THE MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
LVIV POLITECHNIC NATIONAL UNIVERSITY

ACCEPT

Rector of
Lviv Polytechnic
National University
_____ Bobalo Yu.
26 05 2020 p.

EDUCATIONAL-PROFESSIONAL PROGRAM
"ARTIFICIAL INTELLIGENCE"
THE SECOND (MASTER'S) LEVEL OF HIGHER EDUCATION

BRANCH OF KNOWLEDGE	12 information technology
SPECIALTY	122 computer science and information technology
PROGRAM	Artificial intelligence
QUALIFICATION	Master of computer science for the specialized system of artificial intelligence

Considered and approved
by Lviv Polytechnic National University
Scientific Council
"26 05 2020 p.
Protocol № 63

Lviv 2020

LETTER OF AGREEMENT
educational-professional programs

The level of higher education	The second (master's)
Branch of knowledge	12 information technology
Specialty	122 computer science
Specialization	Artificial intelligence
Qualification	Master of computer science for the specialized system of artificial intelligence

DEVELOPED AND APPROVED

Scientific and methodical Commission 122 the speciality "computer science"
Protocol number 6
"16 04 2020
The Chairman of the 122 speciality
U. Marikutsa

RECOMMEND

The scientific-methodical Council of the University
Protocol number 48
"20 05 2020
The head of the CU
A.Zagorodniy

AGREED

The Vice-Rector on scientific and pedagogical
Lviv Polytechnic National University
O.Davydchak
20 05 2020

Head of educational and methodical Department
V.Sviridov
20 05 2020

Director of Educational-Scientific Institute of computer sciences and information technologies
M.. Medykovskyy
16 04 2020

CREATED BY

Developed in accordance with the standard of higher education of Ukraine for the specialty 122 Computer science for the second (master's) level, approved and put into effect by the order of the Ministry of Education and Science of Ukraine dated April 28, 2022. No. 393 by the working group of the Scientific and Methodological Commission of the specialty 122 "Computer Sciences" of the National University "Lviv Polytechnic" in the composition of::

Nataliya Shakhovska	- doctor of Sciences, Professor, head of AI DEPARTMENT
Yaroslav Matviychuk	- doctor of Sciences, Professor, professor of AI DEPARTMENT
Roman Kaminskyy	- doctor of Sciences, Professor, professor of AI DEPARTMENT
Nataliia Melnykova	-PhD, assoc. prof, assoc. professor of AI DEPARTMENT
Nataliya Boyko	– PhD, assoc. prof, assoc. professor of AI DEPARTMENT
Olena Vovk	– PhD, assoc. prof, assoc. professor of AI DEPARTMENT
Ivan Zagorodniy	– Solutions Lead at SoftServe
Andriy Natiyaglyy	– student

guarantor _____ Nataliya Shakhovska

The project of the educational-professional programs are discussed and approved at the meeting of the Scientific Council of the Educational-Scientific Institute of computer sciences and information technologies

Protocol number _____ from _____ 2020

Chairman of the Scientific Council _____ / M. Medykovskyy/

APPROVED AND GIVEN EFFECT

The Rector of the Lviv Polytechnic National University

"02" 06 2020 # 262-1-10

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1. **Profile programs master's degree on a speciality "Computer science" specialization "Artificial intelligence"**

1 – General information	
The full name of the institution of higher education and the structural unit	**Lviv Polytechnic National University**
The full name of the qualification in the original language	Master of computer science for the specialized artificial intelligence
The official name of educational program	Artificial intelligence
Type of diploma and the volume of educational program	A master's degree, unit, 90 ECTS, term of studies is 1.5 years
The availability of accreditation	Accredited By The Ministry Of Education
Cycle/level	The NQF of Ukraine – 7 level, FQ-EHEA-second cycle, QF-LLL-7 level
Prerequisites	The Bachelor's degree
Language (s) of teaching	Ukrainian language
Basic concepts and their definitions	The program uses the basic concepts and their definitions according to the law of Ukraine "on higher education"
2 – the goal of the educational program	
	Ensure that students acquire advanced theoretical and practical knowledge, skills and understanding related to the areas of artificial intelligence systems that will give them the ability to efficiently perform the tasks of the innovative character of the appropriate level of professional activity, which is focused on the study and solution of complex tasks of designing and developing information systems to meet the needs of science, business and businesses in various sectors. Be prepared to successfully mastering more advanced programs for scientific researchers and developers of systems of artificial intelligence (SCHOOL Lane), experts in the field of systems and methods for natural language processing (OM-line).
3-characteristics of the educational program	
Subject area (industry knowledge, speciality)	Systems of artificial intelligence: artificial intelligence, natural language processing techniques to other

The orientation of the educational program	**Orientation research**. The emphasis on personal and group learning outcomes; emphasis on Computational modeling of processes of development of applied information systems analysis and synthesis of data and knowledge, as well as natural language processing systems. Research line is professionally oriented, expert line is practically oriented.
The main focus of educational programs and specializations	is in-depth knowledge of artificial intelligence systems and methods of natural language processing, as well as the ability to use them in information systems design. In the MSAI program, students learn to apply creative thinking, algorithmic design, and coding skills to build modern AI systems
Features and differences	There are 2 lines: 1 Professional and 1 practical. The program develops promising directions of computer modeling of the processes of development of modern software complexes and decision support systems, deep knowledge of the systems of artificial intelligence. Also made emphasis on modeling systems analysis of natural language. Developing structural and object oriented approaches to designing software complexes.
4 – the suitability of graduate educational program to employment and further study	
Suitability for the employment	Jobs in the field of information technology, communications and the management of it projects: IT-companies, finance companies, insurance companies, government agencies, counseling.
Further training	All programs Phd. field of knowledge "information technology".
5 – Teaching and evaluation	
Teaching and learning	Lectures, practical classes, performing coursework, research laboratory work, independent work based on textbooks, manuals and lectures, consultations with teachers, preparation of master's work.
Evaluation	Written and oral examinations, laboratory reports, abstracts, presentations, protection of master's work.
6 – Software competence	
Integrated competence **(INT)**	The ability to use advanced theoretical and fundamental knowledge in the field of information technology, artificial intelligence for effective solving of complex specialized problems and practical problems during professional activities or in the learning process that involves their use for the development of complex systems, which are characterized by uncertain conditions.

Professional competence of the specialty **(FC)**	1) the ability of the flexible way of thinking, which gives the opportunity to understand and solve problems and tasks while maintaining a critical attitude to the established scientific concepts; 2) the ability to use advanced theoretical and fundamental knowledge in the field of artificial intelligence for the development of complex systems; 3) the ability to identify, analyze and synthesize the solution of scientific problems on the abstract level by their decomposition on the components that you can explore the more and less important aspects of; 4) ability to construct appropriate models of complex systems, to investigate them for building projects of information systems; 5) ability to develop and promote models of information systems by means of computer simulation; 6) the ability for communication with colleagues from this area for scientific achievements, both on a general level and at the level of experts, the ability to make oral and written reports, discuss scientific topics in mother tongue and in English; 7) ability to hold an oral presentation and write a meaningful article on the results of the studies as well as modern concepts in systems of artificial intelligence and natural language processing techniques; 8) ability to analyze and formulate conclusions for different kinds of difficult management problems in various sectors of the national economy; 9) ability to articulate (making the presentation, or introducing reports) new hypotheses and research objectives in the field of artificial intelligence and natural language processing to choose the proper directions and appropriate methods for their solution; 10) ability to perceive new gained knowledge in computer science, information technology and artificial intelligence and integrate them with the already existing; 11) the ability to explore and critically evaluate new information technologies, models and methods of artificial intelligence, based on professional in these fields of scientific literary sources.
Professional competency specializations **(FKS)**	**For a line of deep learning** 1) the ability to effectively use the methods of in-depth training for applied tasks; 2) the ability, on the basis of mathematical models and methods of artificial intelligence, to design and parameterize components of the intellectual information system;

	3) the ability to formulate requirements for the development of intelligent systems; **For a line of artificial intelligence systems** 4) the ability to orientate at the level of a specialist in a certain narrow area of artificial intelligence, which lies outside the chosen specialization; 5) the ability to effectively carry out a systematic analysis, to select the conceptual model of the information system environment on the basis of mathematical models and methods of artificial intelligence, parameterization of components of the intellectual information system; 6) the ability to be the leader of the development and implementation of the intellectual information system project;
7-Program learning outcomes	
Learning outcomes	LO1. Student able to communicate, including oral and written communication in Ukrainian and foreign languages LO2. Student able to apply principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed independent decisions. LO3. Student able to realize the need for lifelong learning by deepening the existing and acquiring new professional knowledge and skills. LO4. Student able to formulate and solve a research problem, collect information, present and defend the conclusions in the scientific context LO5. Student able to process, analyze and evaluate information sources with different structure using appropriate machine learning model (regression, classification, clustering, segmentation etc.). LO6. Student able to develop advanced information technologies based on assessment of requirements and available datasets. LO7. Student able to collect and preprocess data from various data sources (tabular, textual, images, times series etc.) including data with outliers and uncertainty for different problems solving LO8. Student able to provide end-to end machine learning process: data ingestion and preprocessing; model train, validation, inference, and feedback loop. LO9. Student able to perform Machine Learning and Deep Learning models selection, development, evaluation, and tuning. LO10. Student able to assess the adequacy of the proposed recommendations for the creation and maintenance of safe working and living conditions, ensuring civil protection

	artificial safety, and responding to emergencies and eliminating their consequences for a given information system. LO11. Student able to perform data analysis (including big data) using modern tools. LO12. Student able to implement and deploy event-driven data pipelines. LO13. Student able to possess sufficient scientific skills to successfully carry out research under a mentor's supervision. LO14. Student able to use a variety of methods, including modern information technology, for effective communication at the professional and social levels LO15. Student able to develop mathematical models and algorithms for pattern recognition and object classification in intelligent decision support systems LO16. Student able to create mathematical models and algorithms for decision making using algorithmic and software tools, using machine learning, artificial neural networks, evolutionary modeling, genetic optimization methods, inductive modeling and fuzzy logic mathematical apparatus LO17. Student able to perform natural language processing using appropriate methods for text retrieval, emotions and sentiment retrieval LO18. Student able to build models of information flows, design datawarehouses and knowledge base, using modern techniques and standards for the development of information systems. LO19. Student able to use professional and specialized knowledge and practical skills to optimize the design of information systems of any complexity and to solve specific tasks of designing intelligent information systems that manage objects of different physical natures LO20. Student able to organize, configure and develop a Web system, using the principles of distributed systems, hypertext systems, appropriate technical and software tools.
Skill **(UM)**	**For a line of deep learning** 1) The ability to use knowledge and understanding related to the basic areas of artificial intelligence and the design of decision support systems. 2) Using the methods of deep machine learning, the ability to create decision support systems. 3) Ability to develop mathematical models and algorithms for image recognition and classification of objects in intelligent decision-making systems. 4) Ability to perform parallel processing and preliminary analysis of data. 5) Ability to apply the theory of databases in the methods of

	pre-processing data. **For a line of artificial intelligence** 6) Ability to use knowledge and understanding related to the basic areas of artificial intelligence and the design of decision support systems. 7) The ability to create mathematical models and algorithms for decision making using algorithmic and software tools, using machine learning, artificial neural networks, evolutionary modeling, genetic optimization methods, inductive modeling and fuzzy logic mathematical apparatus. 8) The ability to develop mathematical models and algorithms for pattern recognition and object classification in intelligent decision-making systems in the design of image recognition systems with the help of appropriate mathematical support, using procedures of formal representation of the system. 9) Ability to develop distributed artificial intelligence systems in the conditions of resource constraints and the necessity of decomposing information processing tasks with the help of models of the theory of distributed artificial intelligence and decision-making theory using artificial intelligence in gaming applications. 10) Ability to apply theoretical and fundamental knowledge of functional dependencies for the development of databases and knowledge. 11) The ability to develop skills in the development of a functional environment of open systems, application programming interfaces, applications and applications with properties: expandability, scalability, interoperability, integration ability, availability and reliability of the system.
Communication **(Com)**	1) Ability to communicate including oral and written communication in English and foreign languages (English, German, Italian, French, Spanish). 2) the ability to use a variety of methods, including modern information technologies, to effectively communicate on a professional and social level.
Autonomy and responsibility **(AiV)**	1) ability to adapt to new situations and take appropriate decisions. 2) ability to realize the need for lifelong learning with the aim of deepening the acquired and gaining new expertise. 3) ability to responsibly treat of work, make decisions, achieve the goal of compliance with the requirements of professional ethics.

	4) ability to demonstrate understanding of the basic ecological principles, labor protection and safety and their application of self-government.

8 – resource providing program	
The specific characteristics of the personnel software	80% of the teaching staff involved to teaching professionally oriented disciplines of specialty 122 "computer science and information technology" for specialization in artificial intelligence have scientific degrees with experience of research work in 40%.
Specific characteristics of logistics	The use of modern computer equipment and software.
The specific characteristics of the informational and methodological support	The use of a virtual learning environment of LPNU and author of the developments of scientific and pedagogical workers, namely textbooks and manuals with signature stamp MES of Ukraine series of "computer science", "Computing and consolidated information "; textbooks and teaching materials approved by the Academic Council of Lviv Polytechnic.
9 – academic mobility	
National credit mobility	Based on bilateral agreements between Lviv Polytechnic national University and technical universities of Ukraine.
International credit mobility	Based on bilateral agreements between the Lviv Polytechnic national University and higher educational institutions of foreign countries.
Foreign applicants for higher education	It is possible, after studying the course.

2. Distribution of content educational-professional programs groups of components and cycle training

#	Cycle training	The volume of the workload in the applicant's higher education (loans/%)			
		The required components of the educational-professional programs	Optional components of the educational-professional programs		Total for the entire period of training
1	2	3	4		5
1.	The cycle of General preparation	**3/3,3**	**3/3,3**		**6/6.6**
2.	Cycle training	**42/46,7**	**37/41.1**	**5/5,6**	**84/93,4**
Total for the entire period of training		**45/50**	**40/44.4**	**5/5,6**	**90/100**

3. List of component educational-professional programs

Code	The name component of LC	Volume component in ECTS	The form of the final control
1	2	3	5
The required components of the specialty			
And the cycle of General preparation			
MC1	Information marketing and management	3	differential. test
	Total cycle:	**3**	
II. Cycle training			
MC2	Professional and civil security	3	differential. test
MC3	Innovative information technology (with course work)	9	exam
MC4	Scientific process *	5	exam
MC5	Machine learning	5	exam
MC6	Big data analysis methods*	5	exam
MC7	Deep Learning Systems Design	5	exam
MC8	Practice	9	differential. test
MC9	Completion of master's qualification work	16,5	master thesis
MC10	Defense of master's qualification work	4,5	

Optional components of the educational-professional programs *And the cycle of General preparation*			
E11	Semantic analysis	3	differential. test
E12	Artificial intelligence in game design	5	exam
	Total cycle:	**8**	
blocks components			
II. Cycle training			
Components selectively block 1: **Systems of artificial intelligence**			
EC11	Intelligent Text Analysis and Text Tonality Analysis*	7	exam
EC12	Deep Learning Modelling and Optimization	5	exam
EC13	Image Processing Based on Artificial Intelligence Methods	5	exam
	Total cycle:	**17**	
	Together, the sample components	**22**	

Components of selective blok2: **Deep learning**			
EC14	Web Mining*	5	exam
EC15	Data Visualization	5	exam
EC16	Evolutionary Programming	7	exam
	Total cycle:	**17**	
	Together, the sample components	**22**	

*courses in English

4. The form of certification of applicants for higher education

Certification of applicants for higher education is examining the compliance of the level and volume of knowledge, skills and competencies the applicant's higher education, which trained for the educational program, the requirements of the standards of higher education.

Certification of graduates of specialty 122 "computer science and information technologies" specialization "of the system of artificial intelligence" is held in the form of protection the degree of work and ends with the issuance of documents of the standard pattern of awarding him the degree awarding qualifications: Master of computer science and information technologies for specialization of artificial intelligence. Certification is carried out openly and publicly.

5. Structure, content and consistency between Learning Outcomes, Teaching Methods, and Assessment for Mandatory/Elective Courses of the Study Programme "Artificial Intelligence"

Mandatory/Elective Courses	Learning Outcomes	Teaching Methods	Assessment
MC1. Information Marketing and Management	**LO1.** Student able **to communicate**, including oral and written communication in Ukrainian and foreign languages.	**Project-based learning.** Students as individuals speaking (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	Students make oral presentations on obtained results.
	LO2. Student able **to apply** principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed independent decisions.	**Role plays:** Students acting out instructor-assigned roles team members, improvising the script of teamwork, in a realistic and problematic social or interpersonal situation.	Students create teams and distribute responsibilities for obtained results.
	LO3. Student able **to realize** the need for lifelong learning by deepening the existing and acquiring new professional knowledge and skills.	**Project-based learning**: Students (as individuals or in groups) applying course knowledge to realize the need for lifelong learning by deepening the existing and acquiring new professional knowledge and skills.	Students have an individual interview with an instructor on obtained results.
MC2. Innovative Information Technology	**LO2.** Student able **to apply** principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed independent decisions.	**Role plays:** Students acting out instructor-assigned roles team members, improvising the script of teamwork, in a realistic and problematic social or interpersonal situation.	Students create teams and distribute responsibilities for obtained results.

	LO4. Student able to **formulate and solve** a research problem, collect information, present and defend the conclusions in the scientific context.	**Project-based learning.** Students as individuals applying principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed, independent decisions.	Students have an individual interview with an instructor on obtained results.
	LO6. Student able **to develop** advanced information technologies based on assessment of requirements and available datasets.	**Project-based learning**: Students (as individuals or in groups) applying course knowledge to develop advanced information technologies based on assessment of requirements and available datasets.	Students prepare a written report on the analysis of requirements and available datasets.
	LO12. Student able **to implement** and deploy event-driven data pipelines.	**Problem-based learning**: Student groups conducting outside research of implementing and deploying the event-driven data pipelines.	Students prepare a written report on implementing and deploying the event-driven data pipelines.
	LO13. Student able **to possess** sufficient scientific skills to successfuliy carry out research under a mentor's supervision.	**Problem-based learning**: Student groups conducting outside research under a mentor's supervision.	Students prepare a written report on state of the art analysis.
	LO14. Student able **to use** a variety of methods, including modern information technology, for effective communication at the professional and social levels.	**Project-based learning**: Students (as individuals or in groups) applying course knowledge to communicate at the professional and social levels and implement information technologies with	Students prepare a written report on results of communicatio n at the professional and social levels and

		elements of artificial intelligence.	about project realization.
MC3. Machine Learning	**LO3.** Student able **to realize** the need for lifelong learning by deepening the existing and acquiring new professional knowledge and skills.	**Project-based learning**: Students (as individuals or in groups) applying course knowledge to realize the need for lifelong learning by deepening the existing and acquiring new professional knowledge and skills.	Students have an individual interview with an instructor on obtained results.
	LO5. Student able **to process, analyze and evaluate** information sources with different structure using appropriate machine learning model (regression, classification, clustering, segmentation etc.).	**Problem-based learning:** Student groups conducting outside research on processing, analyzing and evaluation of information sources with different structure using appropriate machine learning model (regression, classification, clustering, segmentation etc.).	Students prepare a written report on applying machine learning methods for processing, analyzing and evaluation of information sources with different structure.
	LO8. Student able **to provide** end-to end machine learning process: data ingestion and preprocessing; model train, validation, inference, and feedback loop.	**Problem-based learning:** Student groups conducting outside research on the application of machine learning methods to devise one or more solutions or resolutions to fuzzy problems of classification, clustering, and recognition presented in a realistic story or situation.	Students prepare a written report on applying machine learning methods for an actual situation.
	LO9. Student able **to perform** Machine Learning and Deep Learning models	**Project-based learning:** Students (as individuals or in groups) applying course knowledge to	Students prepare a written report on classification,

	selection, development, evaluation, and tuning.	produce computer code based on machine learning and deep learning for solving classification, clustering, and recognition problems.	clustering, and recognition problem-solving.
MC4. Scientific process	**LO2.** Student able **to apply** principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed independent decisions.	**Project-based learning.** Students as individuals applying principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed, independent decisions.	Students have an individual interview with an instructor on obtained results.
	LO10. Student able **to assess** the adequacy of the proposed recommendations for the creation and maintenance of safe working and living conditions, ensuring civil protection artificial safety, and responding to emergencies and eliminating their consequences for a given information system.	**Inquiry-based learning:** Students learning or applying material for the creation and maintenance of safe working and living conditions in order to answer a question, conduct an experiment, or interpret data.	Students prepare a written report on creating and maintaining safe working and living conditions.
MC5. Big Data Analysis Methods	**LO2.** Student able **to apply** principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed independent decisions.	**Project-based learning.** Students as individuals applying principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed, independent decisions.	Students have an individual interview with an instructor on obtained results.
	LO5. Student able **to process, analyze and evaluate** information sources with different structure using appropriate machine	**Problem-based learning:** Student groups conducting outside research on processing, analyzing and evaluation of	Students prepare a written report on applying machine learning

	learning model (regression, classification, clustering, segmentation etc.).	information sources with different structure using appropriate machine learning model (regression, classification, clustering, segmentation etc.).	methods for processing, analyzing and evaluation of information sources with different structure.
	LO7. Student able **to collect and preprocess** data from various data sources (tabular, textual, images, times series etc.) including data with outliers and uncertainty for different problems solving.	**Problem-based learning:** Student groups conducting outside research on the application of data collection and preprocessing, gathered from various data sources (tabular, textual, images, times series etc.) including data with outliers and uncertainty for different problems solving.	Students prepare a written report on applying methods and algorithms of data collection and preprocessing, gathered from various data sources (tabular, textual, images, times series etc.) including data with outliers and uncertainty for different problems solving.
	LO8. Student able **to provide** end-to end machine learning process: data ingestion and preprocessing; model train, validation, inference, and feedback loop.	**Problem-based learning:** Student groups conducting outside research on the application of pattern recognition and computer vision to devise one or more solutions or resolutions to fuzzy problems of detection, tracking, or classification presented in a realistic story or situation.	Students prepare a written report on applying methods and algorithms of pattern recognition and computer vision.

	LO11. Student able **to perform** data analysis (including big data) using modern tools.	**Problem-based learning:** Student groups conducting outside research on the application of data performing and analysis (including big data) using modern tools and special software architectures.	Students prepare a written report on applying methods and algorithms of pattern recognition and computer vision.
MC6. Deep Learning Systems Design	**LO3.** Student able **to realize** the need for lifelong learning by deepening the existing and acquiring new professional knowledge and skills.	**Project-based learning**: Students (as individuals or in groups) applying course knowledge to realize the need for lifelong learning by deepening the existing and acquiring new professional knowledge and skills.	Students have an individual interview with an instructor on obtained results.
	LO9. Student able **to perform** Machine Learning and Deep Learning models selection, development, evaluation, and tuning.	**Project-based learning:** Students (as individuals or in groups) applying course knowledge to produce computer code based on machine learning and deep learning for solving classification, clustering, and recognition problems.	Students prepare a written report on classification, clustering, and recognition problem-solving.
	LO12. Student able **to implement** and deploy event-driven data pipelines.	**Problem-based learning**: Student groups conducting outside research of implementing and deploying the event-driven data pipelines.	Students prepare a written report on implementing and deploying the event-driven data pipelines.
	LO13. Student able **to possess** sufficient scientific skills to successfully carry out	**Problem-based learning**: Student groups conducting	Students prepare a written report

	research under a mentor's supervision.	outside research under a mentor's supervision.	on state of the art analysis.
MC7. Artificial Intelligence in Games	**LO1.** Student able **to communicate**, including oral and written communication in Ukrainian and foreign languages.	**Project-based learning.** Students as individuals speaking (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	Students make oral presentations on obtained results.
	LO6. Student able **to develop** advanced information technologies based on assessment of requirements and available datasets.	**Project-based learning**: Students (as individuals or in groups) applying course knowledge to develop advanced information technologies based on assessment of requirements and available datasets.	Students prepare a written report on the analysis of requirements and available datasets.
	LO12. Student able **to implement** and deploy event-driven data pipelines.	**Problem-based learning**: Student groups conducting outside research of implementing and deploying the event-driven data pipelines.	Students prepare a written report on implementing and deploying the event-driven data pipelines.
	LO14. Student able **to use** a variety of methods, including modern information technology, for effective communication at the professional and social levels.	**Project-based learning**: Students (as individuals or in groups) applying course knowledge to communicate at the professional and social levels and implement information technologies with elements of artificial intelligence.	Students prepare a written report on results of communication at the professional and social levels and about project realization.

EC11. Intelligent Text Analysis and Text Tonality Analysis	**LO3.** Student able **to realize** the need for lifelong learning by deepening the existing and acquiring new professional knowledge and skills.	**Project-based learning**: Students (as individuals or in groups) applying course knowledge to realize the need for lifelong learning by deepening the existing and acquiring new professional knowledge and skills.	Students have an individual interview with an instructor on obtained results.
	LO4. Student able to **formulate and solve** a research problem, collect information, present and defend the conclusions in the scientific context.	**Project-based learning.** Students as individuals applying principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed, independent decisions.	Students have an individual interview with an instructor on obtained results.
	LO9. Student able **to perform** Machine Learning and Deep Learning models selection, development, evaluation, and tuning.	**Project-based learning:** Students (as individuals or in groups) applying course knowledge to produce computer code based on machine learning and deep learning for solving classification, clustering, and recognition problems.	Students prepare a written report on classification, clustering, and recognition problem-solving.
	LO17. Student able **to perform** natural language processing using appropriate methods for text retrieval, emotions and sentiment retrieval.	**Problem-based learning**: Student groups conducting outside research on the application of natural language processing using appropriate methods for text retrieval, emotions and sentiment analysis.	Students prepare a written report on applying methods and algorithms of natural language processing using appropriate methods for text retrieval,

			emotions and sentiment analysis.
EC12. Deep Learning Modelling and Optimization	**LO4.** Student able to **formulate and solve** a research problem, collect information, present and defend the conclusions in the scientific context.	**Project-based learning.** Students as individuals applying principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed, independent decisions.	Students have an individual interview with an instructor on obtained results.
	LO12. Student able **to implement** and deploy event-driven data pipelines.	**Problem-based learning**: Student groups conducting outside research of implementing and deploying the event-driven data pipelines.	Students prepare a written report on implementing and deploying the event-driven data pipelines.
	LO15. Student able **to develop** mathematical models and algorithms for pattern recognition and object classification in intelligent decision support systems.	**Project-based learning:** Students (as individuals or in groups) applying course knowledge to develop mathematical models and algorithms for pattern recognition and object classification in intelligent decision support systems.	Students prepare a written report on developing the mathematical models and algorithms for pattern recognition and object classification in intelligent decision support systems.
	LO16. Student able **to create** mathematical models and algorithms for decision making using algorithmic and software tools, using machine learning, artificial neural networks, evolutionary	**Project-based learning**: Students (as individuals or in groups) applying course knowledge to create mathematical models and algorithms for decision making	Students prepare a written report on creating the mathematical models and algorithms for decision

	modeling, genetic optimization methods, inductive modeling and fuzzy logic mathematical apparatus.	using algorithmic and software tools, using machine learning, artificial neural networks, evolutionary modeling, genetic optimization methods, inductive modeling and fuzzy logic mathematical apparatus.	making using algorithmic and software tools, using machine learning, artificial neural networks, evolutionary modeling, genetic optimization methods, inductive modeling and fuzzy logic mathematical apparatus.
EC13. Image Processing Based on Artificial Intelligence Methods	**LO9.** Student able **to perform** Machine Learning and Deep Learning models selection, development, evaluation, and tuning.	**Project-based learning:** Students (as individuals or in groups) applying course knowledge to produce computer code based on machine learning and deep learning for solving classification, clustering, and recognition problems.	Students prepare a written report on classification, clustering, and recognition problem-solving.
	LO12. Student able **to implement** and deploy event-driven data pipelines.	**Problem-based learning**: Student groups conducting outside research of implementing and deploying the event-driven data pipelines.	Students prepare a written report on implementing and deploying the event-driven data pipelines.
	LO15. Student able **to develop** mathematical models and algorithms for pattern recognition and object classification in	**Project-based learning:** Students (as individuals or in groups) applying course knowledge to develop mathematical	Students prepare a written report on developing the mathematical

	intelligent decision support systems.	models and algorithms for pattern recognition and object classification in intelligent decision support systems.	models and algorithms for pattern recognition and object classification in intelligent decision support systems.
	LO16. Student able **to create** mathematical models and algorithms for decision making using algorithmic and software tools, using machine learning, artificial neural networks, evolutionary modeling, genetic optimization methods, inductive modeling and fuzzy logic mathematical apparatus.	**Project-based learning**: Students (as individuals or in groups) applying course knowledge to create mathematical models and algorithms for decision making using algorithmic and software tools, using machine learning, artificial neural networks, evolutionary modeling, genetic optimization methods, inductive modeling and fuzzy logic mathematical apparatus.	Students prepare a written report on creating the mathematical models and algorithms for decision making using algorithmic and software tools, using machine learning, artificial neural networks, evolutionary modeling, genetic optimization methods, inductive modeling and fuzzy logic mathematical apparatus.
EC14. Web Mining	**LO3.** Student able **to realize** the need for lifelong learning by deepening the existing and acquiring new professional knowledge and skills.	**Project-based learning**: Students (as individuals or in groups) applying course knowledge to realize the need for lifelong learning by deepening the existing and acquiring new	Students have an individual interview with an instructor on obtained results.

		professional knowledge and skills.	
	LO7. Student able **to collect and preprocess** data from various data sources (tabular, textual, images, times series etc.) including data with outliers and uncertainty for different problems solving.	**Problem-based learning:** Student groups conducting outside research on the application of data collection and preprocessing, gathered from various data sources (tabular, textual, images, times series etc.) including data with outliers and uncertainty for different problems solving.	Students prepare a written report on applying methods and algorithms of data collection and preprocessing, gathered from various data sources (tabular, textual, images, times series etc.) including data with outliers and uncertainty for different problems solving.
	LO14. Student able **to use** a variety of methods, including modern information technology, for effective communication at the professional and social levels.	**Project-based learning**: Students (as individuals or in groups) applying course knowledge to communicate at the professional and social levels and implement information technologies with elements of artificial intelligence.	Students prepare a written report on results of communicatio n at the professional and social levels and about project realization.
	LO20. Student able **to organize, configure and develop** a Web system, using the principles of distributed systems, hypertext systems, appropriate technical and software tools.	**Project-based learning**: Students (as individuals or in groups) apply course knowledge to organize, configure and develop a Web system, using the principles of distributed systems,	Students prepare a written report on design documentatio n for the Web-system development.

		hypertext systems, appropriate technical and software tools.	
EC15. Data Visualization	**LO4.** Student able to **formulate and solve** a research problem, collect information, present and defend the conclusions in the scientific context.	**Project-based learning.** Students as individuals applying principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed, independent decisions.	Students have an individual interview with an instructor on obtained results.
	LO6. Student able **to develop** advanced information technologies based on assessment of requirements and available datasets.	**Project-based learning**: Students (as individuals or in groups) applying course knowledge to develop advanced information technologies based on assessment of requirements and available datasets.	Students prepare a written report on the analysis of requirements and available datasets.
	LO14. Student able **to use** a variety of methods, including modern information technology, for effective communication at the professional and social levels.	**Project-based learning**: Students (as individuals or in groups) applying course knowledge to communicate at the professional and social levels and implement information technologies with elements of artificial intelligence.	Students prepare a written report on results of communicatio n at the professional and social levels and about project realization.
	LO18. Student **able to build** models of information flows, design datawarehouses and knowledge base, using modern techniques and standards for the development of information systems.	**Project-based learning:** Students (as individuals or in groups) applying course knowledge to develop datawarehouses and knowledge base systems, to visualize the results of analysis	Students prepare a written report on results of datawarehous es and knowledge base development.

		using modern technics and tools.	
EC16. Evolutionary Programming	**LO2.** Student able **to apply** principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed independent decisions.	**Project-based learning.** Students as individuals applying principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed, independent decisions.	Students have an individual interview with an instructor on obtained results.
	LO4. Student able to **formulate and solve** a research problem, collect information, present and defend the conclusions in the scientific context.	**Project-based learning.** Students as individuals applying principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed, independent decisions.	Students have an individual interview with an instructor on obtained results.
	LO14. Student able **to use** a variety of methods, including modern information technology, for effective communication at the professional and social levels.	**Project-based learning**: Students (as individuals or in groups) applying course knowledge to communicate at the professional and social levels and implement information technologies with elements of artificial intelligence.	Students prepare a written report on results of communicatio n at the professional and social levels and about project realization.
	LO19. Student able to use professional and specialized knowledge and practical skills **to optimize** the design of information systems of any complexity and **to solve** specific tasks of designing intelligent information systems that manage objects of different physical natures.	**Project-based learning:** Students (as individuals or in groups) applying course knowledge to design of information systems of any complexity and **to solve** specific tasks of designing intelligent information systems that manage objects of	Students prepare a written report on designing of information systems of any complexity and **to solve** specific tasks of designing intelligent

		different physical natures.	information systems that manage objects of different physical natures.

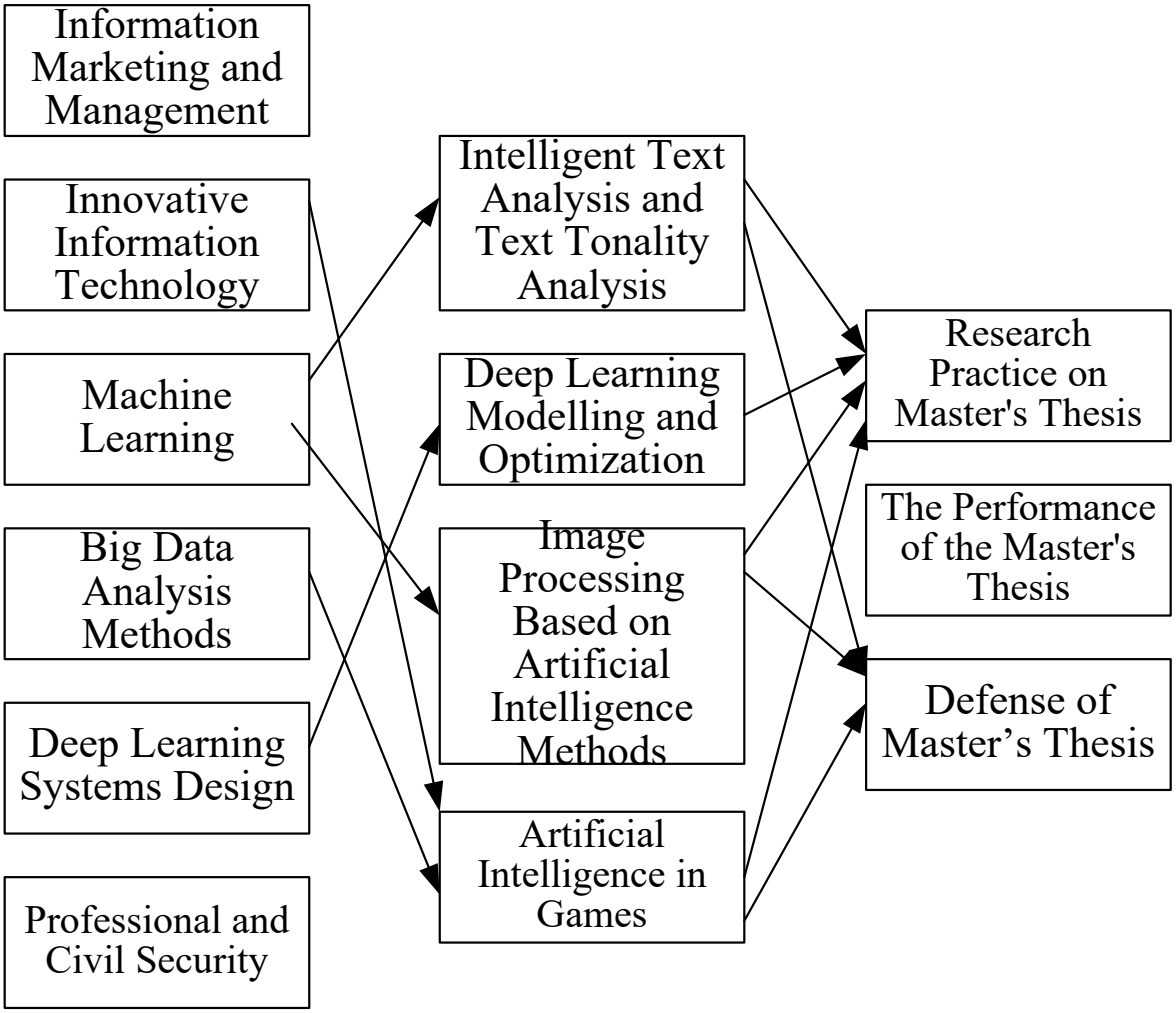
Correspondence of Learning Outcomes with Mandatory/Elective Courses

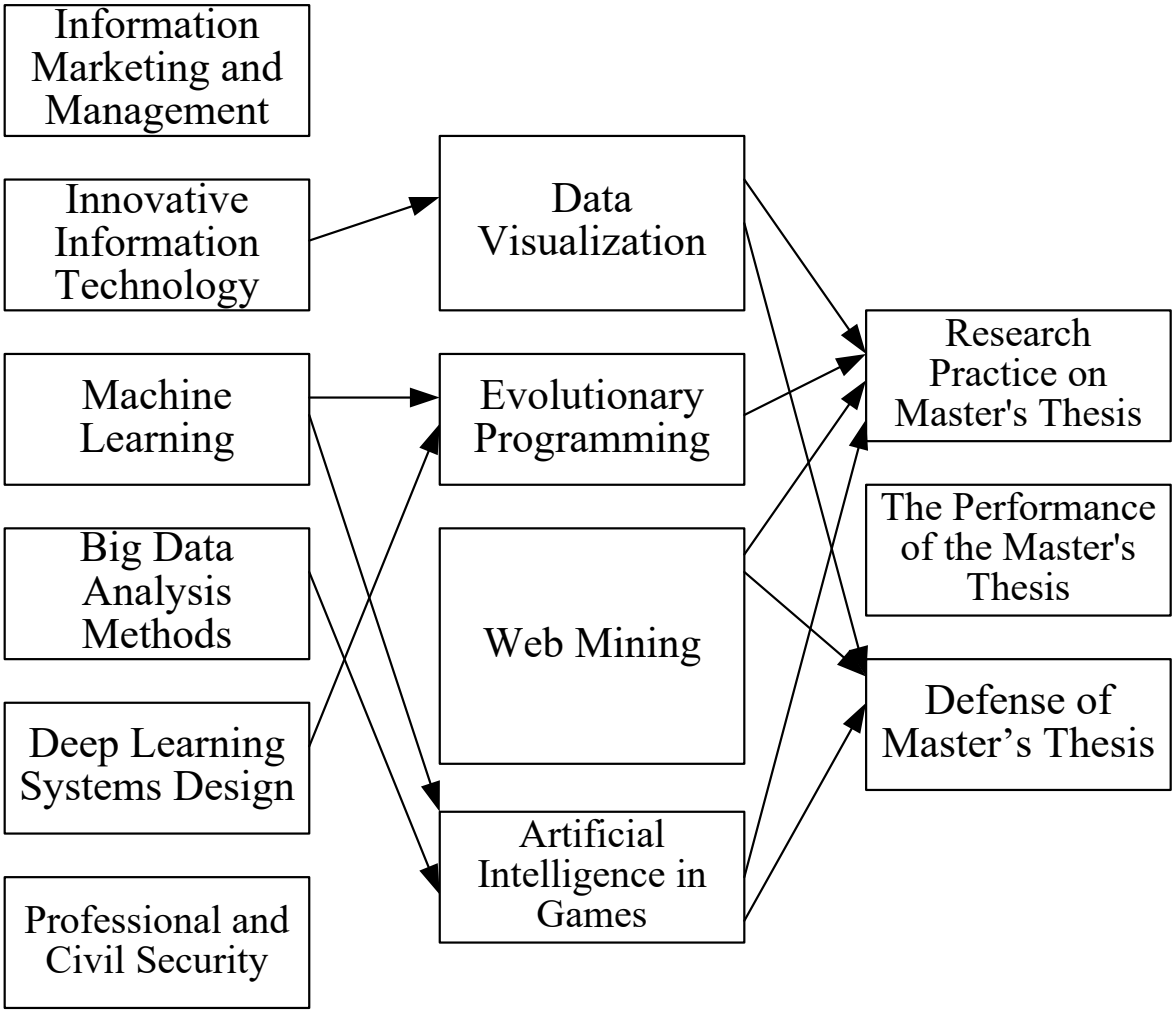
	MC1	MC2	MC3	MC4	MC5	MC6	MC7	MC8	MC9	MC10	EC11	EC12	EC13	EC14	EC15	EC16
LO1	+						+	+	+	+						
LO2	+	+		+	+			+	+	+						+
LO3	+		+			+		+	+	+	+			+		
LO4	+	+						+	+	+	+	+			+	+
LO5			+		+			+	+	+						
LO6		+					+	+	+	+					+	
LO7					+									+		
LO8			+		+											
LO9			+			+					+		+			
LO10				+												
LO11					+			+	+	+						
LO12		+				+	+	+	+	+		+	+			
LO13		+				+		+	+	+						
LO14		+					+	+	+	+				+	+	+
LO15												+	+			
LO16												+	+			
LO17											+					
LO18															+	
LO19																+
LO20														+		

Dublin Descriptors	Outcome	Intended Learning Outcomes
Knowledge and understanding	demonstration	LO4, LO10, LO11, LO17, LO20
Applying knowledge and understanding	problem solving abilities	LO5, LO6, LO8, LO12, LO15, LO18
Making judgments	ability to integrate knowledge and handle complexity, formulate judgment with incomplete and limited information	LO7, LO9, LO16, LO19
Communication	communicate conclusions to specialist and nonspesialist	LO1, LO2
Learning skills	continue the study	LO3

The typical jobs for graduates are the following:

Job	The main Education components responsible for knowledge and skills developments
Data scientist	Deep Learning Systems Design Artificial Intelligence in Games Intelligent Text Analysis and Text Tonality Analysis Deep Learning Modelling and Optimization Image Processing Based on Artificial Intelligence Methods Evolutionary Programing
Big data engineer	Big data Analysis Methods Deep Learning Systems Design
Machine learning engineer	Machine Learning Deep Learning Systems Design Image Processing Based on Artificial Intelligence Methods Evolutionary Programing
MLOps engineer	Big data Analysis Methods Machine Learning Web Mining
Data engineer	Big data Analysis Methods Data Visualization
Backend developer	Web Mining
System Business Analyst	Data Visualization Information Marketing and Management


Information Marketing and Management
Innovative Information Technology
Machine Learning
Big Data Analysis Methods
Deep Learning Systems Design
Professional and Civil Security
Intelligent Text Analysis and Text Tonality Analysis
Deep Learning Modelling and Optimization
Image Processing Based on Artificial Intelligence Methods
Artificial Intelligence in Games
Research Practice on Master's Thesis
The Performance of the Master's Thesis
Defense of Master’s Thesis


Information Marketing and Management
Innovative Information Technology
Machine Learning
Big Data Analysis Methods
Deep Learning Systems Design
Professional and Civil Security
Data Visualization
Evolutionary Programming
Web Mining
Artificial Intelligence in Games
Research Practice on Master's Thesis
The Performance of the Master's Thesis
Defense of Master’s Thesis