

# Brain-Inspired Neural Network Performance Report

## Executive Summary

This report evaluates the performance of the Brain-Inspired Neural Network model on test data. The model was loaded from a pre-trained checkpoint and tested on synthetic data that matches the model's expected input and output dimensions.

## Test Configuration

- **Model:** Brain-Inspired Neural Network with PersistentGRU and Reward-Modulator
- **Input Size:** 64 features
- **Output Size:** 32 features
- **Sequence Length:** 50 time steps
- **Batch Size:** 32
- **Device:** CPU
- **Data Type:** Synthetic test data (100 samples)
- **Execution Time:** 7.3 seconds (real), 6.6 seconds (user), 1.7 seconds (system)

## Performance Metrics

Metric	Value
Mean Squared Error (MSE)	0.9947
Root Mean Squared Error (RMSE)	0.9973
Mean Absolute Error (MAE)	0.7928
R <sup>2</sup> Score	-0.0105
Direction Accuracy	0.00%

## Analysis

The model's performance on the test data shows several concerning issues:

1. **Poor Predictive Accuracy:** The R<sup>2</sup> score of -0.0055 indicates that the model performs worse than a simple mean-based prediction. This suggests that the model is not effectively learning patterns in the data.
2. **High Error Rates:** The RMSE and MAE values are relatively high, indicating significant deviation between predictions and actual values.
3. **No Directional Accuracy:** The direction accuracy of 0% suggests that the model fails to predict even the directional movement of the target variable.

4. **Compatibility Issues:** During testing, several errors related to tensor dimensions were encountered, suggesting that the model architecture may not be fully compatible with the input data format.

## Technical Issues Encountered

1. **Dimension Mismatch:** The model expected input with 64 features, but the real financial data only had 5 features (OHLCV).
2. **Hidden State Initialization:** Errors related to hidden state dimensions indicate potential issues with the PersistentGRU implementation.
3. **Forward Pass Errors:** Multiple errors during the forward pass suggest that the model's internal architecture may have inconsistencies.
4. **Neuromodulator Integration:** While the model includes neuromodulator components, their effect on performance is unclear from the test results.

## Visualizations

The test process generated several visualizations:

1. **Predictions vs Actual:** Comparison of model predictions against actual values
2. **Prediction Error:** Plot of error over time
3. **Error Distribution:** Histogram of prediction errors
4. **Neuromodulator Activity:** Visualization of neuromodulator levels during prediction

## Recommendations for Improvement

1. **Architecture Refinement:**
  - Review and refine the model architecture to ensure consistent tensor dimensions throughout
  - Simplify the hidden state management to avoid initialization errors
2. **Input/Output Handling:**
  - Implement more robust input feature transformation to handle varying numbers of input features
  - Consider dimensionality reduction techniques for high-dimensional outputs
3. **Training Process:**
  - Implement early stopping based on validation performance
  - Use learning rate scheduling to improve convergence
  - Increase training data diversity to improve generalization
4. **Neuromodulation Mechanism:**
  - Evaluate the effectiveness of the neuromodulation components

- Consider simplifying the reward modulation mechanism for more stable learning

#### 5. **Data Preprocessing:**

- Implement more sophisticated feature engineering for financial data
- Consider adding technical indicators as additional features
- Normalize data using more robust techniques (e.g., min-max scaling with outlier handling)

## **Conclusion**

The Brain-Inspired Neural Network model shows potential in its architecture but currently demonstrates poor performance on test data. The integration of brain-inspired mechanisms like persistent memory and neuromodulation is innovative, but further refinement is needed to achieve practical predictive performance.

The primary focus for improvement should be on ensuring dimensional compatibility throughout the model, refining the neuromodulation mechanism, and enhancing the training process to achieve better convergence.