Study Guide for the Midterm Exam –Deep and Reinforcement Learning

Machine learning basics

- Machine learning recipes (their ingredients)
- Fundamental issues in machine learning
    - Generalization and how to improve generalization
- Capacity, overfitting and Underfitting
    - Variance and bias for overfitting
    - Generalization gap
- K-fold cross validation algorithm

Neurons

- Structure of a neuron
- Activation functions (the commonly used ones: ReLU, sigmoid, tanh, hard-tanh, softmax)

Neural networks

- Expressive power of multilayer neural networks
- Neural network architectures
    - Loss functions
        - Cross-entropy loss
        - Softmax (how to compute the output and its gradient)
    - Exponential advantages of deep neural networks
    - Challenges of deep neural networks
        - Saddle points
        - Cliffs and the gradient exploding problem
        - Long-term dependencies
- Backpropagation algorithms
    - Training protocols
    - Computational graphs
    - Forward computation and backpropagation algorithms in general and for fully-connected neural networks

Regularization techniques

- L_2 normalization and early stopping
- Dataset augmentation and local manifolds
- Parameter sharing and parameter tying
- Dropout
- Adversarial training

Optimization algorithms

- Optimization and generalization problems
- Challenges in neural network optimization
- Optimization algorithms
    - Stochastic gradient descent
    - Momentum (need to understand Algorithm 8.2)
    - Adam (How is the Adam algorithm (Algorithm 8.7) related to the momentum term in Algorithm 8.2?)
- Parameter initialization strategies
    - Weight initialization

    - Bias initialization
- Batch normalization

Convolutional neural networks

- Filtering and cross correlation as local template matching
- Zero-padding
- Convolution with a stride
- Convolutional networks (compared to fully and locally connected neural networks)
- Pooling and translation invariance
- Convolutional neural networks for classification (input, multiple convolution layers, fully connected layers, and softmax)

Recurrent neural networks

- Advantages of recurrent neural networks over convolutional neural networks
    - Variable-length sequence processing
- Different RNN input-output architectures
- Training recurrent neural networks
    - Unfolded computational graphs and backpropagation through time
    - Gradient calculation for RNN
    - Gradient vanishing and exploding problems
        - Echo state networks
        - Long short-term memory
        - Gated recurrent units
    - Encoder-decoder sequence-to-sequence architectures

Multi-armed bandit problem

- Exploitation and exploration
- ε-greedy policy
- Incremental implementation
    - Stationary and nonstationary
    - Optimistic initial values
    - Upper-confidence-bound action selection
    - Gradient bandit algorithms

Reinforcement learning – formal tabular approaches

- Return and discounted return
- State value function
- State action value function
- Policy evaluation, policy improvement, and policy iteration for a simple problem like Example 4.1 (even simpler)