SYLLABUS

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**

2. Information regarding the discipline

2.1 Name of the discipline (en) (ro)			**Învățare profundă și tehnici de viziune computerizată / Deep learning and Computer Vision**				
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 Type of discipline	**Compulsory DS**
2.8 Code of the discipline		**MLE5207**					

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	2 LP
3.4 Total hours in the curriculum	48	Of which: 3.5 course	24	3.6 seminar/laboratory	24
Time allotment:					hours
Learning using manual, course support, bibliography, course notes					30
Additional documentation (in libraries, on electronic platforms, field documentation)					50
Preparation for seminars/labs, homework, papers, portfolios and essays					40
Tutorship					4
Evaluations					3
Other activities:					

3.7 Total individual study hours	127
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 competencies	C6.1 Describing the basic concepts for representation and characterization of signals and the basic concepts of artificial intelligence C6.2 Appropriate use of methods for signal analysis and fundamental artificial intelligence algorithms C6.3 Use of simulation and programming environments to process signals and model solutions to problem classes C6.4 Quantitative and qualitative evaluation of the performance of intelligent systems C6.5 Incorporating signal processing methods and artificial intelligence-specific solutions into dedicated applications
Transversal competencies	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 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.

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. **Training a neural network**. Activation functions, weight initialization, hyperparameter tuning, transfer learning.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
6. ***Case study: face analysis using convolutional neural networks***. Multitask networks, triplet loss function.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	

7. **Image segmentation using convolutional neural networks**. Transposed convolutions, Fully convolutional neural networks, U-Net architecture.	• 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 neural networks for object detection: Fast R-CNN, Faster R-CNN, Mask-RCNN, YOLO, SSD	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
10. **Graph convolutional neural networks.**	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
11. **Sequence models. Attention and transformers.**	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
12. **Vision transformers. Self-supervised learning.**	• 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. **Project presentation**	• 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.
8. https://pytorch.org/docs/stable/index.html
9. https://www.tensorflow.org/api_docs

8.2 **Laboratory**	Teaching methods	Remarks

1. Strategies for solving computer vision problems. Introduction to *python* and *keras*.	• Interactive exposure • Explanation • Conversation • Individual and group work • Dialogue, debate	The laboratory is structured as 2 hours per week, every other week
2. Convolutional neural networks (building blocks, simple architectures). Evaluation metrics and visualization (Precision, Recall, TPR, FPS, F1-Score, confusion matrix, activation maps).	• Interactive exposure • Explanation • Conversation • Individual and group work • Dialogue, debate	
3. Optimization algorithms, unbalanced data, data pre-processing, data generators in *keras*. Convolutional neural networks for instance segmentation.	• Interactive exposure • Explanation • Conversation • Individual and group work • Dialogue, debate	
4. Laboratory assignment presentation. Project phase 1.	• Interactive exposure • Explanation • Conversation • Individual and group work • Dialogue, debate	
5. Project phase 2	• Interactive exposure • Explanation • Conversation • Individual and group work • Dialogue, debate	
6. Project phase 3. Project presentation	• Interactive exposure • Explanation • Conversation • Individual and group work • Dialogue, debate	
7. Evaluation (written examination)	• Quiz	
Project		
Phase 1 - each student should pick (or propose) a computer vision problem for the project - 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	• Interactive exposure • Explanation • Conversation • Individual and group work • Brainstorming	

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		

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

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the grade (%)
10.4 Course	• The student has a good understanding of the deep learning concepts. • The ability to apply the course concepts in solving a real-life computer vision problem.	Written examination at the laboratory in the last week of the semester.	40%
10.5 Seminar/lab activities	• The correct specification, design, implementation and evaluation of a computer vision	Continuous observations Practical project	60% (30% laboratory assignments and 30% project)

	problem based on deep learning. • The student is able to apply different techniques for improving the performance of a deep learning system.		
10.6 Minimum performance standards			
➢ 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)			

Date	Signature of course coordinator	Signature of seminar coordinator
30.04.2023	Lect. PhD. Diana Laura Borza	Lect. PhD. Diana Laura Borza

Date of approval	Signature of the head of department
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