Program	Type of studies (cycle)	Third cycle
	Name of the program	Doctoral Studies in Mathematical and Computer Science

COURSE

Course title	**Applied machine learning and deep intelligent systems**

Course code	Semester	Course status	ECTS credits	Contact hours
CS 606	II	elective	10	30

Aims and intended learning outcomes	The primary aim of the course is to deepen and systematize advanced knowledge of applied machine learning, deep learning, and contemporary intelligent systems, with an emphasis on the mathematical understanding of models, experimental evaluation, reproducibility, and applications to real-world research problems. The course provides a contemporary extension of artificial intelligence, symbolic and connectionist reasoning, machine learning, and neural networks, placing them in the context of today's deep, generative, multimodal, and explainable AI systems. Upon successful completion of the course, the student is expected to be able to critically analyze contemporary scientific literature in AI and machine learning, formulate a research problem, select an appropriate model and evaluation methodology, implement and experimentally investigate advanced ML/DL models, interpret their results, identify model limitations and risks, and clearly present original research results in the form of a seminar paper or scientific article.

Course content/topics

- Contemporary intelligent systems: agents, knowledge representation, learning, reasoning, and decision-making under uncertainty.
- Methodological framework of machine learning: datasets, generalization, regularization, validation, performance measures, overfitting, and underfitting.
- Supervised, unsupervised, and self-supervised learning; regression, classification, clustering, dimensionality reduction, and representation learning.
- Advanced machine learning models: SVM, ensemble methods, gradient boosting, probabilistic models, Extreme Learning Machines, and hyperparameter optimization.
- Deep learning: multilayer neural networks, CNN, RNN/LSTM/GRU, autoencoders, Transformer architectures, and attention mechanisms.
- Generative and multimodal models: GANs, variational autoencoders, diffusion models, large language models, and fundamental principles of prompting and fine-tuning.
- Explainable, trustworthy, and responsible artificial intelligence: interpretability, robustness, bias, ethical aspects, and limitations of AI systems.
- Applications of deep intelligent systems in image processing, computer vision, biomedical reconstruction, satellite data, license plate detection, sentiment analysis, and spatiotemporal forecasting.
- Experimental design in AI research: ablation studies, model comparison, statistical analysis of results, reproducible Python/PyTorch/TensorFlow experiments, and research report writing.

LITERATURE

[1] Murphy, K. P., Probabilistic Machine Learning: Advanced Topics, MIT Press, 2023.

[2] Zhang, A., Lipton, Z. C., Li, M., Smola, A. J., Dive into Deep Learning, Cambridge University Press, 2023.

[3] Huyen, C., Designing Machine Learning Systems: An Iterative Process for Production-Ready Applications, O'Reilly, 2022.

[4] Russell, S. J., Norvig, P., Artificial Intelligence: A Modern Approach, 4th ed., Pearson, 2021.

[5] Ethem Alpaydin, Introduction to Machine Learning, 4th edition, MIT Press, 2020.

[6] Raschka, S., Liu, Y., Mirjalili, V., Machine Learning with PyTorch and Scikit-Learn, Packt Publishing, 2022.

[7] Goodfellow, I., Bengio, Y., Courville, A. Deep Learning, MIT Press, 2016.

[8] Selected contemporary scientific papers in the fields of ML/DL/AI.

Grading

	Criterion	Points	Cut-off points
1.	Assignments	20	11
2.	Project	40	22
3	Final exam	40	22
	T o t a l	100	55