Midterm Evaluation Report

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1 Weekly Progress

Week 1:Python Basics , NumPy ,Pandas, Matplotlib

- **Python:** Python is the primary programming language used for implementing machine learning and deep learning algorithms. Fundamental constructs such as variables, data types, conditional statements, loops, and functions enable modular and reusable code development.
- **NumPy:** NumPy provides efficient numerical computation through multi-dimensional arrays. Array creation, indexing, slicing, and broadcasting enable vectorized operations that significantly improve performance.
- **Pandas:** Pandas enables handling of structured datasets using Series and DataFrames. Key operations include reading datasets, selecting rows and columns, filtering data, handling missing values, and computing descriptive statistics.
- **Matplotlib:**Visualization techniques help in understanding data distributions and model behavior.Common plots include line plots, scatter plots, and bar charts. Visualization supports exploratory data analysis and aids in interpreting trends and anomalies in datasets
- **Assignments:** This assignment focused on structured data handling and preprocessing using Python libraries. The dataset was divided into multiple batches to enable efficient processing. Basic inspection of each batch was performed using tabular previews, verifying correct data segmentation and feature integrity before further analysis

Week 2: Regression models and Different Types of Functions Used

- **Regression Model** Linear Regression models gives continuous outputs as linear combinations of input features.Logistic Regression extends linear models to classification by predicting probabilities using the sigmoid function. These models form the foundation of supervised learning.
- **Activation functions:** An activation function in a neural network is a mathematical function applied to the output of a neuron. It introduces non-linearity, enabling the model to learn and represent complex data patterns. Without it, even a deep neural network would behave like a simple linear regression model.

  Types of activation funciton:

  - Sigmoid function: It is a mathematical equation that maps any real-valued number to a value between 0 and 1, making it ideal for probabilistic outputs.

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

– Tanh function: Tanh is a type of activation function that transforms its input into a value between -1 and 1.

$$f(x) = \tanh(x) = \frac{e^x - e^{-x}}{e^x + e^{-x}} \tag{1}$$

– ReLU function: The ReLU (Rectified Linear Unit) function is one of the most widely used activation functions in deep learning, especially in convolutional and feedforward neural networks.

$$f(x) = \max(0, x) \tag{2}$$

– Softmax function: Softmax Activation Function transforms a vector of numbers into a probability distribution, where each value represents the likelihood of a particular class. It is especially important for multi-class classification problems. Each output value lies between 0 and 1. The sum of all output values equals 1. amsmath

$$P(y = i \mid \mathbf{x}) = \frac{\exp(x_i)}{\sum_{j=1}^{C} \exp(x_j)} \tag{3}$$

- **Loss function:** Loss functions quantify the error between predicted and actual outputs. Mean Squared Error (MSE) and Mean Absolute Error (MAE) are commonly used for regression tasks, while Binary Cross-Entropy and Categorical Cross-Entropy are used for classification problems. Selecting an appropriate loss function is essential for effective learning.
- **Gradient Descent Optimmization:** Gradient Descent is an iterative optimization algorithm used to minimize loss functions.Model parameters are updated using gradients of the loss function with respect to the parameters.The learning rate controls convergence speed and training ability
- **Assignments:** This assignment focused on understanding the mathematical foundations of neural networks, including activation functions, loss functions,and gradient descent optimization.

Week 3: Convolutional Neural Network

- **Convolutional operation:** Convolution applies learnable kernels to local regions of an input image to extract spatial features. Feature maps represent the activation of kernels across the image, capturing local patterns such as edges and textures.
- **CNN Architecture:** Convolutional Neural Networks exploit locality and parameter sharing to efficiently learn hierarchical representations from images. Important concepts include local receptive fields, translation invariance, and hierarchical feature extraction
- **Pooling:** Pooling is a downsampling technique used in Convolutional Neural Networks (CNNs) to reduce the spatial dimensions of feature maps while retaining essential information. It slides a filter (window) over the input and aggregates values within that region, lowering computation, controlling overfitting, and introducing translation invariance.

- **Assignments:** This assignment focused on implementing and understanding convolutional neural networks for image-based data. The objective was to analyze how convolution operations extract spatial features and how CNN architectures improve classification performance compared to fully connected networks.

Week 4: Sequence Modeling and Recurrent Neural Networks

- **Sequential Data:** Sequential data contains temporal dependencies between observations. Unlike independent data, sequence data requires models capable of capturing order and contextual relationships.
- **Recurrent Neural Network:** Recurrent Neural Networks process sequential data by maintaining hidden states across time steps. Training is performed using Backpropagation Through Time .
- **Assignments:** This assignment focused on modeling sequential data using recurrent neural networks.The objective was to understand how hidden states capture temporal dependencies and how training dynamics affect sequence-based predictions

Week 5: Modern Recurrent Architecture

- **Long Short-Term Memory Networks:** Long Short-Term Memory (LSTM) networks are a special type of recurrent neural network designed to learn from sequence data while overcoming the limitations of traditional RNNs. With their unique memory-cell structure, LSTMs can remember information over long time intervals, making them highly effective for tasks involving patterns across time.
- **Gated recurrent Units:** The core idea behind GRUs is to use gating mechanisms to selectively update the hidden state at each time step allowing them to remember important information while discarding irrelevant details. GRUs aim to simplify the LSTM architecture by merging some of its components and focusing on just two main gates: the update gate and the reset gate.
- **Assignment:** This assignment focused on understanding modern recurrent neural network architectures such as Long Short-Term Memory (LSTM) networks and Gated Recurrent Units.