Deep Learning Technique

Self Practice / Assignment Questions

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Instructions:

- Answer all questions clearly and concisely.
- Show all necessary steps for numerical problems.
- Diagrams may be used wherever appropriate.
- This assignment is intended for self-practice and conceptual strengthening.

Section A: Conceptual Questions

1. What is meant by building intelligent machines? How does deep learning contribute to this goal?
2. Explain the limitations of traditional computer programs in handling complex real-world problems.
3. Describe a linear perceptron and explain how it can be represented as a neuron.
4. Discuss the mathematical formulation of a linear neuron.
5. Why are linear neurons insufficient for solving complex classification problems?
6. Explain the XOR problem and its significance in neural network history.
7. What is an activation function? Why is non-linearity important in neural networks?
8. Explain the Rectified Linear Unit (ReLU) activation function with its advantages.
9. What are the limitations of ReLU neurons? Explain the dying ReLU problem.
10. Compare sigmoid, tanh, and ReLU activation functions.
11. What is a Softmax output layer? Why is it preferred for multi-class classification?
12. Explain how the Softmax function produces a probability distribution.
13. Describe the architecture of a feed-forward neural network.

14. Explain the role of hidden layers in feed-forward neural networks.
15. What is the Fast-Food Problem, and how does it motivate learning in neural networks?
16. Define gradient descent. How is it used to train neural networks?
17. Explain the concept of a loss function with suitable examples.
18. What is the delta rule? How does it update the weights of a neuron?
19. Explain the role of the learning rate in gradient descent.
20. Describe gradient descent with sigmoidal neurons.
21. What is the backpropagation algorithm? Explain its purpose.
22. Describe the steps involved in the backpropagation algorithm.
23. Why is backpropagation computationally efficient?
24. Differentiate between batch gradient descent and stochastic gradient descent.
25. Explain mini-batch gradient descent and its advantages.
26. What is the role of training, validation, and test datasets?
27. Define overfitting in deep neural networks.
28. How can overfitting be detected during training?
29. Explain any four techniques used to prevent overfitting.
30. Discuss the importance of regularization in deep learning.

Section B: Numerical Problems on Activation Functions

1. Given the input value $x = -2, 0, 3$, compute the output of:
   - Linear activation: $f(x) = x$
   - ReLU activation: $f(x) = \max(0, x)$

   Interpret the results.

2. For the sigmoid activation function:

$$\sigma(x) = \frac{1}{1 + e^{-x}}$$

   Compute the output for $x = -1, 0, 2$. Interpret how the output changes with input.

3. Consider the tanh activation function:

$$\tanh(x) = \frac{e^{x} - e^{-x}}{e^{x} + e^{-x}}$$

   Compute $\tanh(x)$ for $x = -1, 0, 1$ and explain its range and symmetry.

4. A neuron produces the following pre-activation values: $[1.2, 0.3, -0.5]$. Apply the ReLU activation function and explain the effect of ReLU on negative inputs.

5. Given the output layer inputs $z = [2.0, 1.0, 0.1]$, compute the Softmax outputs:

$$\text{Softmax}(z_i) = \frac{e^{z_i}}{\sum_j e^{z_j}}$$

   Interpret the results as class probabilities.

End of Assignment