

## SYLLABUS

### 1. Information regarding the programme

1.1 Higher education institution	<b>Babeş Bolyai University</b>
1.2 Faculty	<b>Faculty of Mathematics and Computer Science</b>
1.3 Department	<b>Department of Computer Science</b>
1.4 Field of study	<b>Computer Science</b>
1.5 Study cycle	<b>Bachelor</b>
1.6 Study programme / Qualification	<b>Computer Science</b>

### 2. Information regarding the discipline

2.1 Name of the discipline (en) (ro)	<b>Computer vision and deep learning</b> <b>Viziune computerizată și deep learning</b>						
2.2 Course coordinator	<b>Lect. PhD. Diana Laura Borza</b>						
2.3 Seminar coordinator	<b>Lect. PhD. Diana Laura Borza</b>						
2.4. Year of study	<b>3</b>	2.5 Semester	<b>5</b>	2.6. Type of evaluation	<b>C</b>	2.7 Type of discipline	<b>Optional</b>
2.8 Code of the discipline	<b>MLE5152</b>						

### 3. Total estimated time (hours/semester of didactic activities)

3.1 Hours per week	3	Of which: 3.2 course	2	3.3 seminar/laboratory	1 lab/ proj
3.4 Total hours in the curriculum	42	Of which: 3.5 course	28	3.6 seminar/laboratory	14
Time allotment:	hours				
Learning using manual, course support, bibliography, course notes	14				
Additional documentation (in libraries, on electronic platforms, field documentation)	16				
Preparation for seminars/labs, homework, papers, portfolios and essays	20				
Tutorship	4				
Evaluations	4				
Other activities: .....					
3.7 Total individual study hours	58				
3.8 Total hours per semester	100				
3.9 Number of ECTS credits	4				

#### 4. Prerequisites (if necessary)

4.1. curriculum	<ul style="list-style-type: none"><li>• Linear Algebra</li><li>• Python programming</li><li>• Statistics</li><li>• Data structures and algorithms</li></ul>
4.2. competencies	<ul style="list-style-type: none"><li>• Average programming skills in a high-level programming language</li></ul>

#### 5. Conditions (if necessary)

5.1. for the course	<ul style="list-style-type: none"><li>• Classroom with blackboard and video projector.</li></ul>
5.2. for the seminar /lab activities	<ul style="list-style-type: none"><li>• Laboratory equipped with high-performance computers and having python installed.</li></ul>

#### 6. Specific competencies acquired

<b>Professional competencies</b>	<ul style="list-style-type: none"><li>• CE1.3 Using the methods, techniques and algorithms from AI in order to model several classes of problems</li><li>• CE1.4 Identify and explain specific AI techniques and algorithms and using them to solve specific problems</li><li>• CE1.5 Integrating the models and the specific solutions from AI in dedicated applications</li><li>• C4.2 Interpretation of mathematical models and computer science (formal)</li><li>• C4.3 Identifying appropriate models and methods to solve real problems</li><li>• C4.5 Incorporation of formal models in specific applications in various fields</li></ul>
<b>Transversal competencies</b>	<ul style="list-style-type: none"><li>• CT1 Ability to conform to the requirements of organized and efficient work, to develop a responsible approach towards the academic and scientific fields, in order to make the most of one's own creative potential, while obeying the rules and principles of professional ethic</li><li>• CT3 Using efficient methods and techniques for learning, information, research and developing capabilities for using knowledge, for adapting to a dynamic society and for communicating in Romanian and in a worldwide spoken language.</li></ul>

#### 7. Objectives of the discipline (outcome of the acquired competencies)

7.1 General objective of the discipline	<ul style="list-style-type: none"><li>• The goal of this course is to acquaint the students with the field of computer vision from a deep learning perspective. The students will learn how to analyse, design, implement, and evaluate any complex computer vision problem. The course covers both image and video processing, including image classification, object detection, object tracking, action recognition, image stylization and synthetic data generation.</li></ul>
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7.2 Specific objective of the discipline	<ul style="list-style-type: none"> <li>• Understand various architectures of Convolutional Neural Networks for image classification, object detection, video analysis, and synthetic visual data generation.</li> <li>• Solve and analyse a Computer Vision problem using a specific theoretical apparatus.</li> <li>• Understand and develop efficient fine-tuning strategies for increasing the performance of Convolutional Neural Networks with applications in the Computer Vision field.</li> <li>• Understand the metrics used to evaluate complex networks, as well as visualizing the features learned by the networks.</li> </ul>
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## 8. Content

8.1 Course	Teaching methods	Remarks
1. <b>Introduction to Computer Vision.</b> Overview, history of computer vision, the three Rs of computer vision.	<ul style="list-style-type: none"> <li>• Interactive exposure</li> <li>• Explanation</li> <li>• Conversation</li> <li>• Didactical demonstration</li> </ul>	
2. <b>Image classification pipeline.</b> Image classification pipeline, image features, filters, convolutions, linear classifiers.	<ul style="list-style-type: none"> <li>• Interactive exposure</li> <li>• Explanation</li> <li>• Conversation</li> <li>• Didactical demonstration</li> </ul>	
3. <b>Shallow neural networks. Optimization and loss functions.</b>	<ul style="list-style-type: none"> <li>• Interactive exposure</li> <li>• Explanation</li> <li>• Conversation</li> <li>• Didactical demonstration</li> </ul>	
4. <b>Introduction to convolutional neural networks.</b> Convolutional neural networks architectures. Elements of a convolutional convolutional neural network: convolutional layers, pooling layers, fully connected layer). Architectures: LeNet, AlexNet, VGG, Inception, Resnet.	<ul style="list-style-type: none"> <li>• Interactive exposure</li> <li>• Explanation</li> <li>• Conversation</li> <li>• Didactical demonstration</li> </ul>	
5. <b>Training a neural network.</b> Activation functions, weight initialization, hyperparameter tuning, transfer learning.	<ul style="list-style-type: none"> <li>• Interactive exposure</li> <li>• Explanation</li> <li>• Conversation</li> <li>• Didactical demonstration</li> </ul>	
6. <b>Case study: face analysis using convolutional neural networks.</b> Multitask networks, triplet loss function.	<ul style="list-style-type: none"> <li>• Interactive exposure</li> <li>• Explanation</li> <li>• Conversation</li> <li>• Didactical demonstration</li> </ul>	
7. <b>Image segmentation using convolutional neural networks.</b> Transposed convolutions, Fully convolutional neural networks, U-Net architecture.	<ul style="list-style-type: none"> <li>• Interactive exposure</li> <li>• Explanation</li> <li>• Conversation</li> <li>• Didactical demonstration</li> </ul>	

8. <b>Generative networks.</b> PixelRNN and PixelCNN, Variational Autoencoders (VAE), Generative Adversarial Networks (GAN).	<ul style="list-style-type: none"> <li>• Interactive exposure</li> <li>• Explanation</li> <li>• Conversation</li> <li>• Didactical demonstration</li> </ul>	
9. <b>Object detection.</b> Object detection, region proposal, ROI pooling. Convolutional neural networks for object detection: Fast R-CNN, Faster R-CNN, Mask-RCNN, YOLO, SSD	<ul style="list-style-type: none"> <li>• Interactive exposure</li> <li>• Explanation</li> <li>• Conversation</li> <li>• Didactical demonstration</li> </ul>	
10. <b>Graph convolutional neural networks.</b>	<ul style="list-style-type: none"> <li>• Interactive exposure</li> <li>• Explanation</li> <li>• Conversation</li> <li>• Didactical demonstration</li> </ul>	
11. <b>Sequence models. Attention and transformers.</b>	<ul style="list-style-type: none"> <li>• Interactive exposure</li> <li>• Explanation</li> <li>• Conversation</li> <li>• Didactical demonstration</li> </ul>	
12. <b>Vision transformers. Self-supervised learning.</b>	<ul style="list-style-type: none"> <li>• Interactive exposure</li> <li>• Explanation</li> <li>• Conversation</li> <li>• Didactical demonstration</li> </ul>	
13. <b>Case studies and demonstrations of state-of-the-art algorithms. Ethics in artificial intelligence. Debate.</b>	<ul style="list-style-type: none"> <li>• Interactive exposure</li> <li>• Explanation</li> <li>• Conversation</li> <li>• Didactical demonstration</li> </ul>	
14. <b>Written examination</b>	<ul style="list-style-type: none"> <li>• Interactive exposure, conversation.</li> </ul>	

#### Bibliography

1. Goodfellow, Ian, Yoshua Bengio, and Aaron Courville. *Deep learning*. MIT press, 2016.
2. Langr, Jakub, and Vladimir Bok. *GANs in Action*. (2018).
3. Trask, Andrew. *Grokking deep learning*. Manning Publications Co., 2019.
4. Prince, Simon JD. *Computer vision: models, learning, and inference*. Cambridge University Press, 2012.
6. Shapiro, Linda G., and George C. Stockman. *Computer vision*. Prentice Hall, 2001.
7. Müller, Andreas C., and Sarah Guido. *Introduction to machine learning with Python: a guide for data scientists*. " O'Reilly Media, Inc.", 2016.
8. Gulli, Antonio, and Sujit Pal. *Deep learning with Keras*. Packt Publishing Ltd, 2017.

8.2 Laboratory	Teaching methods	Remarks
1. Strategies for solving computer vision problems. Introduction to <i>python</i> and <i>torch</i> .	<ul style="list-style-type: none"> <li>• Interactive exposure</li> <li>• Explanation</li> <li>• Conversation</li> <li>• Individual and group work</li> <li>• Dialogue, debate</li> </ul>	The laboratory is structured as 2 hours per week, every other week
2. Artificial neural networks (building blocks,	<ul style="list-style-type: none"> <li>• Interactive exposure</li> </ul>	

simple architectures). Evaluation metrics and visualization (Precision, Recall, TPR, FPS, F1-Score, confusion matrix, activation maps).	<ul style="list-style-type: none"> <li>• Explanation</li> <li>• Conversation</li> <li>• Individual and group work</li> <li>• Dialogue, debate</li> </ul>	
3. Optimization algorithms, unbalanced data, data pre-processing, data generators in <i>torch</i> . Convolutional neural networks.	<ul style="list-style-type: none"> <li>• Interactive exposure</li> <li>• Explanation</li> <li>• Conversation</li> <li>• Individual and group work</li> <li>• Dialogue, debate</li> </ul>	
4. Semantic segmentation, part I: data loaders, models.	<ul style="list-style-type: none"> <li>• Interactive exposure</li> <li>• Explanation</li> <li>• Conversation</li> <li>• Individual and group work</li> <li>• Dialogue, debate</li> </ul>	
5. Semantic segmentation, part II: training, evaluation, fine-tuning	<ul style="list-style-type: none"> <li>• Interactive exposure</li> <li>• Explanation</li> <li>• Conversation</li> <li>• Individual and group work</li> <li>• Dialogue, debate</li> </ul>	
6. Attention models.	<ul style="list-style-type: none"> <li>• Interactive exposure</li> <li>• Explanation</li> <li>• Conversation</li> <li>• Individual and group work</li> <li>• Dialogue, debate</li> </ul>	
7. Portfolio presentation.	<ul style="list-style-type: none"> <li>• Dialogue, conversation</li> </ul>	

#### Bibliography

1. Müller, Andreas C., and Sarah Guido. *Introduction to machine learning with Python: a guide for data scientists*. " O'Reilly Media, Inc.", 2016.
2. Gulli, Antonio, and Sujit Pal. *Deep learning with Keras*. Packt Publishing Ltd, 2017.
3. Anderson, John. *Hands On Machine Learning with Python*. CreateSpace Independent Publishing Platform, 2018.
4. Goodfellow, Ian, Yoshua Bengio, and Aaron Courville. *Deep learning*. MIT press, 2016.

### 9. Corroborating the content of the discipline with the expectations of the epistemic community, professional associations and representative employers within the field of the program

<ul style="list-style-type: none"> <li>• The course follows the ACM and IEEE Curriculum Recommendations for Computer Science majors.</li> <li>• The course exists in the studying program of all major universities in Romania and abroad.</li> <li>• The knowledge and skills acquired in this course give students a foundation for launching a career in scientific research.</li> </ul>
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### 10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the
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			grade (%)
10.4 Course	<ul style="list-style-type: none"> <li>• The student has a good understanding of the deep learning concepts.</li> <li>• The ability to apply the course concepts in solving a real-life computer vision problem.</li> </ul>	Written examination <u>at the laboratory</u> in the last week of the semester.	50%
10.5 Seminar/lab activities	<ul style="list-style-type: none"> <li>• The correct specification, design, implementation and evaluation of a computer vision problem based on deep learning.</li> <li>• The student is able to apply different techniques for improving the performance of a deep learning system.</li> </ul>	Continuous observations	50%
<b>10.6 Minimum performance standards</b>			
<ul style="list-style-type: none"> <li>➤ Students must prove that they acquired an acceptable level of knowledge and understanding of the core concepts taught in the class, that they are capable of using this knowledge in a coherent form, that they have the ability to establish certain connections and to use the knowledge in solving various computer vision problems.</li> <li>➤ The final grade (average between written exam and assignments) should be at least 5 (no rounding)</li> </ul>			

Date

28.04.2023

Date of approval

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Signature of course coordinator

Lect. PhD. Diana Laura Borza

Signature of the head of department

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Signature of seminar coordinator

Lect. PhD. Diana Laura Borza