Report on MLP Implementation with Batch Normalization and Dropout for Modeling Uncertainty

This report summarizes the steps taken to implement a Multilayer Perceptron (MLP) with batch normalization and dropout for modeling uncertainty, using a dataset of international airline passengers. The primary goal was to create a model capable of making time series predictions while also providing an estimation of uncertainty in its predictions.

Actions Performed

Dataset Overview and Preprocessing:

- Loaded the dataset containing two columns: 'Month' and 'Passengers'.
- Converted the 'Month' column to datetime format for better handling.
- Normalized the 'Passengers' column using MinMaxScaler to scale the data between 0 and 1.
- Created sequences from the data with a look-back period of 3 months to frame the problem as a time series forecasting task.
- Split the dataset into training (80%) and testing (20%) sets.

Model Architecture and Training:

- Designed an MLP model adapted for time series data, incorporating batch normalization and dropout.
- Used a hidden layer with 50 neurons, a dropout rate of 50%, and a single output for the forecast.
- Trained the model using the Mean Squared Error loss function and the Adam optimizer over 100 epochs.

Uncertainty Estimation using Monte Carlo Dropout:

- Implemented Monte Carlo Dropout by making predictions with the model in training mode (to enable dropout) multiple times (100 iterations).
- Calculated the mean and standard deviation of these predictions to estimate the model's uncertainty.

Visualization

Analysis of Results

The visualization shows the model's predicted mean passenger numbers over time, along with the uncertainty associated with these predictions. The shaded area represents the model's confidence in its predictions – wider area indicates greater uncertainty. This approach provides a two-fold understanding: the expected trend in passenger numbers and the model's confidence in these predictions.

Key Observations:

- Model Performance: The model appears to follow the general trend of the actual data, suggesting a reasonable level of accuracy in the forecasts.
- Uncertainty Representation: The uncertainty estimation reveals where the model is more or less confident in its prediction and it is represented in the gray area. It seems to be wider at the peaks, which might suggest that the model is less certain about more extreme values, which is valuable for risk assessment in practical applications.