Iran University of Science & Technology

School of Computer Engineering

Assignment #3

Neural Networks

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Due: 1403/09/02

Contents

Notes:

1. Submit the answers in a complete PDF file and the code for the questions in the .ipynb format (including the notebook cell outputs) in a compressed file named HW3_StudentID.zip by the specified deadline.
2. A total of 72+48 hours of delay in submitting the answers is allowed across all projects. After that, for each additional day of delay, 10% of the score will be deducted.
3. If a student submits the project earlier than the deadline and achieves 75% of the score, up to 24 hours will be added to their allowable delay time.
4. The maximum delay for submitting each assignment is 4 days, and after 4 days, submission will not be accepted.
5. It is important to note that the explanation of the code and the obtained results must be included in the PDF file. Code without a report will result in a score deduction.
6. The evaluation of the assignment will be based on the correctness of the solution and the completeness and accuracy of the report.
7. Assignments must be completed individually, and group work on assignments is not allowed.
8. Please allocate sufficient time for the assignment and avoid leaving it until the last days.
9. You can ask your questions in the relevant group.

good luck.

Problem 1

Given the weight matrix below, which represents the weights of a Hopfield network for the input pattern p_1= [1,1,1,0,1] (with threshold θ=0): **(30 points)**

0	1	-1	2	-3
1	0	3	-1	0
-1	3	0	1	-2
2	-1	1	0	1
-3	0	-2	1	0

1. Determine the network's output state for p1 using both synchronous and asynchronous update methods.
2. Explain why the results might differ between these two update methods.
3. Test the network with the pattern p_2= [0,1,0,1,0] and provide the resulting output states for both update methods.

Problem 2

Consider a Hopfield network designed to store a set of binary input patterns, x_1, x_2, x_3, …, x_n, where each stored pattern corresponds to a stable local minimum of the network's energy function. In this network, each input is represented by a vector, and the weights are set such that these patterns are stable states. **(25 points)**

We are given the following patterns to potentially store in the network:

$$(1,1,1,1),(-1,-1,-1,-1),(1,1,-1,-1),(-1,-1,1,1)$$

Determine whether it is possible to store these patterns as stable states in the Hopfield network. If storage is feasible, provide a detailed explanation of why this is the case and calculate the weight matrix for the network.

Your answer should explain how the Hopfield network would store these patterns, ensuring that each one is a local minimum of the energy function.

Problem 3

Your task is to train a Radial Basis Function (RBF) Neural Network using the Iris dataset to analyze how different methods of selecting RBF centers impact the model's performance. In this exercise, you will: **(45 points)**

1. Implement two distinct approaches for selecting the RBF centers:
   - Random selection: Select a subset of data points at random as the RBF centers.
   - K-Means clustering: Use K-Means clustering to group the data, with the resulting cluster centers serving as the RBF centers.
2. Train the RBF Network using each method to classify the Iris dataset.
3. Compare the classification performance of both center selection methods. Discuss the results in terms of accuracy, highlighting any observed differences in model performance and potential reasons for these differences. Include any relevant insights on how the choice of center selection method influences the effectiveness of the RBF Neural Network.