Machine Learning
Sharif University of Technology
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Homework Assignment 3
ML models for tabular datasets & Neural
Networks

1401-1402
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ML models for tabular datasets (100 Points)

1 Comparison between some models

Answer the following questions

1.1 (10 Points)

What are the advantages of Random Forests over decision trees?

1.2 (10 Points)

What are the advantages of XGBoost over random forest, adaboost and gradient boosting?

2 Fitting a model

In this question, we want to fit a model for diabetes according to a given data.

2.1 (30 Points)

How Random Forest and AdaBoost fit a model to the following data?

Blocked Arteries	Weight	Exercise	Genetics	Has Diabetes
No	210	Yes	Yes	No
No	125	No	No	No
Yes	180	Yes	Yes	Yes
Yes	167	No	Yes	Yes

2.2 (30 Points)

Now suppose that two entries of the data table("Blocked Arteries" and "Weight" of the 4th data) are missing. Write step by step how random forest can fill the missing data?

3 Gradient Boost (20 Points)

Write step by step how Gradient Boost fits a model to the following data?

Gender	Height (m)	Blood Pressure	Weight (kg)
Female	1.6	Medium	76
Male	1.6	Low	88
Female	1.5	Low	56
Female	1.4	Low	57
Male	1.8	High	73
Male	1.5	Medium	77

Intro to NNs (100 Points)

4   Descriptive Questions (35 Points)

Give a brief explanation for the following statements.

4.1   (5 Points)

Explain the Exploding Gradient problem. Propose a solution to prevent this issue.

4.2   (5 Points)

What are the Pros. and Cons. of adding more layers to a deep neural network?

4.3   (5 Points)

In Stochastic Gradient Descent algorithm , why does the first step of the procedure require shuffling the training dataset?

4.4   (5 Points)

Consider Sigmoid activation function. What will be the gradient value of this function for a very large input? What problem does this cause for neural network training? How could this be solved?

4.5   (10 Points)

Consider a Multilayer Perceptron which is used to provide a 2-class classifier. Consider the output of the last neuron to be z, and the output of the neural network as:

$$y = \sigma(RELU(z))$$

The Outputs which are greater than 0.5 are considered as class 1. What is the problem of this neural network?
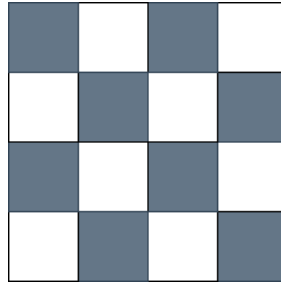
4.6   (5 Points)

What would happen to MLPs if we did not have activation functions?

5   Intuitive Questions (25 Points)

5.1   (20 Points)

Consider a 4*4 image (16 pixels) like the below figure. The black squares have the value 0, and the white ones have the value of 1.
In this task, you have to find the following chess-like pattern by designing a MLP. You have to pick the suitable weights, biases and activation functions(Step, RELU, etc) for the network.
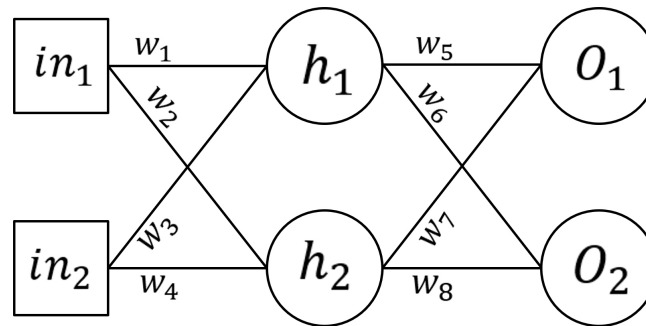
Hint: The input Layer should contain 16 Neurons. The output node specifies whether if the image matches the pattern or not.

5.2 (5 Points)

What are the problems of using MLP as an Image/Pattern Classifier?

6 Computational Question (40 Points)

Take a look at this Neural Network. (The activation function is sigmoid)

Consider these parameters:

$$w_i = i \times 0.1$$

$$in_1 = 0.1$$

$$in_2 = 0.5$$

$$b_{h1} = 0.25$$

$$b_{h2} = 0.25$$

$$b_{o2} = 0.35$$

$$b_{o2} = 0.35$$

$$lr = 1$$

$$t_1 = 0.05$$

$$t_2 = 0.95$$

$$E = \frac{1}{2} \sum (t_1 - o_2)^2$$

Calculate the updated weights after 1 iteration of forward pass and backward pass. Consider decimal accuracy up to 3 digits.