# Deep Learning Applications

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# *COURSE AIMS AND INTENDED LEARNING OUTCOMES*

In recent years, significant advancements in artificial neural networks, bolstered by an abundance of data and computing power, have given rise to deep learning models commonly employed in data analytics frameworks.

This course aims to equip students with the knowledge and skills necessary to develop deep neural network models and comprehend their applications. The curriculum will address the foundational aspects of deep neural networks, such as convolutional neural networks, recurrent neural networks, and transformers, with a special emphasis on reinforcement learning. Students will engage in hands-on sessions, during which they will undertake various deep learning projects, including those involving computer vision, time series forecasting, natural language processing, and deep reinforcement learning. Upon completing the course, students are expected to achieve the following learning outcomes:

* Display a thorough understanding of contemporary deep learning architectures and their corresponding applications (Knowledge and understanding).
* Apply knowledge and understanding by implementing specific neural network models and training algorithms.
* Evaluate the suitability and effectiveness of a deep learning technique for a given task (Making judgments).
* Clearly explain and justify their solution using appropriate computer science terminology (Communication skills).
* Independently consult authoritative documentation for the language and framework used, while recognizing neural network architectures and their applications at an abstract level (Lifelong learning skills).

***COURSE CONTENT***

1. Introduction to Deep Neural Networks: exploring neural network architectures, activation functions, loss functions, and the backpropagation algorithm.
2. Convolutional Neural Networks: understanding image classification, convolutional layers, pooling layers, and transfer learning.
3. Recurrent Neural Networks: delving into time series prediction, long short-term memory (LSTM), and gated recurrent units (GRUs).
4. Transformers: examining attention mechanisms and applications in natural language processing.
5. Markov Decision Process: learning about states, actions, rewards, policies, and value functions.
6. Reinforcement Learning: discussing dynamic programming, SARSA, and Q-learning.
7. Value Function Approximation: addressing the curse of dimensionality and linear value approximation.
8. Policy Gradient Methods: investigating stochastic policies and actor-critic models.
9. Deep Reinforcement Learning: exploring DQN, DDPG, A3C, and ANF algorithms.
10. Imitation Learning: studying behavioral cloning, data aggregation, and inverse reinforcement learning.

***READING LIST***

* Zhang, Z. C. Lipton, M. Li, and A. J. Smola. *Dive into Deep Learning*, 2020. Freely available at <http://d2l.ai>
* Goodfellow, Y. Bengio, and A. Courville. *Deep Learning*, MIT Press, 2016.
* Géron, A. (2022). *Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow*. " O'Reilly Media, Inc.".
* Sutton, R. S., & Barto, A. G. (2018). *Reinforcement learning: An introduction*. MIT press.
* Further instructional material, e.g. class notes, source code, handouts, will be posted on Blackboard.

***TEACHING METHOD***

A blend of classical lectures and practice sessions with computer-based activities (45 hours).

***ASSESSMENT METHOD AND CRITERIA***

A practical assessment consisting of a project for testing student skills in developing and applying deep neural networks to reinforcement learning and natural language processing.

***NOTES AND PREREQUISITES***

Students are supposed to be proficient in using a computer and to have mastered the basic notions and skills in Python programming, i.e., the topics covered in the course of “IT CODING FOR DATA SCIENCE”. Moreover, knowledge of topics in linear algebra, calculus and statistics is required. Finally, a solid background in data analysis and machine learning, i.e., the topics covered in the course of “DATA ANALYSIS TECHNIQUES AND TOOLS” and “ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING”, is highly recommended.

*Further information can be found on the lecturer's webpage at http://docenti.unicatt.it/web/searchByName.do?language=ENG or on the Faculty notice board.*