Machine Learning School

Machine Learning School

A course in modern machine learning methods that covers theoretical and practical aspects. NOTE REGARDING THE WORKLOAD: The requirement is for each participant to complete 12 modules, a team project and a final exam. This works out to a workload of 180h. Since the number of modules available in the course is greater than 12, the total number of hours is greater than 180 – but these modules are not all to be taken by the same participants.

Planned ECTS: 6

Number of learners: 30

Mode of delivery: Blended

Status: IN PLANNING

Course public access: Private

Contributors:
Michal Gregor

Course learning outcome	Level	Weight
The participant is able to explain basic concepts from the field of machine learning such as: machine learning, implicit and explicit knowledge representation, local and global generalization, underfitting, overfitting, bias, variance, regularization and more.	Understanding	1
The participant understands and is able to explain the principle of fundamental machine learning methods.	Understanding	1
The participant is able to assess where and how machine learning methods can be applied.	Evaluating	1
The participant is able to apply machine learning methods and approaches.	Applying	1
The participant is able to identify machine learning problems and search for corresponding state of the art methods.	Evaluating	1
		Total weight: 5

Topic / Unit name	Workload	Learning type	Mode of delivery	Groups	Collaboration	Feedback	Mandatory activity	Assessment		
								Points	Type	Providers
M1-INTRO: Introduction to Artificial Intelligence and Machine Learning										
Welcome meeting (onsite/online)										

Welcome meeting: basic course info The aim of the activity is to present the basic information about the course, its content, activities, requirements and methods of assessment to all participants. The activity is going to be done on-site for participants who can make it to Žilina and online for the rest.	30 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No
Welcome meeting: discussion The aim of the activity is for everybody involved to get acquainted, to discuss what their background is, to communicate their expectations, etc. The activity is going to be done on-site for participants who can make it to Žilina and online for the rest.	30 min	Discussion	Hybrid	Synchronous	Teacher present	No	No	No	No	No
Total unit workload	1h									
Main Content										

Lecture content Content: – Motivational introduction; – What is AI: the 4 approaches; – Explicit / implicit approaches; – Machine learning and its types; – Supervised learning (demonstration using k-nearest neighbours); – Unsupervised learning (demonstration using k-means); – Reinforcement learning; – Local and global generalization; – Search methods (demonstration using naïve search for Sudoku);	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No		
Colab Notebooks A set of colab notebooks, regarding especially these topics: – KNN, an illustration; – KNN on the Iris dataset; – Preprocessing and scikit-learn pipelines; – KNN for regression;	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher
Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No		

Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	150 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No
Team project: selecting topics, forming teams The students select a topic for their team project and form teams.	120 min	Discussion	Online	Asynchronous	Teacher not present	No	Yes	No	No	No
Total unit workload	10h									
M2-DATA-ANALYSIS: The Data Analysis Process										
Main Content										
Lecture content Content: – Data analysis: the steps; – Preprocessing, missing data imputation; – Exploratory data analysis (EDA); – Visualization; – Dimensionality reduction (PCA, t-SNE, UMAP);	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No

Colab Notebooks A set of colab notebooks, regarding especially these topics: – EDA, data examination; – EDA, visualization; – Dimensionality reduction; – More advanced preprocessing, e.g. custom transformer to extract titles from string using regex; – More advanced imputation; – ...	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher
Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	330 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No		
Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No		
Total unit workload	11h											

M3-SIMPLE-ML: Introduction to Simple Machine Learning Methods												
Main Content - Copy												
Lecture content Content: – KNN: a distance-based, lazy method; – Naïve Bayes classifier: considers each feature independently; – Decision Trees: considers combinations of features; – Ensembles: what they are, how they work, why they work;	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No		
Colab Notebooks A set of colab notebooks, regarding especially these topics: – Decision tree based classification and regression; – The impact of pruning hyperparameters: an illustration; – Ensembles: – Homogeneous; – Heterogeneous; – A naïve Bayes model for text classification; – ...	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher

Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	330 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No
Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No
Total unit workload	11h									
M4-CLUST: Cluster Analysis										
Main Content										
Lecture content Content: – Clustering methods; – k-means; – hierarchical; – DBSCAN; – Distance measures; – Application examples;	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No

Colab Notebooks A set of colab notebooks, regarding especially these topics: – Demonstration of k-means, hierarchical clustering and DBSCAN; – Qualitative comparison of the methods; – Cluster analysis: applications examples; – ...	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher
Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	330 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No		
Quiz activities - Copy Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No		
Total unit workload	11h											

M5-CONVEX-OPTI: Convex Optimization

Main Content

Lecture content Content: – Convex optimization tasks, methods, principles;	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No		
Colab Notebooks A set of colab notebooks, regarding especially these topics: – Illustrational notebooks regarding optimization tasks and methods; – Applicational examples; – ...	120 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher
Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	390 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No		
Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No		
Total unit workload	11h											

M6-OPTI-LEARN: Optimization-based Machine Learning

Main Content												
Lecture content Content: – A recap on the "acting rationally" AI paradigm; – What optimization is; – How it is used in machine learning, minimizing a loss function, etc.; – Simple optimization-based approaches: – Linear regression; – Polynomial regression; – Gradient descent; – Logistic regression; – Batch, incremental and mini-batch learning;	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No		
Colab Notebooks A set of colab notebooks, regarding especially these topics: – Gradient descent on a regular and an elongated surface; – Linear, polynomial and logistic regression; – Optimization-based regression in Python using SciPy; – ...	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher

Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	330 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No
Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No
Total unit workload	11h									

M7-EVAL: Evaluating Model Performance

Main Content

Lecture content Content: – Evaluating model performance; – Verifying the ability to generalize: – Split validation; – Stratification; – The validation set and model selection; – Cross-validation; – Performance measures: – For classification: – Why accuracy is not enough; – ROC analysis etc.; – Micro/macro averaging for multi-class problems; – For regression; – Bias vs. variance trade-off; – Regularization methods;	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No		
Colab Notebooks A set of colab notebooks, regarding especially these topics: – Examples on model evaluation; – Performance measures for classification: – Examples with class imbalance – accuracy is not enough; – Performance measures for regression; – Diagnosing underfitting and overfitting; – Regularization methods in classical (shallow) machine learning	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher

Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	330 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No
Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No
Total unit workload	11h									
M8-INTERPRET-TABULAR: Interpretability of Models on Tabular Data										
Main Content - Copy										
Lecture content Content: – Why interpretability can be crucial; – Prediction vs. inference; – Model-agnostic interpretability methods – LIME, – Partial dependence plots; – Feature importance (permutation, etc.);	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No

Colab Notebooks A set of colab notebooks, regarding especially these topics: – Interpretability for tabular ML: sample notebooks; – ...	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher
Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	330 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No		
Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No		
Total unit workload	11h											

M9-AUTODIFF-ANN: Introduction to Neural Networks and Automatic Differentiation

Main Content

Lecture content Content: – Artificial neural networks can be trained using gradient descent; – Artificial neuron, activation functions; – What the artificial neuron does + linear separability, ... – Multiple layers of neurons and universal approximation; – Feed-forward/recurrent, layered/non-layered architectures; – Neural networks for classification and regression; – How to compute the gradients: autodiff; – Motivation: autodiff vs. symbolic and numeric differentiation; – Autodiff: the principle + graphical illustrations; – Backprop through common operations (graphically): – Defining new operations, incl. the caching of intermediate results; – Autodiff: a numeric example;	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No

Colab Notebooks A set of colab notebooks, regarding especially these topics: – Autodiff: an illustrative visual notebook; – Also contains the definition of new operations and caching of intermediate results; – Autodiff vs. symbolic vs. numeric differentiation; – Classification and regression using a multi-layered perceptron; – ...	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher
Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	330 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No		
Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No		

Total unit workload	11h											
M10-DEEP-LEARN: Deep Learning												
Main Content												
Lecture content Content: – Motivational examples; – Why use deep neural nets: the intuition; – Why depth helps; – Neural nets can learn to preprocess; – Visualization of a deep embedding; – The challenges to deep learning in the past + modern deep learning; – Deep learning architectures; – Convolution; – Evolution of different components: ResNet, etc. – Regularization in deep learning: early stopping, dropout, BatchNorm, ... – Popular tricks: – Augmentation; – Transfer learning; – Label smoothing; – ...	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No		
Colab Notebooks A set of colab notebooks, regarding especially these topics: – A model pretrained on ImageNet; – Training a CNN on MNIST; – Transfer learning; – Regularization in deep learning; – Illustration of popular building blocks, tricks, etc. – ...	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher

Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	330 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No
Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No
Total unit workload	11h									
M11-DEEP-LEARN-ADVANCED: Advanced Approaches in Deep Learning										
Main Content										
Lecture content Content: – Unsupervised deep learning: – Autoencoders; – GAN, StyleGAN; – … – Object detection; – Segmentation; – ...	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No

Colab Notebooks A set of colab notebooks, regarding especially these topics: – A StyleGAN notebook; – YOLO; – Segmentation; – Annotation for detection and segmentation; – ...	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher
Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	330 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No		
Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No		
Total unit workload	11h											

M12-INTERPRET-DEEP: Interpretability Methods for Deep Learning

Main Content

Lecture content Content: – Methods, principles, approaches for interpretability in deep neural networks, e.g.: – Saliency; – Pre-images; – Adversarial examples; – Neural artistic style; – ...	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No		
Colab Notebooks A set of colab notebooks, regarding especially these topics: – Adversarial examples; – Visual interpretation; – Generating pre-images; – Neural Art; – ...	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher
Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	330 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No		
Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No		

Total unit workload	11h											
M13-DEEP-LEARN-SEQ: Deep Learning for Sequential Data												
Main Content - Copy												
Lecture content Content: – Deep learning for sequential data; – Training recurrent neural networks using BPTT; – Recurrent architectures: LSTM, GRU; – Sequential attention; – Transformer, Perceiver, Perceiver IO; – The basics of how to work with time series; – Applications; – ...	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No		
Colab Notebooks A set of colab notebooks, regarding e.g. these topics: – Applications, e.g. an example of doing OCR, machine translation, etc.; – Fine-tuning a language model (BERT, GPT), e.g. to Shakespeare's texts; – Fine-tuning a language model to a classification task, e.g. to IMDB; – LSTMs and time series; – Forecasting: ARMA, LSTM, XGBoost, ...; – Optionally also time series decomposition, etc.; – ...	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher

Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	330 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No
Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No
Total unit workload	11h									
M14-ENSEMBLE: Ensemble Methods										
Main Content										
Lecture content Content: – Ensembles; – Homogeneous, heterogeneous; – Independent models (e.g. bagging), dependent models (e.g. boosting); – Bagging, random forests; – Boosting: – AdaBoost; – Gradient boosting; – Stacking;	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No

Colab Notebooks A set of colab notebooks, regarding especially these topics: – Ensembles, homogeneous: – XGBoost, LightGBM; – Ensembles, heterogeneous: – Voting; – Stacking; – ...	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher
Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	330 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No		
Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No		
Total unit workload	11h											

M15-DIMRED: Dimensionality Reduction

Main Content

Lecture content Content: – Dimensionality reduction; – The linear approach: – PCA; – Pros and cons; – Graph embedding methods; – tSNE, UMAP; – Principles and differences;	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No		
Colab Notebooks A set of colab notebooks, regarding especially these topics: – Visualization of high-dimensional data using PCA/UMAP; – Qualitative differences with illustration on a sample dataset; – Comparison between tSNE and UMAP – ...	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher
Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	330 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No		

Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No		
Total unit workload	11h											
M16-EMBED: Embeddings												
Main Content												
Lecture content Content: – Embeddings; – Motivational example: face recognition and clustering; – Why a standard deep classifier would fail; – Distance measures / preprocessing / learning; – Embeddings in general: – Classifiers; – Word embeddings; – Dimensionality reduction; – Reinforcement learning; – ... – Face embeddings and clustering; – ...	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No		
Colab Notebooks A set of colab notebooks, regarding especially these topics: – Word embeddings; – Embedding images using a CNN classifier; – Face clustering: a practical example; – ...	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher

Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	330 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No
Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No
Total unit workload	11h									

M17-GP-HYPEROPT: Gaussian Processes and Hyperparameter Optimization

Main Content

Lecture content Content: – Machine learning and hyperparameters; – Hyperparameter optimization; – Gaussian processes; – MLE, MAPE vs. the full Bayesian approach; – Bayesian optimization;	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No

Colab Notebooks A set of colab notebooks, regarding especially these topics: – Gaussian processes; – Gaussian process regression; – Bayes optimization: an illustrational notebook; – Bayesian hyperparameter optimization; – Grid search; – ...	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher
Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	330 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No		
Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No		
Total unit workload	11h											

M18-RL: Reinforcement Learning

Main Content												
Lecture content Content: – Reinforcement learning; – Motivational examples; – MDPs: the elements of an MDP, the Markov condition; – Policies; – Long-term rewards; – The goal of RL; – The types of RL: – Value-based; – Policy-based; – Actor-critic; – Value functions; – Recursiveness, Bellman equations; – Exploration vs. exploitation; – Greedy, ε-greedy, softmax; – Tabular methods: – Dynamic programming; – Monte Carlo learning; – Temporal difference learning; – SARSA and Q-learning: the difference between on-policy and off-policy methods; – Experience replay;	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No		
Colab Notebooks A set of colab notebooks, regarding especially these topics: – The OpenAI Gym interface; – Illustration of the basic tabular methods using gridworld examples; – Experience replay; – ...	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher

Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	330 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No
Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No
Total unit workload	11h									

M19-DEEP-RL: Deep Reinforcement Learning

Main Content

Lecture content Content: – Value function representation; – Tabular; – Approximation using shallow models; – Deep learning; – DQN; – Policy gradient methods; – With shallow models; – With deep models; – Actor-critic: – REINFORCE, A3C, A2C; – PPO; – DDPG; SAC;	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No		
Colab Notebooks A set of colab notebooks, regarding especially these topics: – DQN applied to the Lunar Lander; – SAC applied to the inverted pendulum; – SAC applied to AntBullet; – ...	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher
Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	330 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No		

Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No		
Total unit workload	11h											
M20-SVM: Support Vector Machines												
Main Content												
Lecture content Content: – Support vector machines; – The maximum margin classifier; – The kernel trick; – ...	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No		
Colab Notebooks A set of colab notebooks, regarding especially these topics: – Classification/regression examples using SVMs; – Preprocessing, kernels, ... – ...	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher

Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	330 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No
Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No
Total unit workload	11h									

M21-SEARCH: Search Methods

Main Content

Lecture content Content: – State space versus the search tree; – Problem formulation; – Uninformed versus informed search; – Comparison criteria (completeness, optimality, time and space complexity); – Search problem examples; – Optionally the basics of constraint programming;	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No		
Colab Notebooks A set of colab notebooks, regarding especially these topics: – Examples using model problems; – 8-puzzle, maze, ... – Implementation and comparison of different search methods; – BFS, UCS, DFS, DLS, IDS, BS, backtracking, FCh, ... – ...	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher

Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	330 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No
Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No
Total unit workload	11h									
M22-ADVERSARIAL-SEARCH: Search Methods in Adversarial Contexts										
Main Content										
Lecture content Content: – The basic idea and zero-sum games; – Minimax; – Alpha-beta search; – Memoization; – MCS, MCTS; – Deep learning in adversarial search: AlphaGo, AlphaZero; – ...	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No

Colab Notebooks A set of colab notebooks, regarding especially these topics: – Minimax and alpha-beta search on tic-tac-toe; – Memoized minimax on tic-tac-toe; – MCTS on tic-tac-toe; – Optionally other model examples; – ...	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher
Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	330 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No		
Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No		
Total unit workload	11h											

M23-METAHEURISTICS: Metaheuristic Optimization

Main Content

Lecture content Content: – Complexity classes: NP, NP-hard, ... – Metaheuristics: the basic idea; – Genetic algorithms (GA); – Genetic programming (GP); – High-level: other approaches, e.g. swarms etc. – Advantages/problems, especially w.r.t. sample efficiency.	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No		
Colab Notebooks A set of colab notebooks, regarding especially these topics: – GA cars in HTML/javascript; – Optimization using GA: an example; – GP for symbolic regression; – GA for evolving a neural network for the “Flappy” game; – ...	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher

Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	330 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No		
Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No		
Total unit workload	11h											
M24-STATE-SPACE: State-space Approaches in Control												
Main Content												
Lecture content Content: – State-space models; – State-space models and control;	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No		
Colab Notebooks A set of colab notebooks, regarding especially these topics: – Code and applicational examples of state-space-based approaches; – ...	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher

Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	330 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No
Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No
Total unit workload	11h									
M25-BAYES-NET: Bayesian Networks										
Main Content										
Lecture content Content: – Bayesian networks; – The model: graphs and CPTs; – Inference methods etc.; – Influence diagrams; – The Kalman filter as a specific type of a Bayesian network;	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No

Colab Notebooks A set of colab notebooks, regarding especially these topics: – Construction of Bayesian networks using existing software tools; – Filtration using the Kalman filter; – ...	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher
Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	330 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No		
Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No		
Total unit workload	11h											

M26-GAMING: AI and Gaming

Main Content

Lecture content Content: – Introduction to ML-Agents – Key components: Agents, Brains, Academy – Training custom AI for simple games	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No		
Colab Notebooks A set of examples regarding ML agents in the context of games.	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher
Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	330 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No		
Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No		
Total unit workload	11h											

M27-FAIRNESS: Fairness in Machine Learning

Main Content

Lecture content Content: – Motivation: why fairness in machine learning is a key topic; – Fairness frameworks for machine learning, e.g.: – demographic parity; – equal odds; – equal opportunity; – ... – Tutorials with group discussions; – ...	120 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No		
Colab Notebooks A set of colab notebooks, regarding especially these topics: – Demonstration + applicational examples of fairness frameworks for ML; – ...	180 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	0	Summative	Teacher
Independent study time + review The estimated additional time required for studying the material independently, using the lecture videos/slides and also referencing other literature and material, as necessary. Facilitates correct understanding of the material. This activity also includes the time required for review before exams.	210 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No		

Quiz activities Quiz activities meant to provide quick, unassessed feedback to students regarding their grasp of the material.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	Teacher	No	No
Tutorials with Group Discussions A discussion regarding the main content delivered in tutorial-style format to smaller groups.	120 min	Discussion	Hybrid	Synchronous	Teacher present	Yes	Yes	No	No	No
Total unit workload	11h									
Team Project										
Team Project Activities										
Literature review, identification of tools, existing code, etc.	900 min	Investigation	Hybrid	Asynchronous	Teacher not present	No	Yes	No	No	No
Preparation of a written report presenting the results	600 min	Production	Hybrid	Asynchronous	Teacher not present	No	Yes	No	No	No
Principal work on the project Principal work on the project, including data preparation, writing code, training, evaluation, ...	1260 min	Production	Hybrid	Asynchronous	Teacher not present	Yes	Yes	No	No	No
Total unit workload	46h									
Total course workload	**343h**									