Advanced Machine Learning

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- 1. Lecture 1: Introduction. Artificial Scientific Discovery.
- 2. Lecture 2: Basic neural network structure.
- 3. Lecture 3: Stochastic Gradient Descent. Backpropagation
- 4. Lecture 4: Loss functions. Overfitting. Dropout. Adaptive Gradient Descent. Convolutional networks.
- 5. Lecture 5: Representation Learning: Goals. Principal Component Analysis.
- 6. Lecture 6: Basic Autoencoders.
- 7. Lecture 7: Contractive Autoencoder. Shannon's Information Theory: Compression and Information.
- 8. Lecture 8: Entropy. Bayes formula.
- 9. Lecture 9: Bayes. Gaussian Random Processes.
- 10. Lecture 10: Inductive Bias. Fisher Information. Information Geometry.
- 11. Lecture 11: Natural Gradient. Kullback-Leibler Divergence. Mutual Information.
- 12. Lecture 12: Mutual Information. Learning Probability Distributions. Normalizing Flows.
- 13. Lecture 13: Invertible Neural Networks. Convolutional and Conditional Invertible Networks.
- 14. Lecture 14: Boltzmann Machines (General Theory).
- 15. Lecture 15: Restricted Boltzmann Machines. Conditional Sampling. Variational Autoencoder.
- 16. Lecture 16: Variational Autoencoder. Generative Adversarial Networks.
- 17. Lecture 17: Generative Adversarial Networks. Recurrent Neural Networks.
- 18. Lecture 18: Recurrent Neural Networks. Graph Neural Networks.
- 19. Lecture 19: Graph Neural Networks. Attention Mechanisms (Basics).
- 20. Lecture 20: Attention. Differentiable Neural Computer. Transformers.
- 21. Lecture 21: Transformers (and examples). Implicit Layers.
- 22. Lecture 22: Implicit Layers. Hamiltonian and Lagrangian Networks. Reinforcement Learning Overview.

- 23. Lecture 23: Reinforcement Learning Policy Gradient and Q-Learning.
- 24. Lecture 24: Advantage Actor-Critic. Trust Regions. Proximal Policy Optimization.
- 25. Lecture 25: Reinforcement Learning: Continuous actions. Model-based. Monte Carlo Tree Search.
- 26. Lecture 26: Active Learning for Network Training: Uncertainty Sampling and other approaches.
- 27. Lecture 27: Bayesian Optimal Experimental Design. Active Learning: Gaussian Processes and Networks.
- 28. Lecture 28: Turing Machines. Algorithmic (Kolomogoroff) Complexity. Universal (Levin) Search.
- 29. Lecture 29: Solomonoff's Algorithmic Probability and Theory of Induction. Conclusions/Outlook.
- 30. Animation: Generative Adversarial Network
- 31. Animation: Graph Neural Network predicting Quantum Ground States
- 32. Animation: Normalizing Flow (Invertible Neural Network)
- 33. Animation: Variational Autoencoder
- 34. Materials

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