



Introduction to

Machine Learning

for Civil Engineering and Architecture



Politecnico di Torino



ArtIStE



Artificial Intelligence in Structural Engineering Machine Learning Academy



DOCTORAL COURSE & SUMMER SCHOOL

In conjunction with

ARTISTE 2025 Conference

Artificial Intelligence in Structural Engineering

3-Day Intensive Course on Machine Learning Tailored for Architecture & Civil Engineering PhD Candidates, Researchers, and Enthusiasts

- I. Venanzi** University of Perugia, Italy
- M.M. Rosso** Politecnico di Torino, Italy
- G. C. Marano** Politecnico di Torino, Italy
- C. Demartino** Roma Tre Univ., Italy
- M. Broccardo** University of Trento, Italy
- G. Quinci** Roma Tre Univ., Italy
- G. Quaranta** Sapienza Univ. of Rome, Italy



Day 1 - Sept, 18th

Machine Learning Basics & Data Exploration

Python Fundamentals, Machine Learning Basics, Data Exploration, Classifiers, Gaussian Process Regression

Day 2 - Sept, 19th

Neural Networks

Basics, Feed-Forward ANN, Advanced Neural Networks: CNNs, RNNs, LSTM, Autoencoders, GANs

Day 3 - Sept, 20th

Regression Methods

Decision Trees, Random Forests, Boosting, Symbolic Regression, Computational Intelligence

VENUE

Room 7

Politecnico di Torino

C.so Duca degli Abruzzi, 24 10129, Turin, Italy



SUMMER SCHOOL ARTISTE 2025 In-person & Remote Attendance

Mastering your Research in Civil Engineering & Architecture with cutting-edge Machine Learning **IN JUST 3 DAYS!**

EXPECTED GOALS

- Establish Core ML Foundations
- Hands-On in Google Colab
- Learn Python with PyTorch, TensorFlow, Scipy and more
- Explore Symbolic Regression & Computational Intelligence
- Optimize Model Performance
- Integrate Advanced Techniques into your Research Field

WEBINAR SERIES: DISTINGUISHED LECTURES

From September, 22nd to December, 12th 2025

Education

Learn with Experts

Eminent Speakers For Real-World Applications

Knowledge

Open-Science

Web-Streaming available on CASSYNI Platform



CASSYNI Research seminars

Enrollments are OPEN!

- G. Karniadakis** Brown University, USA
- M. Shields** John Hopkins University, USA
- C. Ratti** Massachusetts Institute of Technology, USA
- H. Li** Harbin Institute of Technology, P.R.China
- K. E. Willcox** University of Texas at Austin, USA
- K. Worden** University of Sheffield, UK



REGISTRATION

NO registration fees, but only a contribution is required for covering event logistics and services:

In-person 150 € + VAT
Remote Attendance 100 € + VAT

Pre-register on our website & book your spot before August, 31st 2025



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The “Machine Learning for Civil Engineering and Architecture” course is a three-day intensive training designed to respond to the growing demand for data-driven approaches in the built environment. As machine learning (ML) techniques continue to transform research across disciplines, it is becoming increasingly important for researchers in civil engineering and architecture to acquire a solid understanding of these tools—not only to keep pace with innovation but to actively contribute to it. Hosted at Politecnico di Torino and held in conjunction with the ARTISTE 2025 Conference, the course offers a structured path through the fundamentals of ML, from data processing in Python to advanced topics like neural networks, symbolic regression, and computational intelligence. Participants will engage with both theoretical concepts and hands-on sessions tailored to real-world engineering problems, learning how to explore, model, and interpret data in ways that enhance structural design, safety assessment, and performance analysis. By bridging traditional engineering knowledge with modern AI techniques, this course empowers early-career researchers and practitioners to lead the next generation of innovation in the construction and infrastructure sectors.

Venue: Room 7, Politecnico di Torino, C.so Duca degli Abruzzi, 24, 10129, Turin, Italy

Attendance: In-person & Remote Attendance

I. Venanzi University of Perugia, Italy	M.M. Rosso Politecnico di Torino, Italy	G. C. Marano Politecnico di Torino, Italy	C. Demartino Roma Tre Univ., Italy	M. Broccardo University of Trento, Italy	G. Quinci Roma Tre Univ., Italy	G. Quaranta Sapienza Univ. of Rome, Italy
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Teachers:



Teaching assistants: Jonathan Melchiorre (Politecnico di Torino), Carlotta Pia Contiguglia (Roma Tre University), Harrish Joseph (University Sapienza of Rome), Farzin Kazemi (Gdańsk University of Technology), Neda Asgarkhani (Gdańsk University of Technology)

Day 1: Thursday, 18 September 2025 (Introduction)

Time	Topic / Detailed Content	Speakers
8:00 – 8:30	Registration	
8:30 – 8:45	Welcome	G. C. Marano
8:45 – 9:00	Aims and Framework of the Course An overview of the course objectives, the structure of the three days.	G. C. Marano, C. Demartino, G. Quaranta
9:00 – 10:15	Introduction to Machine Learning for Civil Engineering and Architecture.	G. C. Marano, Demartino, G. Quaranta
10:15 – 10:45	Coffee break	
10:45 – 12:30	Introduction to Python for Data Processing.	M.M. Rosso, C. Demartino
12:30 – 13:30	Lunch	
13:30 – 15:00	Data Exploration for Civil Engineering and Architecture.	M.M. Rosso, C. Demartino
15:00 – 15:30	Coffee break	
15:30 – 17:30	Machine Learning for Structural Health Monitoring (SHM) Application of ML for anomaly detection, damage identification, and performance assessment.	I. Venanzi
17:30 – 19:00	Live Workshop: Data Exploration Hands-on session using Python and Google Colab.	





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Day 2: Friday, 19 September 2025 (Neural network)

Time	Topic / Detailed Content	Speakers
8:30 – 10:30	Basics of Neural Networks/1 Perceptron, activation functions, feed-forward architectures, and backpropagation.	M. Broccardo, G. Quinci
10:30 – 11:00	Coffee break	
11:00 – 12:30	Basics of Neural Networks/2 Loss functions, optimizers, and training considerations.	M. Broccardo, G. Quinci
12:30 – 13:30	Lunch	
13:30 – 15:00	Advanced Neural Networks/1 CNNs, RNNs, and their applications in engineering.	G. Quaranta, G. Quinci
15:00 – 15:30	Coffee break	
15:30 – 17:00	Advanced Neural Networks/2 Autoencoders, LSTM, GANs, and advanced applications.	G. Quaranta, C. Demartino, G. C. Marano
17:00 – 19:00	Live Workshop: Neural Networks Implementation using PyTorch/TensorFlow.	

Day 3: Saturday, 20 September 2025 (Regression and optimization)

Time	Topic / Detailed Content	Speakers
8:30 – 10:30	Gaussian Process for Surrogate Models Application of GPs for complex engineering simulations and uncertainty quantification.	M. Broccardo
10:30 – 11:00	Coffee break	
11:00 – 12:30	Tree & Boosting Methods Decision Trees, Random Forests, and Gradient Boosting.	M.M. Rosso, C. Demartino
12:30 – 13:30	Lunch	
13:30 – 15:00	Symbolic Regression Discovering interpretable mathematical models.	G. Quaranta, C. Demartino, M.M. Rosso
15:00 – 15:30	Coffee break	
15:30 – 17:00	Computational Intelligence Evolutionary computation & swarm intelligence.	G. Quaranta, C. Demartino, M.M. Rosso
17:00 – 19:00	Live Workshop: Distilling Equations and Fast Predictions Hands-on with symbolic regression for fast modeling.	

All lectures will be delivered in English, and Zoom will be used as the official platform for remote participation. Participants are required to use their personal computers to complete the hands-on exercises throughout the course. Any operating system is acceptable, as long as it supports running Python or accessing Google Colab via a web browser. For students attending remotely from regions where Google or Zoom services may be restricted, the use of a VPN is strongly recommended to ensure full access to the course content and live sessions. All teaching materials will be distributed in advance of the classes to registered participants. Please note that lectures will not be recorded, and the redistribution or sharing of any course materials is strictly prohibited.

All examples and practical exercises in the course will be based on widely used and open-source Python libraries, including SciPy, TensorFlow/Keras, and PyTorch. These tools have become essential in modern scientific computing and machine learning applications, and the course is structured to provide participants with hands-on experience in using them for real-world problems in civil engineering and architecture. Familiarity with basic Python is helpful but not required, as foundational concepts will be introduced during the sessions.

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WEBINAR SERIES: DISTINGUISHED LECTURES

The Distinguished Lecture series complements the First International ML Academy Course by featuring eminent researchers who explore the frontiers of machine learning in civil engineering and architecture. These keynote-style talks enrich the core course by offering broader context and visionary insights. All lectures will be available on the Cassyni Research Seminar platform, enabling participants to access and revisit the content. This series aims to inspire curiosity, foster interdisciplinary dialogue, and support the next generation of scholars in the era of intelligent built environments.



George Em Karniadakis

29 September 2025 – 15:00 (CET)



From Physics-Informed Machine Learning to Physics-Informed Machine Intelligence: Quo Vadimus?

Abstract: This talk reviews physics-informed neural networks and introduces networks that learn functionals and nonlinear operators for system identification. It discusses applications in digital twins, autonomy, and materials discovery, and introduces bio-inspired solutions like spiking neural networks and neuromorphic computing.

Short Biography: Professor at Brown University and affiliated with MIT and PNNL. Member of the US National Academy of Engineering. He has received numerous prestigious awards, including the GI Taylor Medal and the SIAM/ACM Prize in CSE. His h-index is 151 with over 133,000 citations.

Michael D. Shields

8 October 2025 – 15:00 (CET)



Uncertainty Quantification & Scientific Machine Learning

Abstract: This talk discusses Uncertainty Quantification (UQ) and Machine Learning (ML) in physics-based computational modeling, highlighting recent advances such as Bayesian and spectral stochastic neural operators. With the rise of scientific and physics-informed ML, new tools are tackling increasingly complex problems. UQ is now a core part of modeling, addressing inherent uncertainties.

Short Biography: Professor at Johns Hopkins University, director of the HT-MAX center, and expert in UQ and scientific ML. He has received awards from ONR, NSF, DOE, and Johns Hopkins and leads the development of the UQpy software.

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Keith Worden

29 October 2025 – 15:00 (CET)



Applications of Machine Learning in SHM

Abstract: This talk explores how machine learning has transformed the field of structural health monitoring (SHM) over the past decades. It will introduce key ML tasks—classification, regression, and density estimation—and demonstrate their use in diagnosing and predicting structural behavior. Through real-world case studies, the talk will highlight the strengths and limitations of these approaches.

Short Biography: Professor at the University of Sheffield, with a background in theoretical physics and mechanical engineering. His research focuses on advanced signal processing and ML methods applied to structural dynamics in various industries.

Karen Willcox

6 November 2025 – 15:00 (CET)



Digital Twins and their Impact Across Science, Technology and Society

Abstract: This talk presents digital twins as powerful computational representations of physical systems that evolve over time and interact bidirectionally with their real-world counterparts. It will explore the mathematical and algorithmic foundations behind digital twins, including reduced-order models and scientific machine learning methods. Applications across aerospace, civil infrastructure, and personalized medicine will illustrate their broad societal impact and transformative potential.

Short Biography: Director of the Oden Institute and professor at UT Austin. Former MIT professor and Boeing engineer. Member of the US National Academy of Engineering, with fellowships from SIAM, AIAA, and USACM.





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Carlo Ratti

13 November 2025 – 15:00 (CET)



Senseable Cities

Abstract: This talk investigates how the Internet of Things (IoT) is reshaping urban design and architecture by embedding connectivity into the built environment. Drawing from projects by the MIT Senseable City Lab, it illustrates how data and sensing technologies enable new forms of urban interaction and management. The lecture will critically reflect on the implications of these technologies for energy, mobility, public engagement, and city-making.

Short Biography: Professor at MIT and director of the Senseable City Lab. Founder of Carlo Ratti Associati. Curator of the 2025 Venice Architecture Biennale and author of over 250 publications on urban technologies.

Hui Li

21 November 2025 – 13:00 (CET)



AI-empowered Structural Health Monitoring for Civil Structures

Abstract: This talk introduces AI-driven approaches for enhancing structural health monitoring (SHM) using distributed sensing technologies and high-dimensional data analytics. It will examine how machine learning can improve condition assessment in sparsely instrumented systems and support predictive maintenance strategies. The session concludes with an overview of generative models designed to simulate and guide long-term structural management.

Short Biography: Professor at Harbin Institute of Technology, member of the Chinese Academy of Sciences. Former IASCM president, awarded ASCE George Housner and Robert Scanlan Medals.

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