SYLLABUS

Computer Vision and Deep Learning

University year 2025-2026

1. Information regarding the programme

1.1. Higher education institution	**Babeş Bolyai University**
1.2. Faculty	**Faculty of Mathematics and Computer Science**
1.3. Department	**Department of Computer Science**
1.4. Field of study	**Computer Science**
1.5. Study cycle	**Bachelor**
1.6. Study programme/Qualification	**Artificial Intelligence**
1.7. Form of education	**Full time**

2. Information regarding the discipline

2.1. Name of the discipline	**Deep learning and Computer Vision Techniques**				Discipline code		**MLE5231**
2.2. Course coordinator					**Lect. PhD. Diana Laura Borza**		
2.3. Seminar coordinator					**Lect. PhD. Diana Laura Borza**		
2.4. Year of study	**3**	2.5. Semester	**6**	2.6. Type of evaluation	**E**	2.7. Discipline regime	**Compulsory**

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

3.1. Hours per week	**4**	of which: 3.2 course	**2**	3.3 seminar/laboratory/project	**2 L**
3.4. Total hours in the curriculum	**56**	of which: 3.5 course	**28**	3.6 seminar/laboratory/project	**28L**
Time allotment for individual study (ID) and self-study activities (SA)					**hours**
Learning using manual, course support, bibliography, course notes (SA)					35
Additional documentation (in libraries, on electronic platforms, field documentation)					35
Preparation for seminars/labs, homework, papers, portfolios and essays					40
Tutorship					4
Evaluations					5
Other activities:					

3.7. Total individual study hours	**119**
3.8. Total hours per semester	**175**
3.9. Number of ECTS credits	**7**

4. Prerequisites (if necessary)

4.1. curriculum	• Linear Algebra • Python programming • Statistics • Data structures and algorithms
4.2. competencies	• Average programming skills in a high-level programming language

5. Conditions (if necessary)

5.1. for the course	• Classroom with blackboard and video projector.
5.2. for the seminar /lab activities	• Laboratory equipped with high-performance computers and having python installed.

6. Specific competencies acquired

Professional/essential competencies	• advanced programming skills in high-level programming languages • development and maintenance of software systems • use of software tools in an interdisciplinary context • use of theoretical foundations of computer science as well as of formal models • use of artificial intelligence concepts and techniques to solve real-world problems
Transversal competencies	• application of organized and efficient work rules, of responsible attitudes towards the didactic-scientific field, to bring creative value to own potential, with respect for professional ethics principles and norms • efficient development of organized activities in an interdisciplinary group and the development of empathetic abilities for • use of efficient methods and techniques to learn, inform, research and develop the abilities to bring value to knowledge, to adapt at the requirements of a dynamical society and to communicate efficiently in Romanian language and in an international language

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

7.1 General objective of the discipline	• 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.
7.2 Specific objective of the discipline	• Understand various architectures of Convolutional Neural Networks for image classification, object detection, video analysis, and synthetic visual data generation. • Solve and analyse a Computer Vision problem using a specific theoretical apparatus. • Understand and develop efficient fine-tuning strategies for increasing the performance of Convolutional Neural Networks with applications in the Computer Vision field. • Understand the metrics used to evaluate complex networks, as well as visualizing the features learned by the networks.

8. Content

8.1 Course	Teaching methods	Remarks
1. **Introduction to Computer Vision.** Overview, history of computer vision, the three Rs of computer vision.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
2. **Image classification pipeline.** Image classification pipeline, image features, filters, convolutions, linear classifiers.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
3. Shallow neural networks. Optimization and loss functions.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
4. **Introduction to convolutional neural networks.** Convolutional neural networks architectures. Elements of a convolutional convolutional neural network: convolutional layers, pooling layers, fully connected layer). Architectures: LeNet, AlexNet, VGG, Inception, Resnet.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
5. **Sequential Models, Attention Mechanisms, Transformer Architecture.**	• Interactive exposure • Explanation	

	• Conversation • Didactical demonstration	
6. **Training a Neural Network.** Activation Functions, Weight Initialization, Hyperparameter Tuning, Transfer Learning.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
7. **Image Segmentation.** Transposed Convolutions, Fully Convolutional Networks, U-Net Architecture, SegFormer, SAM.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
8. **Generative networks**. PixelRNN and PixelCNN, Variational Autoencoders (VAE), Generative Adversarial Networks (GAN).	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
9. **Object detection**. Object Detection, Region Proposal, ROI Pooling. Convolutional and Transformer-Based Architectures for Object Detection	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
10. Graph convolutional neural networks. Graphs, Message Passing, Applications in Computer Vision.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
11. **Video Data Analysis.** C3D, I3D, R(2+1)D, SlowFast, TimeSformer, Video Swin Transformer, ViViT, MViT, ActionFormer.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
12. Self-Supervised Learning, Zero-Shot Models. CLIP, BLIP, DINO.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
13. Case studies and demonstrations of state-of-the-art algorithms. Ethics in artificial intelligence. Debate.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
14. Exam	• Interactive exposure, conversation.	

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.
9. https://pytorch.org/docs/stable/index.html

8.2 Seminar / laboratory	Teaching methods	Remarks
Laboratory		
1. Strategies for solving computer vision problems. Introduction to *python* and *torch*.	• Interactive exposure • Explanation • Conversation • Individual and group work • Dialogue, debate	
2. Implementing a linear classifier from scratch. Evaluation metrics.	• Interactive exposure • Explanation • Conversation • Individual and group work • Dialogue, debate	

3. Optimization algorithms, unbalanced data, data pre-processing, data generators in *torch*. Convolutional neural networks for classification.	• Interactive exposure • Explanation • Conversation • Individual and group work • Dialogue, debate	
4. Transfer learning and fine tuning.	• Interactive exposure • Explanation • Conversation • Individual and group work • Dialogue, debate	
5. Semantic segmentation I. Data Processing, Architecture Definition.	• Interactive exposure • Explanation • Conversation • Individual and group work • Dialogue, debate	
6. Semantic segmentation II. Architecture Implementation, Training.	• Interactive exposure • Explanation • Conversation • Individual and group work • Dialogue, debate	
7. Experiment tracking, Deployment.	• Interactive exposure • Explanation • Conversation • Individual and group work • Dialogue, debate	
8. Transformer architectures.	• Interactive exposure • Explanation • Conversation • Individual and group work • Dialogue, debate	
9. Data Management, Annotation.	• Interactive exposure • Explanation • Conversation • Individual and group work • Dialogue, debate	
10. Experiment Management.	• Interactive exposure • Explanation • Conversation • Individual and group work • Dialogue, debate	
11. Deployment.	• Interactive exposure • Explanation • Conversation • Individual and group work • Dialogue, debate	
12. Choosing Project Topics. Establishing Methodology.	• Interactive exposure • Explanation • Conversation • Individual and group work • Dialogue, debate	
13. Project. Presentation of the Models to be Used, Experiment Planning, Ablation Studies.	• Interactive exposure • Explanation • Conversation • Individual and group work • Dialogue, debate	
14. Project evaluation	• Evaluation	
Project		
Phase 1 - each student should pick (or propose) a computer vision problem for the project	• Interactive exposure • Explanation • Conversation	

- discussion about the chosen projects - state of the art analysis (search for other methods that solve the same problem) - short presentation (by the teacher) of the possible computer vision project themes that could be solved using deep learning - presentation (by the teacher) of the methodology that needs to be followed for the project and of the available tools to achieve the project **Phase 2** - establishing the methodology that needs to be followed to solve the project - data gathering, data pre-processing - selection of the appropriate network architectures **Phase 3** - design and implementation of the project - design and implementation of the project - evaluation metrics implementation - visualization - implementation cont'd, evaluation, fine-tuning - project delivery, presentation, demo	• Individual and group work • Brainstorming	

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.
5. https://pytorch.org/docs/stable/index.html
6. https://www.tensorflow.org/api_docs

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

- The course follows the ACM and IEEE Curriculum Recommendations for Computer Science majors.
- The course exists in the studying program of all major universities in Romania and abroad.
- The knowledge and skills acquired in this course give students a foundation for launching a career in scientific research.

10. Evaluation

Activity type	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Percentage of final grade
10.4 Course	• The student has a good understanding of the deep learning concepts.	Written examination at the lecture in the last week of the semester.	50%
	• The ability to apply the course concepts in solving a real-life computer vision problem.		
10.5 Seminar/laboratory	• The correct specification, design, implementation and evaluation of some computer vision problems based on deep learning.	Continuous observations Practical project	50%
10.6 Minimum standard of performance			

- 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. - The final grade (average between written exam and project) should be at least 5 (no rounding)

11. Labels ODD (Sustainable Development Goals)[1]

Not applicable.

Date:	Signature of course coordinator	Signature of seminar coordinator
April 27, 2025	**Lect. PhD. Diana Laura Borza**	**Lect. PhD. Diana Laura Borza**

Date of approval:	Signature of the head of department
...	Assoc.prof.phd. Adrian STERCA

[1] Keep only the labels that, according to the *Procedure for applying ODD labels in the academic process*, suit the discipline and delete the others, including the general one for *Sustainable Development* – if not applicable. If no label describes the discipline, delete them all and write „*Not applicable*.”.