CSCI 416/516 Final Study Guide

Name:

Student ID:

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1 Support Vector Machine

- **Problem 1: Theory of SVMs.**
  Explain the principle of maximizing the margin in SVMs. How does this contribute to the model's generalization ability?
- **Problem 2: Kernel Tricks.**
  What is the kernel trick in SVMs? Provide examples of different types of kernels used in SVMs.
- **Problem 3: Support Vectors.**
  Define support vectors and explain their significance in the context of SVMs.
- **Problem 4: Parameter Tuning.**
  Discuss the role of parameters like C in SVMs. How do they affect the model's performance?
- **Problem 5: Hyperplane Decision Boundary.**
  What is a hyperplane in SVMs, and how does it help in classification tasks?
- **Problem 6: Dual Problem and Kernel Trick.**
  Explain how the dual problem in SVMs facilitates the use of the kernel trick. Why is this significant?
- **Problem 7: Lagrangian Multipliers.**
  Suppose a sample in the training dataset has a Lagrangian multiplier being 0.1. What does this say about this sample?
- **Problem 8: Primal and Dual.**
  How is the Primal in SVMs defined? And how is it related to the Dual?
- **Problem 9: Linear Separability.**
  Describe the techniques or strategies you can use to address the issue of linear inseparability when working with SVMs.
- **Problem 10: Kernel Tricks.**
  What are the advantages and disadvantages of the kernel tricks?

2 Decision Tree

	Cloudy	Not Cloudy
Raining	24/100	1/100
Not Raining	25/100	50/100

- **Problem 11: Joint Entropy.**
  Suppose $X = \{\text{Raining, Not raining}\}$, $Y = \{\text{Cloudy, Not cloudy}\}$. What is the joint entropy, $H(X, Y)$?

- **Problem 12: Specific Conditional Entropy.**
  Following the setup from the previous question, what is the entropy of cloudiness Y, given that it is raining ($X = \text{raining}$)?

- **Problem 13: General Conditional Entropy.**
  Following the setup from the previous question, what is the entropy of cloudiness Y, given the variable X?

- **Problem 14: Information Gain.**
  How is the Information Gain $IG(Y|X)$, given the entropy of Y, $H(Y)$, and the conditional entropy $H(Y|X)$?

- **Problem 15: Information Gain.**
  if X is completely uninformative about Y, what is the value of $IG(Y|X)$?

- **Problem 16: Information Gain.**
  if X is completely informative about Y, what is the value of $IG(Y|X)$?

- **Problem 17: Overfitting.**
  What is overfitting in the context of decision trees?

- **Problem 18: Tree Components.**
  Explain the concepts of nodes, branches, leaves, and root node in a decision tree.

- **Problem 19: IG and Tree.**
  How is the Information Gain used to build a decision tree?

- **Problem 20: Pros and Cons.**
  What are the advantages and disadvantages of using the decision tree?

3 Ensemble Learning

- **Problem 21: Weak Learners.**
  What are weak learners in the context of AdaBoost? Provide examples of common weak learners.

- **Problem 22: Misclassification.**
Discuss the concept of misclassification rate and its role in AdaBoost. How are weights adjusted for misclassified samples?

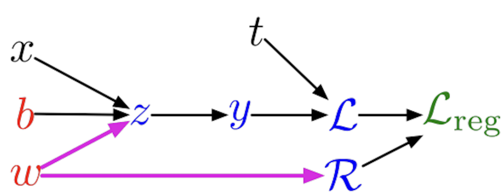
- **Problem 23: Decision Stumps.**
Discuss the relationship between AdaBoost and decision stumps. Why are decision stumps often chosen as weak learners in AdaBoost?

- **Problem 24: Sample weights.**
What does the weight $w_{t,i}$ of a given sample x_i mean in the context of AdaBoost?

- **Problem 25: Objective function.**
Explain what this objective function does, in the context of AdaBoost.

$$\mathcal{J}_{\text{reg}}(\boldsymbol{\theta}) = -\sum_{i=1}^{n} w_i[y_1 \text{log} h_{\boldsymbol{\theta}}(\boldsymbol{x}_i) + (1-y_i)\text{log}(1-h_{\boldsymbol{\theta}}(\boldsymbol{x}_i))] + \lambda||\boldsymbol{\theta}_{[1:d]}||_2^2 \tag{1}$$

4 Multilayer Perceptrons



Forward pass:

$$\begin{aligned} z &= wx + b \\ y &= \sigma(z) \\ \mathcal{L} &= \frac{1}{2}(y-t)^2 \\ \mathcal{R} &= \frac{1}{2}w^2 \\ \mathcal{L}_{\text{reg}} &= \mathcal{L} + \lambda\mathcal{R} \end{aligned}$$

- **Problem 26: Backpropagation.**
What does the back pass look like, given the illustrated forward pass?

- **Problem 27: Architecture.**
Describe the typical architecture of a Multilayer Perceptron. Include details about the input layer, hidden layers, and the output layer.

- **Problem 28: Learning Rate.**
Explain the significance of the learning rate in the training process of an MLP. What are the potential effects of setting it too high or too low?

- **Problem 29: Gradient Descent.**
  What's the relationship between gradient descent and backpropagation?

- **Problem 30: Activation Functions.**
  Explain the role of activation functions in MLPs.

5 Convolutional Neural Networks

- **Problem 31: Convolution.**
  What is the value given a vector a = [2, -1, 1] convolved by a filter b = [1, 1, 2]?

- **Problem 32: Activation Functions.**
  Given the answer from the previous question, what is the outcome after you apply ReLU on it?

- **Problem 33: Kernels.**
  What is the purpose of the filters/kernels used in a convolutional layer?

- **Problem 34: Overfitting.**
  What methods can be used to prevent overfitting in CNNs?

- **Problem 35: Pooling.**
  What is the purpose of pooling layers in a CNN? Compare and contrast Max Pooling and Average Pooling.

6 Attention & Transformers

- **Problem 36: Self-Attention.**
  Explain the concept of self-attention in transformers.

- **Problem 37: Multi-Head Attention.**
  What is multi-head attention in transformers?

- **Problem 38: Encoders and Decoders.**
  Compare the roles of the encoder and decoder in a transformer model. How are they similar and different?

- **Problem 39: Attention.**
  Describe how the concept of attention, as used in transformers, can be applied to domains other than language processing, such as image or video analysis.

- **Problem 40: Application.**
  Suppose you want to use transformers for multiclass classification. How should you modify the existing transformer architecture to achieve this goal?