

Winter Term 2020
05.11.2020 – 18.02.2020
Project Sessions: 11-18.02.2020

Data Driven Engineering 1

Machine Learning for Dynamical Systems

Basics

1. Basics I: Introduction to DDE
 - 1.1. Foundations of Intelligence
 - 1.2. Introduction of AI: Historical Context
 - 1.3. Data-Driven Dynamical Systems
 - 1.4. Contemporary Examples
 - 1.5. The Flow of the Lecture
2. Basics II: An Ode to Learning
 - 2.1. Problem Solving and Reasoning
 - 2.2. Planning
 - 2.3. Theory of Learning and Learning Types
 - 2.4. Decision Theory
 - 2.5. Machine Learning: Overview, Means and Goals

Fundamentals

3. Analysis of Static Datasets I: Classification and Regression
 - 3.1. Supervised ML Landscape
 - 3.2. Classification
 - 3.2.1. Logistic Regression
 - 3.2.2. Gradient Decent
 - 3.2.3. Random Forests
 - 3.2.4. Boosting
 - 3.3. Regression
 - 3.3.1. Lasso
 - 3.3.2. Elastic Net
 - 3.3.3. SVM
 - 3.3.4. Bayesian Ridge Regression
4. Analysis of Static Datasets II: Clustering and Dimensionality Reduction
 - 4.1. Unsupervised ML
 - 4.2. Clustering
 - 4.2.1. K-Means

- 4.2.2. Hierarchical Clustering
- 4.2.3. DBSCAN
- 4.3. Dimensionality Reduction
 - 4.3.1. Sparsity and Compressed Sensing
 - 4.3.2. Linear projection
 - 4.3.2.1. SVD, PCA
 - 4.3.3. Manifold learning
 - 4.3.3.1. Isometric mapping, MDS, LLE
 - 4.3.4. Dictionary Learning
 - 4.3.5. Independent Component Analysis

ML for Dynamical Systems

- 5. Deep Learning for Dynamical Systems
 - 5.1. The Perceptron and Building DNN
 - 5.2. Activation Functions
 - 5.3. Training NN: Backpropagation, Learning Rate, Regularization
- 6. Sequence Modeling
 - 6.1. Neural Networks for Dynamical Systems
 - 6.2. Recurrent Neural Networks
 - 6.3. Backpropagation Through Time and Long-Term Dependencies
 - 6.4. Gated Cells: Long Short-Term Memory (LSTM)
 - 6.5. Forecasting
- 7. Generative Modeling
 - 7.1. Latent Variables and Sparsity
 - 7.2. Representation Learning
 - 7.3. Autoencoders
 - 7.4. Generative Adversarial Network (GAN)
- 8. Machine Learning Control
 - 8.1. Data-Driven Dynamical Systems
 - 8.2. Model Reduction and Linear System Identification
 - 8.3. Regression and DMD
 - 8.4. Sparse Identification of Nonlinear Dynamics and Control
- 9. Emerging Concepts and the Outlook
 - 9.1. Data Driven Scientific Discovery
 - 9.2. Shallow Learning and Sparse Sensing
 - 9.3. Latent Space Physics
 - 9.4. Graph Neural Networks
 - 9.5. Neuro-Symbolic AI
- 10. Project Q&A Sessions