**HOMEWORK 1**

**Course**: Deep Learning (Fall 2024)

**Homework**: Homework 1

**Student Name**: Le Minh Bang

**Student ID**: 313540015

**Submission Date**: 18/10/2024

**Introduction**

This homework focuses on building foundational skills in deep learning by tackling two key tasks: regression and classification using neural networks. The objective is to design and implement neural networks from scratch for both tasks, ensuring that I understand critical concepts like data preprocessing, model architecture design, forward and backward propagation, and performance evaluation.

For the regression task, I worked with the Energy Efficiency dataset, where the goal was to predict the heating load based on various building characteristics. In this task, I applied feature selection techniques to identify the most important features influencing the heating load. For the classification task, I used the Ionosphere dataset to predict whether signals are "good" or "bad" based on radar data.

Through this assignment, I am expected to not only build models but also experiment with different hyperparameters, analyze the model’s performance, and demonstrate an understanding of how to optimize neural networks for better accuracy and generalization. By the end of the homework, I will have applied various activation functions, performed feature selection, and examined how network configurations affect model outcomes.

**Regression Task (Energy Efficiency Dataset)**

**Data Preprocessing**

**Dataset Description**:

A brief description of the **energy efficiency dataset** (8 features, 2 target labels: heating load and cooling load).

Mention the categorical features that you **one-hot encoded** (e.g., Orientation, Glazing Area Distribution).

Explain how you shuffled and split the dataset (75% training, 25% testing).

***To Fill****:*

Dataset shape, encoding process, etc.

**Neural Network Architecture**

Describe the **architecture** of your neural network, including:

Number of input features: 16

Number of hidden layers and neurons in each layer: One hidden layer with 8 neurons

The activation functions used (e.g., ReLU, Sigmoid, Tanh): Can be choose (In this case: Tanh)

Learning rate, number of epochs, and mini-batch size.

***To Fill****:*

Detailed information about your architecture (e.g., 1 hidden layer with 16 neurons, learning rate: 0.001, etc.).

**Training and Results**

**Learning Curve**: Include the learning curve that shows how the loss changes over time.

**Performance Metrics**:

Report the **training RMSE** and **test RMSE**.

Show the regression results on both **training labels** and **test labels** by plotting the predicted values against the actual values.

***To Fill****:*

Loss curves, training and test RMSE values, and the plots.

**Feature Selection and Analysis**

Describe your **feature selection procedure** (correlation-based, recursive feature elimination, etc.).

Show which features had the most significant impact on the heating load.

**Explanation**: Explain why the feature selection procedure works and how the chosen features influence the energy load.

***To Fill****:*

Methodology used for feature selection (e.g., weight analysis, correlation) and comparison of results with different features.

**Classification Task (Ionosphere Dataset)**

**Data Preprocessing**

**Dataset Description**:

Description of the **Ionosphere dataset** with 34 features and binary labels ("g" and "b").

Mention how the dataset was shuffled and split (80% training, 20% testing).

***To Fill****:*

Preprocessing steps like normalizing the features if necessary.

**Neural Network Architecture**

Describe the architecture of your neural network for classification, including:

Number of input features, hidden layers, neurons, and activation functions.

Learning rate, epochs, and mini-batch size.

***To Fill****:*

Network architecture details.

**Training and Results**

**Learning Curve**: Plot the learning curve showing how the error rate changes over epochs.

**Performance Metrics**:

Report the **training error rate** and **test error rate**.

***To Fill****:*

Learning curve and performance metrics.

**Node Analysis**

**Latent Features Analysis**:

Compare the results of choosing different numbers of nodes in the layer before the output.

Plot the distribution of latent features at different stages of training to show how they evolve.

***To Fill****:*

Graphs and comparison of results with different node configurations.

**Conclusion**

Through the completion of this homework, I have gained a deeper understanding of key deep learning concepts, particularly in the areas of regression and classification using neural networks. I learned how to effectively preprocess data, design and implement neural network architectures, and use forward and backward propagation to train models. The task of performing feature selection in the regression task gave me insights into the importance of selecting the right input features for model accuracy, while the classification task helped me understand how different network configurations and activation functions affect model performance.

Moreover, I realized the importance of fine-tuning hyperparameters and the impact of regularization on preventing overfitting. By experimenting with various activation functions and analyzing node configurations, I gained practical insights into how neural networks work at a fundamental level. Overall, this homework has significantly strengthened my understanding of deep learning, and I am confident that these skills will be valuable in future projects.

Finally, I would like to thank the instructor and teaching assistants for their guidance and support throughout this assignment. Their resources and feedback have been invaluable in helping me complete this homework and deepen my knowledge in this fascinating field of study.