HPC

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Academy
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AI
ACADEMY

DIGITAL LEARNING HUB · AI ACADEMY

AI Academy Curriculum

Detailed overview of the courses, modules and key learning objectives.

DIGITAL LEARNING HUB · AI ACADEMY

AI Academy Curriculum

The AI Academy prepares learners to design, build and apply artificial intelligence. The programme starts with a Common Core shared by all learners, continues with one of two specialisations, and ends with a Capstone Project in which learners apply everything they have learned to a real-world challenge.

Programme structure

PART 1
Common Core
Python, mathematics and data foundations shared by all learners.

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PART 2 · SPECIALISATION
Data Science
Applied AI and data-driven solutions.

OR

PART 2 · SPECIALISATION
Machine Learning
The science behind AI.

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PART 3
Capstone Project
A real-world project in the chosen specialisation.

Two specialisations, two profiles

Data Science
Applied AI and data-driven solutions

FOCUS
Turning data into working AI solutions for real problems.

APPROACH
Established libraries, frameworks and pretrained models, applied across the full workflow from data to AI-powered applications.

LEARNERS BECOME
Practitioners who choose, combine and evaluate the right AI methods.

Machine Learning
The science behind AI

FOCUS
Understanding how machine learning models work.

APPROACH
Most algorithms coded from scratch, supported by additional mathematics.

LEARNERS BECOME
Engineers who can design, build and adapt models from the ground up.

PART 1

Common Core

The foundation for every AI path

Every learner starts here. The Common Core builds the technical foundation that all AI work relies on: programming in Python, the essential mathematics behind machine learning, and working with data. By the end, learners are ready to choose the specialisation that matches their goals.

What you will learn

1 Software foundations

The developer's toolkit.

- Unix command line and shell navigation
- File ownership and permissions
- Version control with Git and GitHub
- Development environment set-up

2 Programming in Python

Clean, structured and reliable code.

- Syntax, control flow and functions
- Lists, tuples, sets and dictionaries
- Object-oriented programming
- Exception handling, file I/O and JSON

3 Mathematical foundations

Linear algebra and probability.

- Vectors, matrices, matrix multiplication and array operations
- Poisson, exponential, normal and binomial distributions: PMF, PDF and CDF

4 Data manipulation and visualisation

Working with tabular data.

- Handling DataFrames: indexing, filtering, sorting, merging and aggregation
- Creating different types of charts and plots: line plots, scatter plots, bar charts and histograms

PART 2 · SPECIALISATION

Data Science

Applied AI and data-driven solutions

Develop the skills to transform data into insights and build AI-powered solutions using established libraries and frameworks. Learners follow the applied workflow used in industry, from data acquisition to AI-powered applications.

What you will learn

1 Data Handling

Data collection, exploration, cleaning and preparation.

- Data acquisition: web scraping, REST APIs, SQL and NoSQL databases
- Exploratory data analysis and visualisation
- Data cleaning: missing values, duplicates and data types
- Statistical testing, feature encoding, scaling and data splitting

2 Classical Machine Learning

Supervised and unsupervised learning, and model interpretability.

- Linear and logistic regression, regularised models and support vector machines
- Decision trees, random forests and gradient boosting
- Clustering and dimensionality reduction: K-means, hierarchical clustering and PCA
- Model evaluation and interpretability through explainable AI (XAI)

3 Deep Learning

Neural network architectures, model training and evaluation.

- Building neural networks: layers, activation and loss functions
- Training, monitoring, evaluating and saving models
- Improving training: optimisers, regularisation, early stopping and hyperparameter tuning

4 Advanced Deep Learning

Image classification, object detection, text processing, large language models and transfer learning.

COMPUTER VISION

- Convolutional neural network architectures for image classification
- Transfer learning and fine-tuning of pretrained vision models
- End-to-end object detection with YOLO

LANGUAGE AND LARGE LANGUAGE MODELS

- Text preprocessing and word embeddings
- Transformer-based large language models and pretrained models
- Fine-tuning a pretrained language model for a specific task
- LLM applications: prompting, tool-using agents and retrieval-augmented generation (RAG)

PART 2 · SPECIALISATION

Machine Learning

The science behind AI

Understand how AI works from the inside by building its core models from scratch. Learners start from the mathematics that drives machine learning and progress to modern neural architectures for vision, language and decision-making, coding most algorithms themselves before working with deep learning frameworks.

What you will learn

1 Math for Machine Learning

Advanced linear algebra, calculus and probability theory.

- Determinants, matrix inversion and definiteness
- Derivatives, partial derivatives and integrals
- Multivariate distributions, covariance and correlation
- Bayes' theorem and Bayesian inference

2 Supervised and Unsupervised Learning

Classical algorithms.

- Data preparation and preprocessing, through exploratory data analysis, statistical testing and feature preparation
- Regression and tree-based models
- Clustering: K-means, Gaussian mixture models with expectation–maximisation, and hierarchical clustering
- Dimensionality reduction: PCA and t-SNE

3 Deep Learning Basics

Designing and training neural networks.

- Neurons and deep neural networks built from scratch: forward propagation, backpropagation and gradient descent
- Optimisation algorithms
- Regularisation techniques
- Model evaluation
- Building and training models with a deep learning framework

4 Computer Vision

Convolutional neural networks and transfer learning.

- Convolution and pooling, the building blocks of convolutional neural networks
- Deep convolutional architectures: Inception, ResNet and DenseNet
- Transfer learning: feature extraction, fine-tuning and data augmentation

5 Sequence and Generative Modelling

Modelling sequences and generating new data.

- Autoencoders and their variants
- Generative adversarial networks (GANs) and their variants
- Word embeddings, from numerical word vectors to contextual embeddings
- Recurrent architectures: RNN, GRU, LSTM and bidirectional networks
- Attention mechanisms and the Transformer architecture
- Evaluating generated text
- Question answering with pretrained Transformer models

6 Reinforcement Learning

Value-based and policy-based methods.

- Value-based methods: Q-learning with an epsilon-greedy strategy
- Policy-based methods: policy gradients and the REINFORCE algorithm

PART 3

Capstone Project

Bring it all together

The capstone project is the culmination of your specialisation, designed to showcase your skills in real-world applications. It is primarily driven by your own idea, and may also be developed in collaboration with an industry partner

Examples of capstone projects

1. Build an assistant that answers questions from a company's internal documents, combining a large language model with document retrieval.
2. Detect and count objects in real-time video, for example to monitor occupancy, traffic or safety on a site.
3. Detect fraudulent or unusual financial transactions with machine learning and anomaly detection.
4. Train a generative model to create synthetic data that protects privacy or enriches a small dataset.
5. Train a reinforcement learning agent to optimise decisions, such as energy use in a building or resource allocation.

BEYOND THE PROGRAMME

More than an Academy, a whole learning experience

The learning experience goes beyond the hands-on projects. Participants also get opportunities to connect with Luxembourg's artificial intelligence and data ecosystem through talks with industry professionals, researchers and companies, organised workshops, hackathons and outdoor events. These activities encourage networking, collaboration, knowledge sharing and community building, giving participants the chance to develop the skills and connections that support a career in AI.

Talks with professionals **Workshops** **Hackathons** **Outdoor events** **Networking**