Syllabus
Course Program

Image Processing Methods

Specialty
113 Applied mathematics

Institute
Educational and Scientific Institute of Computer Science and Information Technology

Educational program
Intelligent Data Analysis

Department
Computer Mathematics and Data Analysis

Level of education
Master's level

Discipline type
Special (professional), Selective

Semester
2

Language of instruction
Ukranian, English

Lecturers and course developers

Vladyslav Kolbasin
vladyslav.kolbasin@khpi.edu.ua
Senior teacher of the Department of Computer Mathematics and Data Analysis

Work experience - 15 years. Leading lecturer in the disciplines: "Object-oriented programming", "Computer geometry and graphics"

More about the lecturer on the website

General information

Summary

The discipline is aimed at mastering the theoretical and practical foundations of image processing. Both basic but outdated methods and modern methods based on artificial neural networks are considered.

Course objectives and goals

The goal of the discipline is the formation of ideas about the main problems, mathematical methods, models and some practical tools of image processing.

Format of classes

Lectures, laboratory works, self-study, consultations. Final control in the form of an exam.

Competencies

GC 3. The ability to continuously study, acquire new knowledge and skills, including in a field other than a professional one.
GC 4. The ability to identify, pose and solve problems in professional activities.
GC 5. The ability to generate new ideas (creativity) and non-standard approaches to their implementation, flexible adaptation to real professional situations, to show a creative approach, initiative.
GC 6. The ability to critically evaluate and rethink the accumulated experience (own and others), to

analyze one's professional and social activities.
GC 7. The ability to work with information: to find and use information from various sources, necessary for solving professional tasks.
GC 8. The ability to effectively build communication, based on the goals and situation of communication.
GC 10. The ability to carry out professional scientific and project-production activities in an international environment.
SC 1. The ability to formulate a mathematical statement of a problem, relying on the statement in the language of the subject field, to check the correctness of the statement, including in conditions of uncertainty.
SC 2. The ability to choose, develop and investigate a mathematical analytical or numerical method for solving practical problems, which ensures the required accuracy and reliability of the result.
SC 3. The ability to choose, develop, research and apply mathematical methods to solve practical problems of modeling, design, management, forecasting, decision-making.
SC 4. Ability to develop algorithms for the analysis of uncertain big data, develop appropriate software tools and documentation, design software systems, databases and knowledge bases.
SC 5. The ability to conduct mathematical and computer modeling and computational experiments, collect, visualize, analyze and process the received data, solve formalized problems using specialized software tools.
SC 11. Ability to develop, investigate and apply mathematical methods and algorithms of machine learning, soft computing and computational intelligence for the analysis of uncertain data, forecasting and decision making.
SC 14. The ability to use modern information technologies for intelligent data analysis, forecasting, decision-making, information search and knowledge extraction.

Learning outcomes

LO 1. Demonstrate knowledge and understanding of basic concepts, principles, theories of fundamental and applied mathematics and use them in practice.
LO 2. Be able to formalize problems formulated in the language of a certain subject area and choose a rational solution method; solve problems by analytical or numerical methods, evaluate the accuracy and reliability of the obtained results and perform their interpretation.
LO 3. To have the methods of development, research and application of mathematical models of complex objects and processes, including with the use of methods of computational intelligence.
LO 6. To be able to choose, develop and research methods and algorithms for solving mathematical problems of system optimization, operations research, optimal management and decision-making.
LO 7. To be able to apply modern technologies of programming and software development, software implementation of numerical and symbolic algorithms.
LO 12. Know and understand modern methods of solving mathematical problems, statistical and intellectual data analysis, forecasting, etc.
LO 14. To be able to apply existing existing and develop new algorithms and software tools for statistical and intellectual analysis of uncertain data.
LO 15. To be able to apply existing existing and develop new algorithms and software tools for processing data, texts, signals and images.
LO 16. To be able to apply modern information technologies and software for processing large data sets based on distributed and cloud services.

Student workload

The total volume of the course is 150 hours (5 ECTS credits): lectures – 32 hours, laboratory classes – 32 hours, self-study – 86 hours.

Course prerequisites

To successfully complete the course, you must have knowledge and practical skills from the discipline "Mathematical methods of machine learning 1", as well as from the disciplines of the profile package VP2.*, namely, VP2.1 - "Analysis and synthesis of natural language information", or VP2.2 - "Methods of signal processing".

Features of the course, teaching and learning methods, and technologies

Programming skills are required. Study materials are available to students on the teacher's website.

Program of the course

Topics of the lectures

Topic 1. Introduction to the subject.
Topic 2. Image formation methods. Discretization and quantization. Pseudotoning.
Topic 3. Image processing using linear filters.
Topic 4. Fourier transformation in image processing.
Topic 5. Wavelets and their use.
Topic 6. Geometric transformations.
Topic 7. Detection of signs and correspondence.
Topic 8. Markov random fields.
Topic 9. Basic elements of convolutional neural networks: convolution, pooling layer, dropout, batch normalization, softmax layer. Examples of problems that can be solved using convolutional networks.
Topic 10. Generative adversarial networks (GAN).
Topic 11. Image alignment and stitching.
Topic 12. The task of coloring.
Topic 13. Motion estimation.
Topic 14. Epipolar geometry.
Topic 15. Depth estimation.
Topic 16. Review of the course and discussion of the achieved results.

Topics of the laboratory classes

Topic 1. Digital filtering of raster images.
Topic 2. Work with wavelet image representation.
Topic 3. Stitching of images.
Topic 4. Motion estimation from a sequence of images.
Topic 5. Depth estimation based on images.

Self-study

During self-stury, students study lecture material, prepare for tests, and exams.

Non-formal education

In non-formal education according to the relevant Regulation (http://surl.li/pxssv), the educational component or its individual topics can be taken into account in case of independent completion of professional courses/trainings, obtaining civic education, online education, professional internship, etc.

In particular, individual topics of this component may be taken into account upon successful completion of the following courses:

- Topic 9. Basic elements of convolutional neural networks: convolution, pooling layer, dropout, batch normalization, softmax layer. Examples of problems that can be solved using convolutional networks. https://www.coursera.org/learn/convolutional-neural-networks?specialization=deep-learning
- Topic 10. Generative adversarial networks (GAN). https://www.coursera.org/projects/deep-learning-with-pytorch-generative-adversarial-network

Course materials and recommended reading

Main literature

1. Richard Szeliski. Computer Vision: Algorithms and Applications (Texts in Computer Science) 2nd ed. 2022 Edition. – ISBN 978-3-030-34372-9 (eBook).

2. Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learning, – MIT Press, 2016.
http://www.deeplearningbook.org/
3. «Digital Image Processing» авторства Rafael C. Gonzalez та Richard E. Woods.
https://dl.ebooksworld.ir/motoman/Digital.Image.Processing.3rd.Edition.www.EBooksWorld.ir.pdf

Assessment and grading

Criteria for assessment of student performance, and the final score structure

A necessary condition for passing the test or exam is the completion of laboratory work.
30 points are awarded for writing control tests.
Passing laboratory tests - 30 points.
Exam – 40 points.

Grading scale

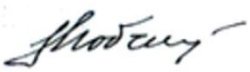
Total points	National	ECTS
90–100	Excellent	A
82–89	Good	B
75–81	Good	C
64–74	Satisfactory	D
60–63	Satisfactory	E
35–59	Unsatisfactory (requires additional learning)	FX
1–34	Unsatisfactory (requires repetition of the course)	F

Norms of academic integrity and course policy

The student must adhere to the Code of Ethics of Academic Relations and Integrity of NTU "KhPI": to demonstrate discipline, good manners, kindness, honesty, and responsibility. Conflict situations should be openly discussed in academic groups with a lecturer, and if it is impossible to resolve the conflict, they should be brought to the attention of the Institute's management.

Regulatory and legal documents related to the implementation of the principles of academic integrity at NTU "KhPI" are available on the website: http://blogs.kpi.kharkov.ua/v2/nv/akademichna-dobrochesnist/

Approval

Approved by	Date, signature 31.08.2023		Head of the department Olena AKHIIEZER
	Date, signature 31.08.2023		Guarantor of the educational program Leonid LYUBCHYK