Ministry of Education and Science of Ukraine
Ivan Franko National University of Lviv
Faculty of Electronics and Computer Technologies
Department of Optoelectronics and Information Technologies

Approved
Department of Optoelectronics and Information Technologies
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Ivan Franko National University of Lviv
(Meeting Minutes #6 from August 29, 2023)

Head of Department _____ Oleh KUSHNIR

Academic Discipline Syllabus
"Digital Image Processing and Pattern Recognition"
which is taught within the Education Program «Computer Science»
for the second (master) higher education level
in the Specialty 122 – Computer Science

Lviv 2023

Discipline	Digital Image Processing and Pattern Recognition
Address	Building of Faculty of electronics and computer technologies, Ivan Franko National University of Lviv 107 Tarnavskoho Street, Lviv
Faculty	Faculty of electronics and computer technologies, Chair of Optoelectronics and Information technologies
Branch of science	12 Information Technologies, 122 Computer Science
Instructors	Yuriy Furgala, Ph.D., Accos. Professor
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Consulting resources	Consultations on the day of lectures (by prior arrangement) are possible: Room 209, Faculty Building 107, Tarnavskyi Street, Lviv. Online consultations via MS Teams are also possible. To agree on the time of online consultations, you should write to the e-mail address of the teacher.
Discipline page	https://electronics.lnu.edu.ua/course/rozpiznavannya-obraziv http://194.44.208.156/moodle/course/view.php?id=125
Discipline information	The discipline "Pattern recognition" is a selective discipline of in-depth knowledge formation from the specialty 122 Computer science for the educational and professional program "Computer science", which is taught in the 2nd semester in the amount of 7.0 credits (according to the European Credit Transfer System - ECTS)
Abstract	The educational discipline is designed for students to acquire theoretical knowledge of image processing and pattern recognition, methods of determining key features, their analysis, and assigning them to a certain class. The basis of the course is consideration of mathematical models that ensure the selection of features of images, their classification, methods of analyzing the received information and making a decision on establishing correspondences, as well as software implementation of recognition algorithms in various artificial intelligence systems.
Goal and objectives	The purpose of studying the discipline "Pattern Recognition" is to acquaint students with the theoretical foundations of solving the problem of pattern recognition, in particular, on images, and the goals are to form practical skills in them that would enable them to effectively apply the acquired knowledge, algorithms, methods and existing libraries and online resources for solving such problems.
References	Basic: 1. Image Processing: Principles and Applications**.** Rafael C. Gonzalez and Richard E. Woods, Pearson Education Inc., 2008, - 954 p. 2. Computer Vision: A Modern Approach. David Lowe. Pearson Education, Inc.2012 – 793 c. 3. Computer Vision: Algorithms and Applications. Richard Szeliski, Springer; 2nd Edition 2022. – 947p. 4. Davies E. R. Machine Vision: Theory, Algorithms, Practicalities, Morgan Kaufmann, San Francisco. 2005 – 200 p. Additional: 5. Evaluation of objects recognition efficiency on maps by various methods / Yuriy Furgala, Yuriy Mochulsky, Bohdan Rusyn // Data Stream Mining & Processing (DSMP 2018), IEEE Second International Conference. Lviv, Ukraine August 21-25, 2018, pp. 595-598. 6. Yu. Furgala, A. Velgosh, B. Rusyn, Yu. Korchak Proceedings of the Xth International Scientific and Practical Conference "Electronics and Information Technologies" (ELIT-2018)**,** Lviv, Ukraine, August 30 - September 2, 2018, pp.

	A57-A60 7. A. Fesiuk, Y. Furgala. Key points on the images: comparison of detection by different methods. Електроніка та інформаційні технології. – 2023. – Вип. 21 – С. 15-23. 8. Yufei Bai. Research of image detection and matching algorithms. Proceedings of the 3rd International Conference on Signal Processing and Machine Learning. SPML-2023, Chicago, USA, February 25-27, 2023, p.519-526
Teaching duration	210 hours totally. Particularly 32 hours of lectures, 48 hours of practice and 130 hours of self-training.
Expected results	Upon completion of this course, the learner will: – *to know* the basic principles of pattern recognition theory using deterministic and probabilistic approaches, features of stochastic classification and optical pattern recognition; – *to be able* to solve problems of image classification using solving functions and distance functions, using appropriate software for this, create software modules based on standard recognition methods from the OpenCV library and use them. After studying the course, applicants will acquire the following competencies (ZK, SK) and program results (PH): ZK1. Ability to abstract thinking, analysis and synthesis. ZK2. Ability to apply knowledge in practical situations. ZK5. Ability to learn and master modern knowledge. ZK6. The ability to be critical and self-critical. ZK7. Ability to generate new ideas (creativity). SK1. Understanding the theoretical foundations of computer science. SK2. The ability to formalize the subject area of a certain project in the form of an appropriate information model. SK3. Ability to use mathematical methods to analyze formalized models of the subject area. SK6. Ability to apply existing and develop new algorithms for solving problems in the field of computer science. SK8. Ability to develop and implement software development projects, including in unpredictable conditions, with unclear requirements and the need to apply new strategic approaches, use software tools to organize teamwork on the project. SK9. Ability to develop and administer databases and knowledge bases. SK13. Ability to apply methods and approaches of artificial intelligence, intellectual analysis and data science and optimization approaches to solving specific computer science problems. PH1. Have specialized conceptual knowledge that includes modern scientific achievements in the field of computer science and is the basis for original thinking and conducting research, critical thinking of problems in the field of computer science and at the border of the fields of knowledge. PH3. It is clear and unambiguous to convey one's own knowledge, conclusions and arguments in the field of computer science to specialists and non-specialists, in particular to persons who are studying. PH4. Manage work processes in the field of information technologies, which are complex, unpredictable and require new strategic approaches. PH5. Evaluate the results of teams and collectives in the field of information technologies, ensure the effectiveness of their activities. PH6. Develop a conceptual model of an information or computer system. PH7. Develop and apply mathematical methods for the analysis of information models. PH8. Develop mathematical models and data analysis methods (including large ones). PH9. Develop algorithmic and software for data analysis (including large data).

	PH10. Design architectural solutions of information and computer systems for various purposes. PH11. Create new algorithms for solving problems in the field of computer science, evaluate their effectiveness and limitations on their application. PH12. Design and support databases and knowledge. PH13. Assess and ensure the quality of information and computer systems for various purposes. PH16. Conduct research in the field of computer science. PH19. To analyze the current state and global trends in the development of computer sciences and information technologies. PH 20. To have the methods and means of artificial intelligence, engineering and data analysis, pattern recognition and adaptive processing of information, analysis and processing of natural language, modeling and optimization. PH21. Create new data systems, high-level embedded systems, specialized computer systems and intelligent systems using basic knowledge of hardware and software of microcontrollers and microcomputers.
Key words	Image processing and analysis, image recognition, image classification, image features
Course format	Full-time study format
	Conducting lectures, laboratory works and consultations for in-depth understanding of topics
Topics	See the COURSE SCHEME
Knowledge control	Assessment at the end of the semester
Pre-requisites	To study the course, graduate students need basic knowledge of the disciplines "Higher mathematics", "Discrete mathematics", "Algorithms and data structures", "Numerical methods", "Probability theory and mathematical statistics", "Object-oriented programming ", "Theory of decision-making".
Teaching methods and techniques	Lectures, presentations, laboratory and practical works, individual practical tasks, discussions.
Equipment	Multimedia, MS Teams platforms, software: Python, OpenCV
Assessment criteria	Assessment is carried out throughout the semester and during the assessment session on a 100-point scale. Points are awarded for the following types of work with the following ratio: • practical work: 50% of the grade; the maximum number of points is 50. Jobs #1-3 – 10 points, Job #4 – 20 points • theoretical knowledge: 50% of the grade; the maximum number of points is 50. 2 modular surveys of 25 points each. A total of 100 points. _____ **Control measures of knowledge are carried out in the form of standard practical tasks and theoretical questions.** **Academic integrity:** Applicants' papers are expected to contain an original analytical component in reviewing the results obtained. Lack of references to used sources, fabrication of sources, writing off, interference in the work of other acquirers are, but are not limited to, examples of possible academic dishonesty. The discovery of signs of academic dishonesty in the applicant's work is a reason for the teacher not to credit it, regardless of the scale of plagiarism or attempted deception. **Attending classes is an important component of learning.** All applicants are expected to attend all lectures and practical sessions of the course. Students must inform the teacher about the impossibility to attend classes. Applicants are obliged to comply with all the deadlines specified for the performance of the types of work provided for in the course.

	Literature. All literature that students cannot find on their own will be provided by the teacher exclusively for educational purposes without the right to transfer it to third parties. Applicants are also encouraged to use other literature and sources, in particular scientific literature, which is not among the mandatory and recommended. **Scoring policy.** The points scored on the current survey, independent work and module controls are taken into account. Attendance at classes and the student's activity during practical classes must be taken into account; it is emphasized that it is inadmissible to miss or be late for classes, use a mobile phone, tablet or other mobile devices during classes for a purpose not related to learning, writing off and plagiarism, late completion of assigned tasks, etc. others Any form of breach of academic integrity will not be tolerated**.**
Self-control questions	The list of questions and tasks for the final assessment of knowledge of all course topics before the control papers is placed in the course program.
Questionary	An evaluation questionnaire for the purpose of assessing the quality of the course will be provided at the end of the course.

COURSE SCHEME

Week	Theme	Type of classes	Literature	Practice	Deadline
1, 2	**Introduction.** Pattern recognition. The concept of recognition. Basic concepts: image, sign, class. Recognition systems, their classification	Lecture	1, 2	Introduction. Academic integrity.	3rd week
3, 4	**Classification of images.** Resolving functions. Space of images and space of weights.	Lecture	1, 3	Linear solving functions. Dichotomies.	5th week
5, 6	**Recognition of optical images.** Search for objects in images. Formation of the alphabet of signs. The correlation comparison method.	Lecture	2, 4, 5	SURF, SIFT, ORB, BRISK methods	7th week
7, 8, 9	**Geometric interpretation of classification.** Classification of images by minimum distance. Similarity measures. Clustering criteria.	Lecture	2, 4, 6	Euclidean and non-Euclidean measures of distance	9th week
10, 11, 12	**Classification of images using the likelihood function.** Bayesian classifier. Probability of errors	Lecture	1, 4, 7	Minimax criterion. Neumann-Pearson test	12th week
13, 14	**Fourier analysis and image processing.** Linear optical systems. Formation of images. Fourier transform. Melin transform.	Lecture	4, 5, 6	Optical filtering	13th week
15, 16	**Methods and systems of optical information processing.** Coherent optical Fourier processor. Spatial filtering. Optical correlators.	Lecture	5, 6	Van der Lugt correlator	15th week