Doctoral program name

Artificial Intelligence, Data Science, and Visualization

Program Leader

Dr. András Hajdu

Objectives of Doctoral Programme

This doctoral program aims to provide PhD students with comprehensive and in-depth knowledge of the mathematical and algorithmic foundations of data science and artificial intelligence, as well as advanced methods in machine learning and deep learning. The program emphasizes the practical applications of artificial intelligence, along with related ethical, security, and interpretability considerations. A key objective of the program is to equip PhD students with the ability to extract meaningful information from large and complex datasets, interpret the results, and present them visually using various modelling and visualization techniques.

Academic and Research Fields

Data analysis and statistical modelling

Foundational models in probability and statistics. Parametric and non-parametric estimation methods. Regression techniques. Dimensionality reduction methods. Classification and predictive modelling. Time series analysis and modelling of seasonal patterns. Multivariate statistical methods. Handling heterogeneous and incomplete data. Model diagnostics, overfitting, and regularization. Visual analysis of static and dynamic data. Data structuring and preprocessing.

Machine and deep learning, artificial intelligence systems

Machine learning paradigms: supervised, unsupervised, and reinforcement learning. Classical learning algorithms (e.g., decision trees, k-NN, SVM, ensemble models). Deep learning architectures: feedforward and convolutional neural networks, recurrent networks, generative models, transformer-based architectures, and large language models. Optimization methods. Representation learning and dimensionality reduction. Graph-based learning. Explainable artificial intelligence. Ethical and secure AI systems. Agent-based modelling and intelligent simulation systems.

Visualization and visual analytics

Scientific and information visualization. Visualization pipelines and rendering techniques. Visualization of 2D and 3D data. Volume and surface-based rendering methods. Dimensionality reduction for visualization. Visualization systems and human-computer interaction. Interactive and exploratory visualization techniques. Visual pattern and anomaly detection. Visual analytics workflows and human decision support.

Image processing and shape recognition

Medical and biological image processing. Object recognition, pattern matching, and segmentation. Surface and volumetric reconstruction from projection images. Integration of multimodal sensor data in image processing. Biometric identification. Character recognition and text extraction from images. Image databases, indexing, and semantic querying. Content-based image and video analysis.

Geometric modeling and digital geometry

Parametric curves and surfaces. Subdivision techniques and surface smoothing. Projective and descriptive geometric transformations in computer graphics applications. 3D modelling, mesh generation, and preprocessing for finite element analysis. Discrete geometric representations. Mathematical morphology. Topological and algebraic features in digital image representations.

Members of the doctoral programme

Name	Academic degree	Topic poster	Instructor
Dr. Sándor BÁCSÓ	CSc habil.	-	x
Dr. Ágnes Éva BARAN	PhD habil.	-	x
Dr. Marianna BODROGINÉ ZICHAR	PhD habil.	x	x
Dr. Gergő BOGACSOVICS	PhD	x	x
Dr. Miklós EMRI	PhD habil.	x	-
Dr. Attila FAZEKAS	PhD habil.	x	x
Dr. András HAJDU	DSc	x	x
Dr. Lajos HAJDU	DSc	-	x
Dr. Sándor HAJDU	PhD	x	-
Dr. Balázs HARANGI	PhD habil.	x	x
Dr. Miklós HOFFMANN	DSc	x	x
Dr. László KOVÁCS	PhD	x	-
Dr. Roland Imre KUNKLI	PhD	x	x
Dr. Tamás MANKOVITS	PhD habil.	x	x
Dr. Ildikó PAPP	PhD habil.	x	x
Dr. Andrea PINTÉR-HUSZTI	PhD habil.	x	x
Dr. Szilvia SZEGHALMY	PhD	-	x
Dr. Attila TIBA	PhD	-	x
Dr. Henrietta TOMÁN	PhD	-	x
Dr. Róbert TORNAI	PhD habil.	x	x
Dr. János TÓTH	PhD	x	x
Dr. Balázs UJVÁRI	PhD	-	x

Subjects

	Subject name	Credit	Subject teacher
Compulsory elective subjects	Big Data processing	2	Dr. Henrietta Tomán
	Computer-aided design and simulation	2	Dr. Ildikó Papp
	Deep learning	2	Dr. Balázs Harangi
	Discrete mathematics	2	Dr. Lajos Hajdu
	Image processing algorithms	2	Dr. János Tóth
	Information and scientific visualization	2	Dr. Marianna Bodroginé Zichar
	Machine learning	2	Dr. Balázs Harangi
	Mathematics of data science	2	Dr. Ágnes Éva Baran
	Multimodal data analysis	2	Dr. András Hajdu
	Optimization of artificial intelligence systems	2	Dr. András Hajdu
	Topics in geometry	2	Dr. Sándor Bácsó
Elective subjects	Accelerator architectures	2	Dr. Róbert Tornai
	Advanced computer graphics	2	Dr. Róbert Tornai
	Agent-based systems and simulation	2	Dr. András Hajdu
	Applied descriptive and projective geometry	2	Dr. Sándor Bácsó
	Artificial intelligence security	2	Dr. Andrea Pintér-Huszti
	Bioinformatics	2	Dr. András Hajdu
	Computer-aided modelling of curves and surfaces	2	Dr. Miklós Hoffmann
	Data fusion models	2	Dr. Henrietta Tomán
	Deep learning on graphs	2	Dr. Attila Tiba
	Digital geometry and mathematical morphology	2	Dr. Attila Fazekas
	Explainable and ethical artificial intelligence	2	Dr. János Tóth
	Finite element analysis	2	Dr. Tamás Mankovits
	Generative artificial intelligence	2	Dr. Gergő Bogacsovics
	Geospatial intelligence	2	Dr. Marianna Bodroginé Zichar
	Image processing in medicine and biology	2	Dr. Attila Fazekas
	Large language models	2	Dr. Gergő Bogacsovics
	Low-level image processing	2	Dr. Szilvia Szeghalmy
	Sensor-based data collection and processing	2	Dr. Balázs Ujvári
	Visual analytics methods	2	Dr. Roland Imre Kunkli