MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
ODESSA NATIONAL UNIVERSITY NAMED I.I. Mechnykova
Department of mathematical support of computer systems

"APPROVED"
Vice-rector for scientific and pedagogical work
_____
_____ 20___

WORKING PROGRAM OF EDUCATIONAL COURSE

OK4 "Image processing methods and algorithms and computer vision"
(course name)

Level of higher education *Second (master's)*

Field of knowledge 12 – Information technologies

Specialty *126 – Information systems and technologies*
(code and name of specialty(s)

Educational and professional program Information systems and technologies
(EPP/ESP name)

Working program of the course "Image processing methods and algorithms and computer vision"– Odesa: ONU, 2022. –9 p.

Developers:
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The working program was approved at the meeting of the Department of Mathematical Support of Computer Systems

Protocol No. 1 from "25" 08 2022 year

Head of the department _____ (Eugene MALAKHOV)
(signature) (First Name Surname)

Agreed with the guarantor of the EPP "Information systems and technologies"

(signature) (First Name Surname) _____ (Eugene MALAKHOV)

Approved by the educational and methodological commission (EMC) for IT specialties of the FMPhIT

Protocol No. 1 from "31" 08 2022 year

Head of EMC _____ (Alla Rachynska)
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Reviewed and approved at the meeting of the department _____

Protocol No. 1 from "29" 08 2023 year

Head of Department _____ (Е. Малахов)
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Reviewed and approved at the meeting of the department _____

Protocol No. ___ from "____" _____ 20__ year

Head of Department _____ (_____)
(signature) (First Name Surname)

1. C**ourse Description**

<table>
<tr><td rowspan="2">Name of indicators</td><td rowspan="2">Field of knowledge, direction of training, educational and qualification level</td><td colspan="2">Characteristics of the course</td></tr>
<tr><td>full-time education</td><td>external form of education</td></tr>
<tr><td rowspan="15">The total number of:

credits - 4

hours - 120

content modules - 2</td><td>Branch of knowledge
12 - Information technologies
(code and name)</td><td colspan="2">Mandatory</td></tr>
<tr><td rowspan="5">Specialty
126 – Information systems and technologies</td><td colspan="2">Year of preparation:</td></tr>
<tr><td>1st</td><td></td></tr>
<tr><td colspan="2">Semester</td></tr>
<tr><td>2nd</td><td></td></tr>
<tr><td colspan="2">Lectures</td></tr>
<tr><td rowspan="10">Level of higher education:
Second (master's)</td><td>16 hours</td><td>8 hours</td></tr>
<tr><td colspan="2">Practical, seminar</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Laboratory</td></tr>
<tr><td>18 hours</td><td>6 hours</td></tr>
<tr><td colspan="2">Independent work</td></tr>
<tr><td>86 hours</td><td>106</td></tr>
<tr><td colspan="2">Individual tasks:</td></tr>
<tr><td colspan="2">Final control form:
credit</td></tr>
</table>

2. The purpose and tasks of the educational course

The purpose of the course is an introduction to the broad context of the field of machine vision, a theoretical study of the basic tasks of machine vision and modern approaches to their practical solution.

Tasks:

– structuring the spectrum of machine learning tasks;
– formalization of individual stages of the video data processing pipeline;
– software implementation of individual stages of this pipeline.

The process of studying the course is aimed at forming elements of the following competencies (according to the OPP "Information Systems and Technologies" from 2019):

1) general: -
2) special (professional):

SC01. The ability to develop and apply ICT (Information and Communication Technology) necessary for solving strategic and current tasks.

SC07. The ability to develop and implement innovative projects in the field of ICT.

SCM03. The ability to mathematically model digital data and apply efficient algorithms for the analysis and transformation of multimedia data in modern information systems.

Program learning outcomes:

LO04. Manage complex, unpredictable processes related to the development, implementation, and operation of ICT, requiring new strategic and team approaches.

LOM03. Determine the types of signals, dynamic and spectral forms of their mathematical models, methods of mathematical signal modeling, and methods of transforming information signals during processing, transmission, and storage of information in computer systems.

LOM06. Develop mathematical models and software-information systems to solve current problems of multimedia information analysis and processing.

Expected learning outcomes. As a result of studying the course, the student should

***know**: the main assortment of tasks in the context of machine vision, to have the theoretical apparatus used in the process of implementing machine vision tasks, to know the structure of the sequence of image processing stages and to understand the logic of their interaction, to know the main methods used at different stages of video information processing.*

***be able**: develop software for obtaining and analyzing video information; design the structure and functions of typical image analysis modules; develop software for searching for objects in the image; create a comprehensive description of the objects in the image; use modern image analysis technologies.*

3. Course Content

Content module 1 Low-level processing of video information.
Тема 1. Introduction, basic concepts, fields of application and promising tasks.
Literature: [1,3,4].
Тема 2. Formation of images. Image presentation formats.
Literature: [2,3].
Тема 3. Basic operations at the image preprocessing stage.
References: [3, 5].
Тема 4. Extraction of three-dimensional information. Processing of binocular stereo data and texture.
Literature: [2,4,5].

Content module 2 Some further stages of processing video information.
Тема 5. Analysis of the movement of objects.
Literature: [1, 4, 5].
Тема 6. Recognition of objects on the scene. Image understanding.
Literature: [3,4,5].
Тема 7. Modeling the neurobiology of vision.
Literature: [6].
Тема 8. Compression of visual data.
Literature: [2, 3].

4. The structure of the course

Names of content modules and topics	Number of hours									
	Full-time									
	That's all	including				That's all	including			
		l	p	lab	Wed		l	p	lab	Wed
1	2	3	4	5	6	7	8	9	10	11
Content module 1. Low-level processing of video information.										
Topic 1.	12	2			10		1			12
Topic 2.	14	2		2	10		1			12
Topic 3.	14	2		2	10		1		1	12
Topic 4.	16	2		2	12		1		1	14
Content module 2. Some further stages of processing video information.										
Topic 5.	16	2		2	12		1		1	14
Topic 6.	18	2		4	12		1		1	14
Topic 7.	16	2		4	10		1		1	14
Topic 8.	14	2		2	10		1		1	14
Hours in general	**120**	**16**		**18**	**86**		**8**		**6**	**106**

5. Topics of seminar classes

Seminar classes are not provided

6. Topics of practical classes

Practical classes are not provided

7. Topics of laboratory classes

No s/p	Topic name	Number hours
1	Setting up the OpenCV library environment in the Python interpreter	2
2	Uploading an image, creating an image, creating a simple filter.	4
3	Creating a universal bitmap filter	2
4	Building a histogram of brightness with one and several channels, contrasting images.	2
5	Binarization of images. Correcting the shape of objects in the image.	4
6	Search and selection of features of objects. Selection of a moving object	4
	Together	**18**

8. Independent work

No s/p	Topic name	Number hours
1	Types of nonlinear filtering. Median filtering	4
2	Morphological transformations. Hit-miss transformations	8
3	Fourier transform and its properties. Function transformation, sequence transformation, discrete transformation and its FFT implementation	8
4	Finding the same points on different images. Creating a panoramic image.	16
5	Construction of point descriptors. Invariance of descriptors with respect to rotations. Descriptors based on histograms	24
6	Individual task on image processing	26
	Together	**86**

Independent work includes:
[1] – preparation for lectures and laboratory classes;

9. Teaching methods

Lectures using multimedia presentation material.

10. Control methods

During the final control, the student must answer 2 questions of the examiner from the list given in clause 11.1.

11. Evaluation criteria at the final control:

The examination ticket for the course consists of two parts: theoretical and practical. The minimum number of points counted as a positive result is 60 (on a 100-point scale). Points are distributed as follows: 60 points - theoretical part and 40 points - practical.
The theoretical part contains 2 questions, the practical part - 1 question.
For an impeccable answer to each theoretical question, the student receives - 30 points. At the same time, the answer is considered flawless if the student fully disclosed the essence of the question, presented it consistently and logically, gave examples, illustrated the answer with the necessary and sufficient number of records, graphs, formulas, schemes; made references to relevant literary sources.
For perfect performance of the task of the practical part, the student receives - 40 points. The task of the practical part of the exam is considered flawlessly completed if the correct answer is obtained, the solution is presented consistently and logically, and all the results formulated in the task are obtained.

11.1. Questions for the final control

1. The role and place of machine vision tasks in the context of the modern approach to the development of artificial intelligence systems.
2. The applied value of machine vision systems in modern automated information processing systems.
3. Formats and data structures for presenting a two-dimensional image.
4. An approach to machine vision based on the extraction of image characteristics.
5. Approach to machine vision taking into account the world model.
6. Low-level machine vision tasks.
7. High-level machine vision tasks.
8. Tasks that are solved taking into account the results of machine vision.
9. Formalization of the task of forming a two-dimensional image.
10. Obtaining an image without lenses - camera obscura.
11. Concepts of perspective projection and scaled orthogonal projection.
12. Obtaining an image using a lens.
13. Basic concepts of photometry.
14. Specular and diffuse reflection.
15. Concept of color based on image spectrophotometry.
16. Image smoothing using Gaussian convolution.
17. Edge detection task. Edge typification.
18. Interaction of smoothing and Kenny edge detection.
19. The nature of the image segmentation problem.
20. Object recognition as extraction of three-dimensional information.
21. Determining the position and orientation of the object relative to the observer.
22. Methods of object motion analysis.
23. Analysis of binocular stereo data.
24. Detection and use of texture gradients.
25. Detection and processing of shading effects.
26. Approach to the analysis of scenes taking into account contour images.

12. Distribution of points received by students

Current testing and independent work								Sum
Content module #1				Content module No. 2				
T1	T2	T3	T4	T5	T6	T7	T8	
10	14	14	14	14	14	10	10	100

T1, T2 ... - topics of content modules.

Evaluation scale: national and ECTS

Total points	ECTS assessment	National scale	
90 — 100	A - "excellent"	5 "excellent"	"test"
85 - 89	B - "very good"	4 "good"	
75 - 84	C - "good"		
70 - 74	D - "satisfactory"	3 "satisfactory"	
60 - 69	E - "permissible"		
35 — 59	F - "unsatisfactory with the possibility of reassembly"	2 "unsatisfactory"	"uncountable"
0 — 34	FX – "unsatisfactory with mandatory repeat course"		

13. Educational and methodical software

Synopsis of lectures in electronic format.

14. Recommended Books

14.1. Basic literature

1. Reinhard K., Concise Computer Vision: An Introduction into Theory and Algorithms. - Springer London, 2014. – 429 p.
2. ParagiosN., Yunmei Chen Y.,FaugerasO.,Handbook of Mathematical Models in Computer Vision. - Springer 2015. - 640 p.
3. Radke R., Computer Vision for Visual Effects. - Cambridge University Press, 2013. - 405 p.
4. Mark N., Alberto A., Feature Extraction and Image Processing for Computer Vision (4th ed.). - Academic Press 2019. – 650 p.
5. Russell S., Peter Norvig P., Artificial Intelligence: A Modern Approach. - Global Edition, 2016. - 1152 p.
6. Gage N., Baars B., Fundamentals of Cognitive Neuroscience: A Beginner's Guide. - Elsevier Inc., 2013. - 547 p.

14.2. Supporting literature

7. R. Fisher R., Dawson-Howe K., Fitzgibbon A., Robertson C., Trucco E., Dictionary of Computer Vision and Image Processing. - John Wiley, 2005. – 364 p.
8. Sonka M., Hlavac V., Boyle R., Image Processing, Analysis and Machine Vision. - Thomson, 2008. - 829 p.
9. Burger W.; Burge M.,Digital Image Processing: An Algorithmic Approach Using Java. -Springer, 2007. – 107 p.
10. Azad R., Gockel T., Dillmann R.,Computer Vision - Principles and Practice. - Elektor International Media BV, 2008. – 270p.
11. Szeliski R.,Computer Vision: Algorithms and Applications. Springer-Verlag 2010. – 925p.
12. Parker J., Algorithms for Image Processing and Computer Vision (2nd ed.). - Wiley, 2011. - 504 p.
13. Morris T., Computer Vision and Image Processing. - Palgrave Macmillan, 2004. – 300 p.
14. Forsyth D., Ponce, J., Computer vision: a modern approach. - Pearson, 2012. - 800p.

15. Electronic information resources

15. Ecole polytechnique Computer vision - Access mode:http://moodle.epfl.ch/course/view.php?id=472
16. Introduction to Computer vision -Access mode:http://cs.brown.edu/courses/cs143/
17. MIT Computer vision -Access mode: http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-801-machine-vision-fall-2004/
18. Stanford course Computer vision -Access mode:http://vision.stanford.edu/teaching/cs223b/