Neural Network to Predict Rock or Metal from Sonar Signals

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Introduction

This report presents the development and analysis of a neural network model designed to classify sonar signals as either rocks or mines. The dataset encompasses signals acquired through sonar waves directed at metal cylinders and rocks under varying conditions. The primary objective is to construct a robust classification model using TensorFlow, capable of accurately categorizing the data.

Dataset Description

The dataset comprises two distinct files: "sonar.mines" and "sonar.rocks". The "sonar.mines" file consists of 111 patterns derived from metal cylinders, while the "sonar.rocks" file contains 97 patterns originating from rocks. Each pattern encompasses 60 numerical values, all of which fall within the range of 0.0 to 1.0. These values represent energy levels within specific frequency bands. Notably, these frequency bands are obtained through frequency-modulated chirp sonar signals.

Data Labeling

Each individual pattern is associated with a label, which serves to denote the object's classification as either a rock or a mine. Labels are indicated by the letters "R" for rock and "M" for mine (metal cylinder). Although the labels are sequentially ordered based on ascending aspect angles, it is important to clarify that these labels do not encode the angle itself directly.

Model Architecture

The architecture of the neural network for this classification task incorporates multiple hidden layers, each with varying neuron counts and distinct activation functions. The model's structure is as follows:

1. Input Layer: Comprises 60 neurons, reflecting the dataset's number of features.
2. Hidden Layers: Consists of four hidden layers, each with 60 neurons and employing different activation functions (RELU and sigmoid).
3. Output Layer: Comprises two neurons, representing the rock ("R") and mine ("M") classes respectively.

Hyperparameters

To facilitate the training process, the following hyperparameters are defined:

- Learning Rate: 0.2
- Number of Epochs: 500
- Number of Hidden Layers: 4
- Number of Neurons per Hidden Layer: 60
- Batch Size: Full-batch training

Training and Evaluation

The model is trained using TensorFlow's Gradient Descent optimizer. During the training process, the cost (cross-entropy loss) and accuracy for each epoch are computed. Once trained, the model's performance is assessed on a distinct test set. Additionally, the Mean Squared Error (MSE) is calculated to quantitatively measure the discrepancy between predicted and actual outputs.

Results and Analysis

- The observed decrease in cost over epochs suggests the model's convergence.
- The accuracy on the test set serves as an indicator of the model's classification capabilities.
- The computed MSE provides a valuable assessment of prediction accuracy.

Graphical Analysis

- Cost per Epoch Graph: This graph visually presents the diminishing cost as epochs progress.
- Accuracy per Epoch Graph: Illustrating the evolution of training accuracy throughout epochs.

Conclusion

The neural network model showcases promising potential in the accurate classification of sonar signals into rock or mine categories. The training process implies that the model effectively captures the underlying data patterns. The assessment of test accuracy and MSE furnishes a quantitative evaluation of the model's performance. Continued enhancements could encompass hyperparameter fine-tuning, exploration of diverse architectures, and comprehensive cross-validation procedures.