

# Indian Institute of Science

E9: 253 Neural Networks and Learning Systems - I

Instructor: Shayan Srinivasa Garani

Mid Term Exam, Fall 2021

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**Name and SR.No:**

**Instructions:**

- There are four main questions. None of them have negative marking.
- Attempt all of them with careful reasoning and justification for partial credit.
- There is absolutely no collaboration with any one or referring to any code from the web except referring to the web/class notes or text for any source of conceptual information you may need. You should not refer to any solutions if there are any. Cite all the resources used.
- This exam is assigned on 11/10/2021 at 11:59 pm. and to be turned in by Wed. 13/10/2021 11:59 pm. This is a hard deadline.
- Do not panic, do not cheat, good luck!

Question No.	Points scored
1	
2	
3	
4	
Total points	

**PROBLEM 1:**

Solve the second problem in homework 2 i.e., the ternary alphabet XOR problem using the back propagation algorithm using  $\tanh(\cdot)$  and  $\text{sigmoid}(\cdot)$  activation functions. Plot the decision boundary contours. How many hidden neurons are needed? Strive to get the least number of neurons, overall. (20 pts.)

**PROBLEM 2:**

Solve problem 4.18 (a) from S. Haykin. Does the BP solution approach  $\sigma_x^2$ ? (3rd edition, hard copy edition). (20 pts.)

**PROBLEM 3:**

In the class, we worked out the Bayes classifier for a Gaussian distribution. Under the same covariance matrix constraint, but with different mean vectors, we established the decision boundary to be a hyperplane. Assuming a 2D multivariate Gaussian distribution, under what conditions can the decision boundary be a circle or an ellipse? Justify your answer mathematically in the most general form. (20 pts.)

**PROBLEM 4:**

This question has several parts:

- (1) Are all neurons in the brain identical? Justify why or why not. Your argument must be technically precise. (5 pts.)
- (2) Suppose you want to solve the 2-variable XOR problem through a perceptron, how would you proceed? Indicate the lowest dimension where there is linear pattern separability. Show all the steps. (5 pts.)
- (3) For the previous part, suppose data points are perturbed by Gaussian distributed noise with covariance of the form  $\sigma^2\mathbb{I}$ ,  $\mathbb{I}$  corresponds to the identity matrix in the lifted data space. What is the probability of error under Bayes classification? (15 pts.)
- (4) You were supposed to design a robot that must navigate through a maze. Which learning paradigm would you choose? Provide a high level mapping of the constraints the robot must learn to reach the destination from the start of the maze. I do not need all the mathematical details for this problem. If you can do so, it is great. All I need is a sketch of ideas to map the problem. (15 pts.)