep Learning", 2020 2. http://www.deeplearningbook.org/ - Ian Goodfellow and Yoshua Bengio and Aaron Courville, "Deep Learning", 2016. 3. https://github.com/fastai/fastbook - Jeremy Howard and Sylvain Gugger, "Deep Learning for Coders with fastai and PyTorch", 2020 4. https://pytorch.org/assets/deep-learning/Deep-Learning-with-PyTorch.pdf - Eli Stevens, Luca Antiga, and Thomas Viehmann, "Deep learning with PyTorch", July 2020. 5. Gonzales R., Woods R. : "Digital Image Processing", Third Edition, Pearson Prentice-Hall, 2002. 6. D.A. Forsyth, J. Ponce: "Computer Vision A Modern Approach". Pearson Prentice-Hall, 2003.

No. of active teaching hours	Lectures: 30	Practice: 30	
Teaching methods Problem-oriented teaching, practical teaching, independent work of students, consultations. Combination of classical teaching with e-learning with appropriate literature. Practical classes are conducted in computer classrooms, where students independently or with the help of assistants solve real problems in the field of application of Python programming language.			
Examination (maximum number of points 100)			
Exam prerequisites	70 points	Final exam	30 points
In class activity	10	oral exam	15
Practice	30	written exam	15
Test(s)			
Seminars			
Project	30		
Other			

Study program: MAS Artificial Intelligence
Course title: DATA PROTECTION (Encryption techniques)
Teacher(s): Vladimir M. Milovanović Lecturer from industry: Srđan Atanasijević
Course status: Elective
No. of ECTS: 10
Prerequisites: /
Course objective: Introducing students to the basic concepts of data protection and systems, as well as security policy, attacks, vulnerabilities and encryption. Understanding the basics of cryptography and security protocols. Introduction to basic and general principles for implementation, maintenance and improvement of information security management in the system; sources of security threats, methods, techniques, procedures and products used for data protection.
Course learning outcomes: After passing the exam, students will: • know the basic principles of information management; • know possible sources of security threats; • know methods and techniques for detecting, preventing and neutralizing security breaches; • get acquainted with the need to use modern technological protection tools and the methodology of their application
Course contents: <i>Lectures</i> Basic terms: threats, attacks, security and methods of protection; Availability, authentication, authorization, confidentiality, integrity and access control; Applied cryptography: cryptographic algorithms; Security protocols; Access control and network barriers; Intrusion detection and prevention systems; Malware; Electronic business and Internet security; Database security; Computer network monitoring; Organizational, physical and legal methods of protection, social aspects; Ethical hacking and penetration testing; Safety standards and certification programs. <i>Practice</i> Security protocols; unauthorized access to the system; examples of free tools in the field of data protection; protection system design. <i>Project-based exercises</i> Project-based exercises will be realized in cooperation with the company Comtrade, which has a comprehensive security framework for processing genomic data in the cloud, which covers three main areas: • DATA SECURITY: Ensuring the protection of all sensitive data throughout its life cycle. This includes data encryption and secure user authentication. • PLATFORM AND INFRASTRUCTURE SECURITY: Ensuring that the software platform and its underlying infrastructure (server and network) support a secure architecture. • SECURITY CONTROLS: Ensuring system security by applying administrative, technical and other security controls, simultaneously ensuring compatibility with a wide range of reliable information security frameworks and compliance requirements. In this way, students will be able to have a direct insight into the example of good practice and to implement their projects in cooperation with people from the industry who have many years of experience in data protection.
Literature: 1. Stallings W., Brown L.: Computer security: principles and practice, Prentice Hall, 2007, ISBN 978-0136004240 2. Stallings W.: Cryptography and Network Security. Principles and Practice, fifth edition, Prentice Hall, 2011, ISBN 978-0136097044

3. Pleskonjić D., Maček M., Đorđević B., Carić M.: Security of computer systems and networks, Mikro knjiga, Belgrade, 2007, ISBN 978-8675553052 (Плескоњић Д., Мачек Н., Ђорђевић Б., Царић М.: Сигурност рачунарских система и мрежа, Микро књига, Београд, 2007, ISBN 978-8675553052)			
4. Tipton H., Krause M.: Information Security Managment Handbook, 6th edition, Auerbach Publications, 2006, ISBN 978-0262611954			
No. of active teaching hours:	Lectures: 30		Practice: 30
Teaching methods			
Lectures, auditory exercises, laboratory exercises, independent work.			
Examination (maximum number of points 100)			
Exam prerequisites	70 points	Final exam	30 points
student's participation during lectures		oral	20
practical exercises		written	10
test(s)	10+10		
seminar(s)			
project	50		
other			

Study program: MAS Artificial Intelligence
Course title: DATAFLOW COMPUTERS AND THEIR APPLICATION
Teacher(s): Filipović D. Nenad, Milica Nikolić Lecturer from a foreign university: Milutinović M. Veljko
Course status: Elective
No. of ECTS: 10
Prerequisites: /
Course objective: The goal of the course is the introduction to contemporary architectures of DataFlow computers and acquiring of necessary knowledge of DataFlow computers for independent research, solution modelling and application of these computers. DataFlow computers can reach the acceleration 10 to 100 times faster compared to ControlFlow computers, under certain conditions even a larger acceleration is possible, while having 10 times less consumption of electric energy and 10 times less physical volume allowing for a greater flexibility and precision in processing certain issues. In addition, the goal of this course is to teach students to use creative techniques in this domain, as well as the techniques necessary for the management of complex projects in the field covered by this course.
Course learning outcomes: Students are expected to develop skills to understand and independently design contemporary systems based on DataFlow computers using program models that Intel announced for its chip processor to be brought on market by the end of 2020. In addition, students are expected to develop skills to program DataFlow computers at higher abstraction levels, as well as to compare various paradigms per parameters, such as speed, consumption of electric energy, the transistor count in a single chip and flexibility in the treatment of algorithms.
Course contents: <i>Lectures</i> The course analyses the development of super computers (Feynman and Neumann paradigm), defines DataFlow SuperComputing paradigm, describes its advantages and introduces newest DataFlow program model to the students. The course covers all the phases of the system development based on DataFlow paradigm: program compilation, operating system, methods for algorithm acceleration, methods for decreasing energy consumption, synergy with IoT и WSN, i.e. with systolic fields and ASIC components. DataFlow computers are presented through a comparative analysis with ControlFlow computers. Special attention is paid to contributions of 4 Nobel Prize winners (Feynman, Prigogine, Kahneman, Hunt), which can make the cumulation process much more effective under adequate conditions. In addition, the focus is placed on the issues related to efficacy and effectiveness in domain of research and development <i>Practice</i> Practical exercise includes the analysis of tools for the development of programs using DataFlow computers, before all by introducing students to MaxIDE program environment. During practical exercises students are introduced to a number of examples for the application of DataFlow computers in the following fields: algorithmic mathematics, image processing, machine learning, tensor account (which can be applied in genomics, financial analyses, simulations in natural sciences, security, etc.). The course includes 4 homework assignments (algorithmic mathematics, image processing, machine learning and tensor account). Study research includes an opportunity for the cooperation related to DataFlow book series published by Springer and Elsevier (on the list of SCI indexed publications), as well as a possibility of the participation in creative scientific research projects. <i>Project-based exercises</i> Project development will be organized in cooperation with Steinbeis Advanced Risk Technologies Institute doo, Kragujevac, which is a branch of Steinbeis GmbH & Co. KG für Technologietransfer (StC), Stuttgart, Germany and directly deals with DataFlow computers and programming on FPGA chips, i.e. hardware accelerations. Through one larger, or a few smaller projects, students will be able to configure a neural network (e.g., a perceptron) directly on the hardware and compare execution speeds by using the ControlFlow and DataFlow paradigms.
Literature

1. ELSEVIER: Stojanovic, S., Bojic, D., Bojovic, M., Valero, M., Milutinovic, V., "An overview of selected hybrid and reconfigurable architectures," Elsevier
2. ELSEVIER: Korolija, N., Popovic, J., Cvetanovic, M., and Bojovic, M., "Dataflow-Based Parallelization of Control-Flow Algorithms," Advances in Computers
3. ACM: Trobec, R. Vasiljevic, R., Tomasevic, M., Milutinovic, V., et al, "Interconnection Networks for PetaComputing," ACM Computing Surveys, November 2016.
4. ACM: Flynn, M., Mencer, O., Milutinovic, V., et al, "Moving from PetaFlops to PetaData," Communications of the ACM, May 2013.
5. IEEE: Milutinovic, V., "The HoneyComb Architecture," Proceedings of the IEEE, 1989.
6. IEEE: Milutinovic, V. et al, "Splitting Spatial and Temporal Localities for Entropy Minimization" Tutorial of the IEEE ISCA, 1995.
7. SPRINGER: Kotlar, M., Milutinovic, V., "The Tensor Calculus Operations for the Data Flow Paradigm," Springer, 2019
8. SPRINGER: Milutinovic, V., and Kotlar, M., editors, "Exploring DataFlow Paradigm," Springer 2019
9. SPRINGER: Milutinovic, V., Kotlar, M., et al, "DataFlow SuperComputing Essentials," Springer, 2017
10. SPRINGER: Milutinovic, V., et al, "Guide to DataFlow SuperComputing," Springer, 2015, 2016, 2017, 2018 (textbooks)
11. IET: Jovanovic, Z. and Milutinovic, V., "FPGA accelerator for floating-point matrix multiplication," IET Computers & Digital Techniques, Vol. 6, 2012 pp. 249-256.
12. ELSEVIER: Milutinovic, V., editor, Advances in Computers: "DataFlow," Elsevier, 2015, 2016, 2017, 2018, 2019, 2020 (SCI Book).

No. of active teaching hours:	Lectures: 30	Practice: 30	
Teaching methods			
Lectures, auditory exercises, laboratory exercises, independent work.			
Examination (maximum number of points 100)			
Exam prerequisites	70 points	Final exam	30 points
student's participation during lectures		oral	20
practical exercises		written	10
test(s)	10+10		
seminar(s)			
project	50		
other			

Study program: MAS Artificial Intelligence			
Course title: DECISION SUPPORT SYSTEMS			
Teacher(s): Nenad Filipović			
Teacher from abroad: Themis Exarchos			
Course status: Elective			
Number of ECTS: 10			
Prerequisites: -			
Course objective The goal of the course is the introduction to concepts, theoretical bases, and possibilities of decision support systems. Students should acquire skills to independently apply the acquired knowledge in resolving actual problems.			
Course learning outcomes Students should acquire skills to model and resolve actual problems of optimal decision-making in the conditions of uncertainty and unpredictability.			
Course content <i>Lectures</i> Basic concepts of decision support systems. Decision making theory. The problem of rationality in decision making. Decision making factors. Decision making phases. Types of decision making systems. The structure of decision making systems. Research and analysis of data for the support of decision making. Decisions made on K-nearest neighbors rules. Reasoning in the conditions of uncertainty. Bayes decision rule. Bayes networks and training. Belief networks. Neural networks. Fuzzy logic. Method of support vectors. Classifiers and classification. Stable and unstable predictors. Class imbalance problem. Data pre-processing. Outlier detection and prediction of missing data. Designing tools for decision support: data acquisition, knowledge recording and modelling, system validation. Examples of decision support systems. <i>Practice</i> Practical exercises are conducted in a computer classroom. Work on the project with a concrete practical problem - application of several algorithms such as decision trees, neural networks, k nearest neighbors, Bayesian networks, random forest methods of support vectors, etc., to the presented problem and discussion of the obtained results. Comparison of results obtained by different methods, critical emphasis on the advantages and disadvantages of applied algorithms. <i>Project</i> Searching of the available literature. Creating a project task individually or in a team. Application of acquired knowledge on a current problem from practice. Realization of problems in Python programming language, with libraries like opencv, numpy, scikit-learn, etc. Discussion of the obtained results, possibilities of algorithm improvement, acceleration, complexity reduction, etc. In cooperation with the company Vodéna, the students will have the opportunity to implement internships and develop projects based on real problems. With its many years of experience in projects such as artificial intelligence decision support systems based on artificial intelligence, Vodéna provides students with a direct connection with industry and work in real conditions, and projects arising from student practice will have direct application in practice.			
Literature 1. C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006. 2. M. R. Berthold, D. Hand, Intelligent Data Analysis, Springer, 2007. 3. M. G. M. Hunink, P. P. Glasziou, J. E. Siegel, J. C. Weeks, J. S. Pliskin, A. S. Elstein, M. C. Weinstein, Decision Making in Health and Medicine: Integrating Evidence and Values, Cambridge University Press, 2001.			
No. of active teaching hours		Lectures: 30	Practice: 30
Teaching methods Lectures, auditory exercises, laboratory exercises, independent work			
Examination (maximum number of points 100)			
Exam prerequisites	70 points	Final exam	30 Points
Students' participation during lectures		Oral exam	20
Practice	10+10	Written exam	10
Test(s)			
Seminar(s)			
Project- based exercises	50		

Other			
-------	--	--	--

Study program: MAS Artificial Intelligence
Course title: DEEP LEARNING
Teacher(s): Branko Arsić Lecturer from business sector: Jovan Stojanović
Course status: Mandatory
No. of ECTS: 10
Prerequisites: Enrolled in the appropriate semester
Course objective: Enabling students to understand the paradigm of deep learning as a branch of machine learning, which is based on the presentation of data at a high degree of abstraction. The course introduces students to the key elements of classical neural networks, building techniques of scientific computation, regularization techniques and learning algorithms and considers models such as: convolutional, recurrent and generative rival neural networks. Deep learning methods in important areas of artificial intelligence such as: forecasting, computer vision, natural language processing, speech comprehension and sound signals are studied. The course involves the development of applications in modern software frameworks for deep learning (Tensorflow, Keras, R, Python).
Course learning outcomes: The mastered material will enable the student to: essentially understand the advantages of deep learning in relation to alternative approaches to machine learning; to master the techniques of learning deep learning models; to explain the areas of application of discriminant and generative deep learning models; to apply models for supervised, semi-supervised and unsupervised learning appropriately; to apply deep learning methods and techniques to the understanding of images, text and speech; to evaluate the quality metrics of deep learning models; to design and shape deep learning models in high-level languages.
Course contents: <i>Lectures</i> Building blocks of deep learning. Linear algebra (Special types of matrices and vectors, tensors, eigenvalues, norms, PCA, etc.). Probability and information theory (distribution laws, Bayesian rules, etc.). Elements of numerical calculation (stabilization of functions in terms of errors - overflow, underflow, gradient optimization methods, optimization with constraints, etc.). Elements of machine learning (learning algorithms, overfitting, underfitting, hyperparameters and validation sets, maximum plausibility method, supervised and supervised learning, stochastic gradient descent, etc.). Deep neural network architecture (multilayer architecture of process units, backpropagation algorithm). Regularization of deep networks (L1, L2, dropout, data set expansion, noise, multitask learning, etc.). Optimization of deep network training (challenges - vanishing / exploding gradient, parameter initialization strategies, adaptive learning algorithm, etc.). Convolutional networks (convolution, pooling, parameter sharing, convolutional functions, structured outputs, efficient convolutional algorithms, etc.). Sequential models (recurrent and recursive networks, LSTM, GRU). Generative models (Boltzmann machines, autoencoders, GANN, etc.). Practical methodology and application of depth models (performance metrics, selection of appropriate model, hyperparameter selection strategies, debugging, large-scale deep learning, CUDA, computer vision, speech recognition, natural language processing, other applications). <i>Practice</i> Application of software frameworks for deep learning (Tensorflow, Keras, R, Python). Work on exercises implies the application of acquired knowledge to solve specific current problems in various areas of deep learning. <i>Project-based exercises</i> In cooperation with the company NGO Novi Sad Artificial Intelligence, students will work on problems from practice where the focus will be on the application of acquired knowledge in the field of deep learning, as well as the optimization of created models. With its many years of experience working on projects in the field of artificial intelligence, NGO Novi Sad Artificial Intelligence will provide students with the opportunity to try to respond to the real demands of the industry.
Literature: 1. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Deep learning, MIT Press, 2017.

2. Michael Nielsen, Neural Networks and Deep Learning, Determination press, 2015.
3. Stuart Russel, Peter Norwig, Artificial Intelligence: a modern approach, translation of the 3rd edition, RAF School of Computing, Belgrade/CET Computer Equipment and Trade, Beograd / Portalibris, Beograd, 2011, (Veštačka inteligencija, savremeni pristup, prevod trećeg izdanja, RAF Računarski fakultet, Beograd/ CET Computer Equipment and Trade, Beograd / Portalibris, Beograd, 2011).

No. of active teaching hours:	Lectures: 30	Practice: 15+15	
Teaching methods			
Problem-oriented teaching, practical classes and exercises with software support, independent student work and consultations.			
Examination (maximum number of points 100)			
Exam prerequisites	70 points	Final exam	30 points
student’s participation during lectures		oral	10
practical exercises	10	written	20
test(s)	10		
seminar(s)			
project	50		
other			

Study program: MAS Artificial Intelligence		
Course title: ETHICS IN ARTIFICIAL INTELLIGENCE		
Teacher(s): Ružica Petrović		
Course status: Elective		
No. of ECTS: 10		
Prerequisites: /		
Course objective: The aim of the course is to provide a thorough overview of many ethical and social issues raised by information and communication technologies (ICT), with special attention to artificial intelligence and its impact on society and individuals.		
Course learning outcomes: At the end of the course, the student should understand the main ethical aspects related to the creation and use of artificial intelligence systems. The student will be able to critically consider the main issues of machine ethics related to the moral behaviour of intelligence systems that have autonomous decision-making abilities and is able to assess the impact of ethical and legal aspects related to intelligence systems.		
Course contents: <i>Lectures</i> Students will learn about the most relevant social and ethical challenges posed by ICT and how to approach them in a critical way. Conceptual analysis will be supported by a discussion of practical case studies. The course will cover topics such as safety and responsibility, free will, awareness, machine ethics, ethics and artificial intelligence in health care, the legal significance of ethics in artificial intelligence. <i>Practice</i> Practical classes will include modelling of legal and ethical norms and explanations, as well as panel discussions on the topic of ethics in artificial intelligence. The exercises will include a number of practical examples in practice where the presence of ethics combined with artificial intelligence is mandatory. <i>Project-based exercises</i> Application of acquired knowledge in solving of a specific problem and implementation of projects with reference to ethical aspects. Cooperation related to ethical aspects will be organized in cooperation with the company NVS Strategy, which specializes in software and data analytics, and has years of experience in working with patient data and their protection. In cooperation with the professional teams of this company, students will be able to solve ethical issues that arise in connection with problems in artificial intelligence.		
Literature: 1. Anderson, Michael and Susan Leigh Anderson, 2007, "Machine Ethics: Creating an Ethical Intelligent Agent", AI Magazine, 28(4): 15–26. 2. 2003c, "Transhumanist Values", in Ethical Issues for the Twenty-First Century, Frederick Adams (ed.), Bowling Green, OH: Philosophical Documentation Center Press. 3. Stahl, Bernd Carsten and David Wright, 2018, "Ethics and Privacy in AI and Big Data: Implementing Responsible Research and Innovation", IEEE Security Privacy, 16(3): 26–33. 4. Wallach, Wendell and Peter M. Asaro (eds.), 2017, Machine Ethics and Robot Ethics, London: Routledge. 5. Walsh, Toby, 2018, Machines That Think: The Future of Artificial Intelligence, Amherst, MA: Prometheus Books.		
No. of active teaching hours:	Lectures: 30	Practice: 30
Teaching methods Lectures, auditory exercises, laboratory exercises, independent work.		
Examination (maximum number of points 100)		

Exam prerequisites	70 points	Final exam	30 points
student's participation during lectures		oral	20
practical exercises	50	written	10
test(s)			
seminar(s)			
project	20		
other			

Study program: MAS Artificial Intelligence
Course title: IMAGE PROCESSING
Teacher(s): Gordana Jovičić, Saša Čuković
Course status: Elective
No. of ECTS: 10
Prerequisites: /
Course objective: The goal of this course is to introduce students to the basics of computer graphics such as visual signal processing, edge detection and line extraction, texture processing, presentation of scene characteristics, movement, stereovision and various image processing methods. Introducing students to the basics of digital image processing in the time and frequency domain, the nature of noise in the image, methods of image segmentation, shape description and their recognition in the image. The goal is also for students to be able to do a complex project on their own.
Course learning outcomes: After mastering the program and passing the exam in the subject Image Processing, candidates will be able to engage in research and scientific work in this new field. They will be trained to process visual signals, use image processing methods, and form a three-dimensional image in computed tomography, as well as use Fuzzy logic in image processing. Candidates will be able to apply this knowledge in the software industry in the field of educational software development, film animations, commercials, military industry, automotive industry, biomedical industry, etc.
Course contents: <i>Lectures</i> Visual signal processing. Histogram modification, Noise elimination. Two-dimensional Fourier transformation applied to the image. Edge sharpening and their detection. Generalized image segmentation. Morphological processing. Representation of objects by attributes. Shape recognition. Mathematical setting of tomography. Radon transformation. Reverse projection method and filtered back projection method using Fourier transform. Least squares method. Edge detection and line extraction. Analysis by parts. Texture. Presenting the characteristics of the scene. Move. Stereovision. Shape determination methods. X-ray image processing method. Method for image formation and analysis in computed tomography. Methods for analysis of ultrasound images. Thermovision image processing method. Methods of forming a three-dimensional image in computed tomography. Fuzzy logic in image processing. Application of shape recognition - Blob trackers, Kalman filters, Particle Filters, Markov Process. <i>Practice</i> Practicing the application of theoretical elements and algorithms on various examples of images as preparation for work on an independent project that will be included in the evaluation. Independent development of programs for quality repair, image filtering and segmentation, separation of objects in the image and their specification. Creating tasks in the field of image reconstruction. <i>Project-based exercises</i> Within the study research work, students will implement a project in the field of subjects, which will include solving current problems in the field of image processing - face detection, face recognition, license plate recognition, car tracking, etc. NSV Strategy with its practical examples directly enables students to implement projects in the field of application of artificial intelligence in image processing, where each project will have a practical application and represent a real problem in the industry.
Literature: 1. M. Popović, Digital Image Processing, Akademska misao, 2006 (Digitalna obrada slike, Akademska misao, 2006). 2. R. C. Gonzalez, R. E. Woods: "Digital Image Processing", Second Edition, Prentice Hall, 2002. 3. R. C. Gonzalez, R. E. Woods, S. L. Eddins: "Digital Image Processing using MATLAB", Prentice Hall, 2004.

4. Dey, S. (2018). Hands-On Image Processing with Python: Expert techniques for advanced image analysis and effective interpretation of image data. Packt Publishing Ltd.			
No. of active teaching hours:	Lectures: 30		Practice: 30
Teaching methods			
Lectures, auditory exercises, laboratory exercises, independent work.			
Examination (maximum number of points 100)			
Exam prerequisites	70 points	Final exam	30 points
student’s participation during lectures		oral	20
practical exercises		written	10
test(s)	10+10		
seminar(s)			
project	50		
other			

Study program: MAS Artificial Intelligence			
Course title: INTRODUCTION TO DATA SCIENCE			
Teacher(s): Nenad Filipović, Vladimir M. Milovanović			
Course status: Elective			
Number of ECTS: 10			
Prerequisites: -			
Course objective: The goal of the course is the introduction to all major aspects of data science, learning how to use software tools, data management, data presentation, and data analysis. Within the course, students will be introduced to best practices from the field of industry and research.			
Course learning outcomes: Students should acquire skills in data management techniques. They should learn to choose adequate methods for presenting data, as well as use the basic methods of machine learning and statistics. Students should be skilled to prepare adequate reports, to recognize potential security, personal and ethical problems when processing data. They should learn to choose the right license for work and software.			
Course content: <i>Lectures</i> The course offers an introductory overview of the topics which are relevant for data science. Data processing – Acquisition. Storage. Cleaning. Summing up. Visualization. Analysis - Prediction. Clasterization. Statistical conclusion. Business and social aspects – Privacy.Security. Ethics. Licenses. Intellectual property. <i>Practice</i> Python и R libraries. Use of auxiliary tools for versioning (Github) and repetitions (Jupyter). Use of public repositoria - ArXiv, Zenodo. <i>Project-based lectures</i> Application of acquired knowledge in solving a specific problem and implementation of projects within student internships. Project development will be organized in cooperation with the company NVS Strategy, which specializes in software and data analytics. In cooperation with the professional teams of this company, students will be able to work on real problems, and student projects will have a direct application in practice.			
Literature 1. W. Hadley, G. Grolemund, R for statistical data processing, Mikro knjiga, 2017 2. S. E. Buttrey, L. R. Whitaker, A Data Scientist's Guide to Acquiring, Cleaning, and Managing Data in R, John Wiley & Sons, 2017. 3. G. Reese, Cloud Application Architectures: Building Applications and Infrastructure in the Cloud, O'Reilly Media, 2009. 4. H. Wickham, Elegant Graphics for Data Analysis, Springer, 2015.			
No. of active teaching hours	Lectures: 30	Practice: 30	
Teaching methods Lectures, exercises, and independent work of students.			
Examination (maximum number of points 100)			
Exam prerequisites	70 points	Final exam	30 points
Student’s participation during lectures		oral exam	20
Practice	50	written exam	10
Test/s			
Seminar/s			
Project – based exercises	20		

Other			
-------	--	--	--

Study program: MAS Artificial Intelligence
Course title: MACHINE LEARNING
Teacher(s): Tijana Geroski Visiting professors: Zoran Bosnić, Zlatan Car
Course status: Mandatory
No. of ECTS: 10
Prerequisites: /
Course objective: Enabling students to understand and practically apply the concepts of supervised machine learning in the field of regression and classification.
Course learning outcomes: The mastered material enables the student to: • Understand key concepts of machine learning (theoretical assumptions, mathematical foundations, advantages and disadvantages of supervised and unsupervised machine learning algorithms). • Distinguish basic approaches to machine learning. • Apply the process of selecting and evaluating optimal models for a given problem. • Effectively apply fundamental regression and classification algorithms to problems of medium complexity.
Course contents: <i>Lectures</i> Basic concepts of machine learning. Areas of application. Types of machine learning. Supervised learning. Setting supervised learning problems. Model. Minimizing model error. Adjustment and sub-adjustment. Cross-checking. Loss functions. Regularization. Balance between systematic deviation and variance. Tree-based models. Training decision trees. Pruning decision trees. Representation of decision trees in the form of rules. The methods of the nearest neighbours. Separating boundaries. The curse of dimensionality. Linear models for regression and classification. Linear regression. Multiple linear regression. Logistic regression. Multinomial logistic regression. Artificial neural networks. Perceptron. Gradient descent. Artificial neural networks with advance propagation. Activation functions. Probabilistic models. Naive Bayesian classifier. Methods based on core functions. Support vector methods. Maximum margin problem. Group training. AdaBoost. Random Forest. Evaluation and model selection. Confusion matrix. Sensitivity and specificity. ROC curve. Area below ROC curve (AUC). <i>Practice</i> Application of software tools and implementation of solutions in R environment and Python programming language. Work on exercises implies the application of acquired knowledge to solve specific tasks in the field of supervised machine learning. <i>Project-based exercises</i> In cooperation with the company Vodéna, students will have the opportunity to realize internships and create projects based on real problems. With its many years of experience working on projects such as monitoring data integration and system support, Vodéna enables students to connect directly with the industry and work in real conditions, meaning that the projects derived from student internships will have direct application in practice.
Literature: 1. Tom Mitchell, <i>Machine Learning</i> . New York: Mc Graw-Hill, 1997.

2. Ethem Alpaydin, Introduction to Machine Learning, Third Edition, The MIT Press Cambridge, Massachusetts, London, England, 2014.
3. John D. Kelleher, Brian Mac Namee, Aoife D'Arcy, Fundamentals of machine learning for predictive data analytics, Algorithms, Worked Examples, and Case Studies, The MIT Press Cambridge, Massachusetts, London, England, 2015.
4. Kevin P. Murphy, Machine Learning: A Probabilistic Perspective, The MIT Press Cambridge, Massachusetts, London, England, 2012.
5. Stuart Russel, Peter Norwig, Artificial Intelligence: a modern approach, translation of the 3rd edition, RAF School of Computing, Belgrade/CET Computer Equipment and Trade, Beograd / Portalibris, Beograd, 2011, (Veštačka inteligencija, savremeni pristup, prevod trećeg izdanja, RAF Računarski fakultet, Beograd/ CET Computer Equipment and Trade, Beograd / Portalibris, Beograd, 2011).

No. of active teaching hours:	Lectures: 30	Practice: 30
--------------------------------------	---------------------	---------------------

Teaching methods

Lectures: Lectures and discussions with the use of multimedia content; case studies.

Practice lessons: Practical work with e-learning tools, project work; the assistant provides all the necessary assistance to the students. Interactive participation of students, which includes analysis of cases from the practice, development of project tasks within the content of the subject.

Examination (maximum number of points 100)

Exam prerequisites	70 points	Final exam	30 points
student's participation during lectures		oral	20
practical exercises		written	10
test(s)	10+10		
seminar(s)			
project	50		
other			

Study program: MAS Artificial Intelligence			
Course title: MASTER THESIS			
Teacher(s): All teachers in the study program			
Course status: Mandatory			
No. of ECTS: 15			
Prerequisites: Passed all exams from the master's academic studies			
Course objective: The aim of the master thesis is for the student to show the ability to independently process a topic in the field of informatics. The student should also show that he / she can use the available software and available literature (including literature from the Internet), write the paper correctly and precisely, know how to list the used literature and present his / her work orally in a precise way.			
Course learning outcomes: The student showed independence in processing the given topic and precision in writing the text. The student also showed that he / she can make an electronic presentation of his work.			
Course contents: The master's thesis is an independent student's work made in writing, with instructions of and consultations with the subject teacher. The student chooses a topic for the preparation of a master's thesis in the field of scientific-professional and professional-applied subjects. The paper is the result of previous practical research in the form of a project task.			
Literature: Depends on the chosen topic.			
No. of active teaching hours:		Lectures: 0	Practice: 10
Teaching methods The student submits at least three hard copies of the completed work to the subject teacher and one copy to the University library. The student also submits his / her work to the University library in electronic form. The Labour Defence Commission is formed by the Council for IMT Areas. The date and time of the public defence of the paper are published on the notice board of the University at least five working days before the scheduled defence date, and the assessment of the candidate's success in this exam is announced to the candidate immediately after the defence, with appropriate explanation.			
Examination (maximum number of points 100)			
Exam prerequisites		Final exam	
student's participation during lectures		oral	
practical exercises		written	
test(s)			
seminar(s)			
project			
other			

Study programme: MAS Artificial Intelligence
Course title: MATHEMATIC – SELECTED CHAPTERS
Lecturer: Nenad Stojanović
Course status: Compulsory
No. of ECTS: 6
Prerequisites: /
Course objectives Acquiring knowledge from advanced chapters of mathematics, especially in relation to differential equations, functional series, partial differential equations, vector spaces and vector analysis, complex analysis, graph theory, optimization, probability and statistics.
Course learning outcomes Upon completion of the course, students will be able to use the acquired knowledge in the fields of computer science. Candidates will be able to use different mathematical tools, such as: differential equations, Fourier transform, partial differential equations, vector analysis, complex analysis, graphs, probability and statistics as a tool to solve different problems.
Course contents <i>Lectures</i> Ordinary Differential Equations. Basic terms. First Order Differential Equations. Higher-Order Differential Equations. Existence and uniqueness of solutions. Linear Differential Equations with constant coefficients. Nonhomogeneous Linear Differential Equations. Vector Spaces and elements of Vector Analysis. Eigenvalues and Eigenvectors of a linear operator and square matrix. Diagonalization of endomorphism and square matrix. Invariant subspaces. Cayley-Hamilton theorem. Scalar product axioms and basic features. Schwarz inequality. Gram-Schmidt orthogonalization. Orthogonal complement and the Spectral Theorem. Fourier analysis. Partial differential equations. Functional arrays and rows. Ordinary and Uniform convergence of functions. Cauchy's criterion for convergence. Uniform convergence of functional series. Weierstrass criterion, Abel's test and Dirichlet's test. Functional properties of a boundary function. Degree series, analytic functions. Trigonometric Fourier series. First-order partial differential equations. Classification and canonical form of second-order partial differential equations. Hyperbolic equations. Parabolic equations. Elliptic equations. Integral equations. Laplace transform. Complex numbers. Complex variable function. Differentiability. Geometric interpretation. Graph optimization. Space probability. σ -field. Probability. Conditional probability. Law of total probability. Independence (probability theory). Random variable. Types of random variables (discrete and continuous). Probability distribution. Some important distributions of random variables. Mathematical expectation. Moments. Dispersion. Chebyshev's inequality. Covariance and Correlation coefficient. Conditional expectation. Statistical model and task of mathematical statistics. Population, feature, sample. Order statistics and variation series. Empirical distribution function. Sample distributions. Sampling middle and sample dispersion and their numerical characteristics. T-distribution. Chi-squared distribution. <i>Practice</i> Practical use of knowledge acquired through theoretical classes. <i>Project</i> Students will have the opportunity to create projects based on real mathematical problems. This shall represent the grounds for different courses in the field of artificial intelligence.
Literature: 1. Erwin Kreyszig, <i>Advanced Engineering Mathematics</i>, JOHN WILEY & SONS, INC., ISBN 978-0-470-45836-5 2. Д. Аднађевић, З. Каделбург, <i>Математичка анализа I</i>, Београд, 1998. 3. С. Раденовић, <i>Збирка задатака из математичке анализа I</i>, Београд, 1997.

4. Д. Цветковић, С. Симић, <i>Одабрана поглавља из дискретне математике</i> , Академска мисао, Београд, 2012.			
5. Д. Аднађевић, З. Калдебург, <i>Математичка анализа II</i> , Наука, Београд, 1994.			
6. С. Раденовић, <i>Математичка анализа II – збирка задатака</i> , ПМФ Крагујевац, 1997.			
7. Љ. Петровић, <i>Теорија вероватноћа</i> , Економски факултет, Београд, 2006.			
No. of active teaching hours	Lectures: 45		Practice: 45
Teaching methods			
Lectures, exercises, independent work.			
Examination (maximum number of points 100)			
Exam prerequisites	70 points	Final exam	30 points
In class activity		oral exam	20
Practice		written exam	10
Test(s)	20+20		
Seminars			
Project	30		
other			

Study program: MAS Artificial Intelligence		
Course title: NEURAL NETWORKS		
Teacher(s): Vesna M. Ranković Lecturer from a foreign university		
Course status: Elective		
No. of ECTS: 10		
Prerequisites: /		
Course objective: Introducing students to the basic concepts of neural networks, different architectures and training algorithms. Enabling students to independently design neural networks for engineering applications.		
Course learning outcomes: Students will be able to independently implement different types of neural networks that can be further applied in many areas of engineering.		
Course contents: <i>Lectures</i> Definition of a neural network. Properties of neural networks. Neuron model. Types of activation functions. Neural network architectures. Presentation of knowledge in neural networks. General form of training rules. Heb's teaching. ADALINA. Single-layer perceptron. Multilayer perceptron. Backward error propagation algorithm, weight initialization, training coefficient, target function, correction rules, data set for training and generalization, number of hidden layers and number of neurons in hidden layers. Convergence problem. Classification and clustering with neural networks. Cohonen and Hopfield neural networks. Approximation of nonlinear functions by neural networks. Introduction to deep learning. Convolutional neural networks. Convolutional network architecture, input layer, convolution layer, compression layer, activation function layer, fully connected layer. Deep neural network training. <i>Practice</i> Exercises are performed in a computer classroom. Software is used that enables the implementation of various neural network architectures. <i>Project-based exercises</i> Search of available literature. Creating a project task individually or in a team. Application of acquired knowledge on a current problem from practice. Realization of problems in Python programming language, with libraries like opencv, numpy, scikit-learn, etc. Discussion on the obtained results, possibilities of optimization of network hyperparameters, acceleration, reduction of complexity, etc. In cooperation with the companies Vodéna and NGO Novi Sad Artificial Intelligence, students will have the opportunity to practice and apply theoretical knowledge acquired in the field of neural networks. With their many years of experience in working on various projects, these companies will provide students with direct contact with industry and work in real conditions, and projects derived from student practice will have direct application in industry.		
Literature: 1. M. T. Hagan, H. B. Demuth, M. H. Beale, O. D. Jesus, Neural Network Design, 2nd Edition. The book is available at: http://hagan.okstate.edu/NNDesign.pdf 2. Bishop, Neural Networks for Pattern Recognition, Oxford University Press, 2000.		
No. of active teaching hours:	Lectures: 30	Practice: 30
Teaching methods Lectures, auditory exercises, laboratory exercises, independent work.		
Examination (maximum number of points 100)		

Exam prerequisites	70 points	Final exam	30 points
student's participation during lectures		oral	10
practical exercises	50	written	20
test(s)			
seminar(s)			
project	20		
other			

Study program: MAS Artificial Intelligence			
Course title: SOFTWARE ENGINEERING 2			
Teacher (s): Ivan Krstić			
Course status: Elective			
No. of ECTS: 6			
Prerequisites: /			
Course objective: Understanding and mastering the concepts of software modeling and design using project samples. Learning standard graphical notation for UML modeling through 13 types of diagrams, as well as the most commonly used design patterns of structure, behavior and creation.			
Course learning outcome: A student knows the concepts of software modeling and design. A student is able to model complex software systems using the standard language UML 2. When designing software, a student is able to recognize the conditions for application and to apply adequate project samples from the GoF catalog of project samples.			
Course contents: <i>Lectures</i> An overview of UML modeling concepts and languages. Diagrams of classes, objects, packages, sequences, communications, cases of usage, activities, interaction overviews, states, components, layouts, complex structures, and time. Concepts and classification of project samples. Object and class patterns of structure (e.g. composition), behavior (e.g. observer) and creation (e.g. prototype). <i>Exercises</i> Auditory, laboratory demonstration and laboratory control exercises. Homework. <i>Project-based practice</i> Through one major or several smaller projects, students will be able to work and collaborate with companies such as Vodena, where they will have the opportunity to implement the acquired knowledge in practice and on real problems.			
Literature: 1. Veljović, A., UML Osnove objektnog modeliranja, Kompjuter biblioteka Čačak, 2005. 2. Gama, E., Helm, R., Johnson, R., Vlissides, J., "Gotova rešenja", CET, Beograd, 2002., Gama, E., Helm, R., Johnson, R., Vlissides, J., "Design Patterns", Addison-Wesley, 1998 3. Rumbaugh, J., Booch, G., Jacobson., I., "The Unified Modeling Language Reference Manual", 2nd edition, Addison-Wesley, 2005.			
No. of active teaching hours:		Lectures: 30	Practice: 30
Teaching methods Lectures, auditory exercises, laboratory exercises, independent work.			
Examination (maximum number of points 100)			
Exam prerequisites	70 points	Final exam	30 points
Student's participation during lectures		oral exam	20
Practical exercises		written exam	10
Test/s	40		
Seminar/s			
Project – based exercises	30		
Other			

Study program: MAS Artificial Intelligence			
Course title: SOFTWARE ENGINEERING			
Teacher (s): Nenad Filipović, Dalibor Nikolić			
Lecturer from industry: Bogdan Vukobratović			
Course status: Obligatory			
No. of ECTS: 10			
Prerequisites: -			
Course objective Упознавање са методама и техникама за развој софтвера у свим фазама животног циклуса.			
Course learning outcome			
Course contents: <i>Lectures</i> Introduction to software engineering. Fundamentals of deep learning. The course starts gradually with MLPs and moves to more complex concepts. Deep learning models. Kaggle components to explore multiple types of architectures. Fine-tuning and continuous model improvement. Model-based software creation. Software design. Basic principles and development of software documentation. Analysis phase. Structural design. Object-oriented design. Software application. Testing systems. Functional testing. Software metrics. Software maintenance. Software cost estimation. Functional rules. Data-oriented rules. Object-oriented analysis. Software specification and verification. Reverse engineering, quality, and standardization. Ergonomics, Project Management. <i>Practice</i> Data processing in the Python programming language. Application of software tools based on machine learning, including PyTorch, Keras, TensorFlow, data collection and preprocessing (normalization, standardization, etc.), work with continuous and discrete data. Work on exercises involves the application of acquired knowledge to solve specific current problems in various areas of machine learning (object recognition, image and video processing, text analytics, natural language processing, reference systems, and other types of classifiers). <i>Project-based practice</i> Creating a complex software project in a team or individual work. The project is designed to cover one of the complex problems of machine learning where the knowledge gained in lectures and exercises should be applied to solve a specific problem. Through the project, students aim to independently master the process of creating a workflow for deep learning, apply knowledge of deep learning to improve the model using real data, but also demonstrate the ability to present and communicate project results. All this will be realized in cooperation with Comtrade, which is a leading expert in the field of software engineering and employs young staff in its offices.			
Literature 1. BOOCH, Grady, et al. Object-oriented analysis and design with applications. ACM SIGSOFT software engineering notes, 2008, 33.5: 29-29. 2. ZHANG, A., Lipton, Z. C., Li, M., & Smola, A. J. Dive into deep learning. Unpublished Draft. Retrieved, 19, 2019. 3. LEWIS, N.D. Deep Learning Step by Step with Python: A Very Gentle Introduction to Deep Neural Networks for Practical Data Science, ISBN-10: 1535410264, 2016. 4. RASCHKA, Sebastian; MIRJALILI, Vahid. Python machine learning: Machine learning and deep learning with Python, scikit-learn, and TensorFlow 2. Packt Publishing Ltd, 2019.			
No. of active teaching hours:		Lectures: 30	Practice: 30
Teaching methods Lectures, auditory exercises, laboratory exercises, independent work.			
Examination (maximum number of points 100)			
Exam prerequisites	70 points	Final exam	30 points
Student’s participation during lectures		oral exam	20
Practical exercises	5+5	written exam	10
Test/s	10		
Seminar/s			
Project – based exercises	50		

Other			
-------	--	--	--

Study program: MAS Artificial Intelligence			
Course title: STUDY RESEARCH			
Teacher (s): All teachers of the study programme			
Course status: Obligatory			
No. of ECTS: 10			
Prerequisites: enrolled in a final semester of basic academic studies			
Course objective: To introduce students to the rules, procedures, and processes of independent and comprehensive research work, as well as writing professional/scientific texts.			
Course learning outcomes: The student is trained in the application of principles and theoretical basics, practical knowledge acquired during the studies, and for the use of both written literature and content that can be found on the Internet, thus being able to independently improve their knowledge.			
Course contents: <i>Study Research</i> The content of the course is determined by the mentor for each candidate separately and is made by the candidate's independent work on the topic he has selected from the list of available topics for the Final Paper. This work is continuously monitored by the mentor. The student should also research, for the preparation of the Final Paper, the basic results of the narrow areas on which the Final Paper is based. The student should master the style of writing and be able to use literature independently, including the reviewed texts (scientific works and books).			
Literature Literature is determined by the mentor, depending on the subject of the Final Paper.			
No. of active teaching hours:		Lectures:: 0	Practice: 10
Teaching methods The mentor introduces a student to the subject of the Final Paper and recommends the literature. The student works independently in consultation with the mentor. If necessary, the student can also consult with other teachers, who deal with issues related to the topic of work itself.			
Examination (maximum number of points 100)			
Exam prerequisites	70 points	Final exam	30 points
student's participation during lectures		oral exam	30
practice	70	written exam	
test/s			
seminar/s			
project	70		
other			

Study program: MAS Artificial Intelligence			
Course title: VIRTUAL REALITY SYSTEMS			
Teacher(s): Filipovic D. Nenad, Isailovic M. Velibor, Sasa Cukovic			
Course status: Elective			
No. of ECTS: 6			
Prerequisites: -			
Course objective: Enabling students to design and implement virtual/augmentative reality systems. Augmented and virtual reality equips students with theoretical and practical knowledge to enable them to participate in the design and development of technology that supports the fast video game market, as well as providing transferable career-relevant skills in the wider interactive entertainment, media, and communications industry.			
Course learning outcomes: Upon completion of the course, students will be able to use the acquired knowledge and skills to develop virtual/augmentative reality systems with practical experience with various VR (Virtual reality) devices (such as Microsoft HoloLens Development Edition, Oculus Rift, Oculus Go), AR (Augmented reality) devices (like Magic Leap One) or work in Mixed reality.			
Course contents: <i>Lectures</i> Milgram's real-virtual continuum and metrics of virtuality/augmentation. Elements of VR systems, VR devices - immersive and non-immersive class, 3D audio, 3D video and tactile devices, body, head, limb and eye-tracking techniques, VR / AR interactivity, VR system programming techniques on examples (e.g. using OpenGL). Examples of VR systems, augmentative reality systems, basic architectures of AR systems, examples of AR systems. <i>Practices</i> <i>Exercises are performed in a computer classroom. Simple VR / AR scenes with non / semi / immersive devices are developed in a program (e.g. using OpenGL or Unity) or a modern authoring system.</i> <i>Project teaching</i> <i>Creating a project with a practical and specific problem. Project development will be organized in cooperation with NVS Strategy, which has many years of experience in the development of virtual reality applications. Project testing using emulators and real available hardware. Organizing a competition to create the best game within the group.</i>			
Literature: 1. R. Szeliski: Computer Vision: Algorithms and Applications, Springer, 2010. (ISBN 978-1848829343) 2. E.R. Davis: Computer and Machine Vision: Theory, Algorithms, Practicalities, Academic Press, 2012. (ISBN 978-0123869081) 3. Jerald, J. (2015). The VR Book: Human-centered design for virtual reality. Morgan & Claypool. 4. Linowes, J. (2015). Unity virtual reality projects. Packt Publishing Ltd.			
No. of active teaching hours		Lectures: 30	Practices: 30
Teaching methods			
Lectures, auditory exercises, laboratory exercises, independent work of students.			
Exam prerequisites	70 points	Final exam	Points
Student's participation during lectures	5	Oral exam	30
Practice	15		
Test/s			
Seminar/s			

Projects	50		
Other			