# Forecasting Stock Market Volatility Using AI and Machine Learning

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# Introduction

- Stock market volatility is important for investors to understand risk and make informed decisions.
- We compare AI and machine learning models to predict stock market volatility more accurately.
- This study aims to identify the most effective model for forecasting volatility, benefiting investors and financial analysts.

# Literature Review

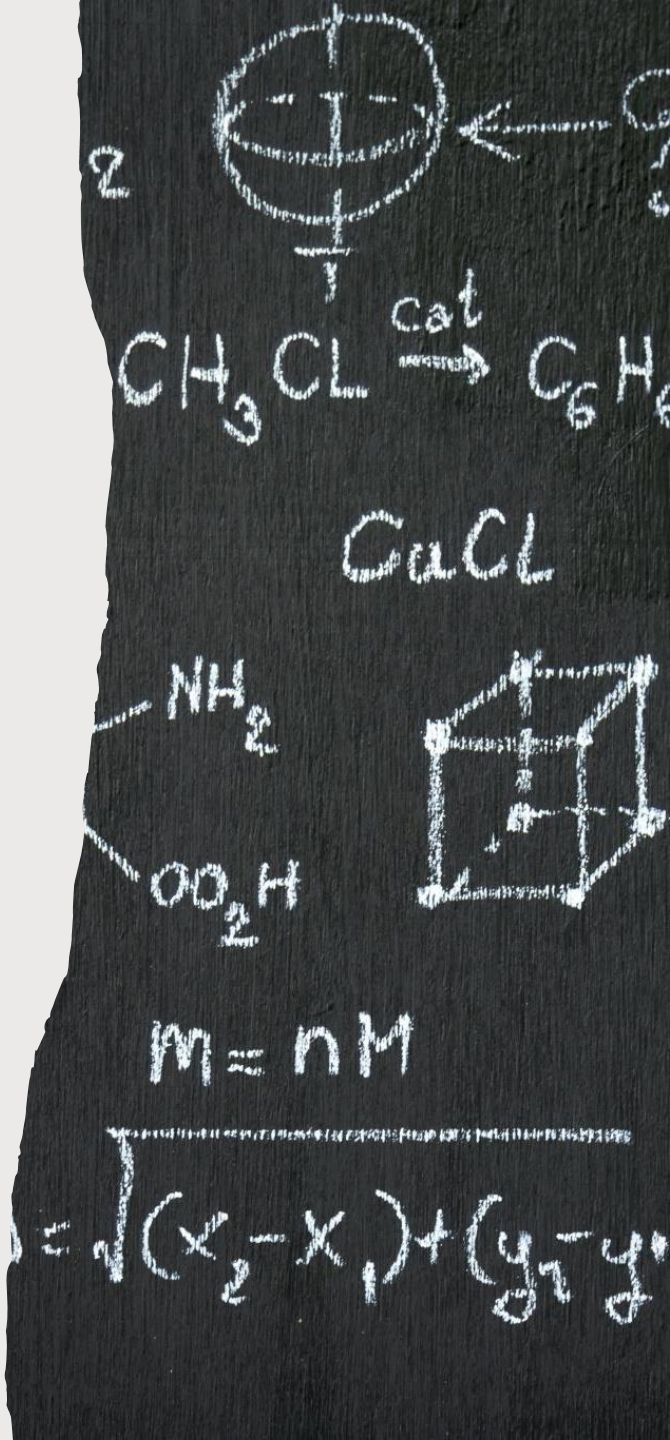
- Machine learning now plays a leading role in forecasting, and neural networks are at the forefront of research in most fields of science (Petropoulos et al., 2022)
- Most researchers using neural networks employed LSTM networks to extract sequential information but overlooked the local information hidden in time series" (Zhao et al., 2024)
- High volatility leads to larger price swings and increased uncertainty, making it challenging for models to identify underlying patterns. This distinct volatility patterns among the metals can also be linked to the patterns related to storage costs or supply disruptions (Raza et al., 2023).
- "Noise in stock prices is not dealt with effectively" (Zhao et al., 2024).

# Data Description

- We used 10 years of weekly data from 6/14/2013 to 9/21/2023.
- Weekly data helps reduce daily noise and shows clearer trends.

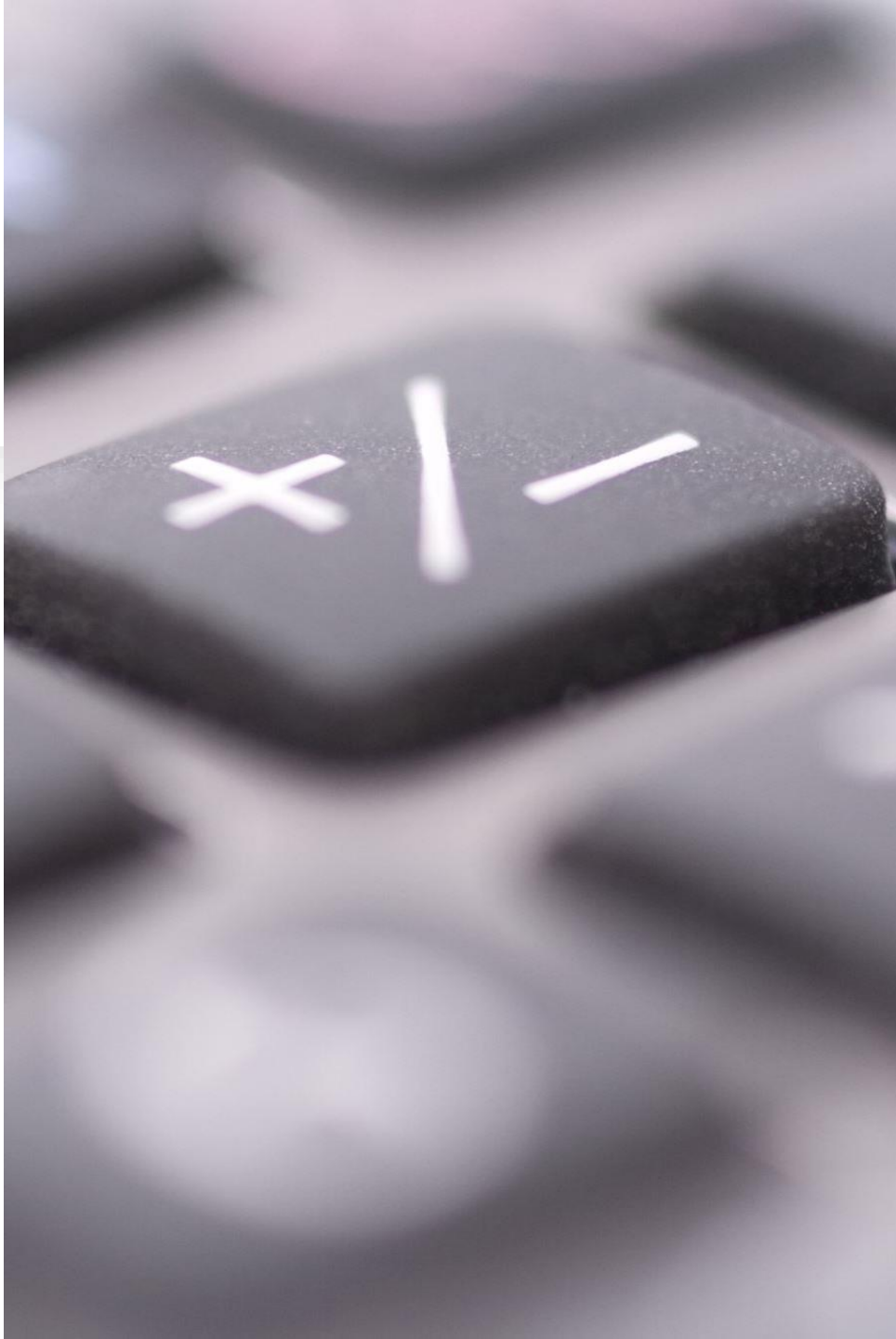
# Model Description

- Model Equation:
- SP500 = c + DAXβ1 + CAC40β2 + NI225β3 + error
- Description:
- - The model predicts the SP500 index based on other indices: DAX, CAC40, and NI225.
- - c is the intercept, and β1, β2, β3 are the coefficients for the respective indices.



# Machine Learning Models

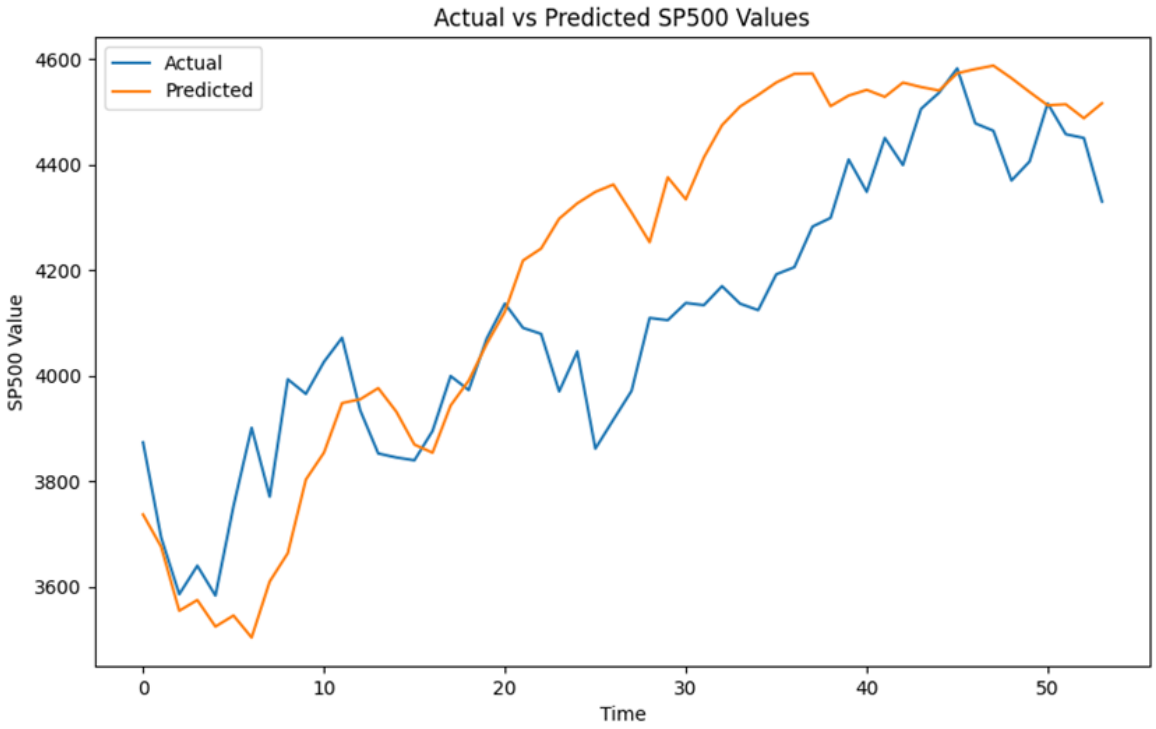
- LSTM:
- - RMSE: 213.09, MAE: 168.15
- GRU:
- - RMSE: 983.80, MAE: 807.54
- CNN-LSTM:
- - RMSE: 167.53, MAE: 137.98



# Descriptive statistics

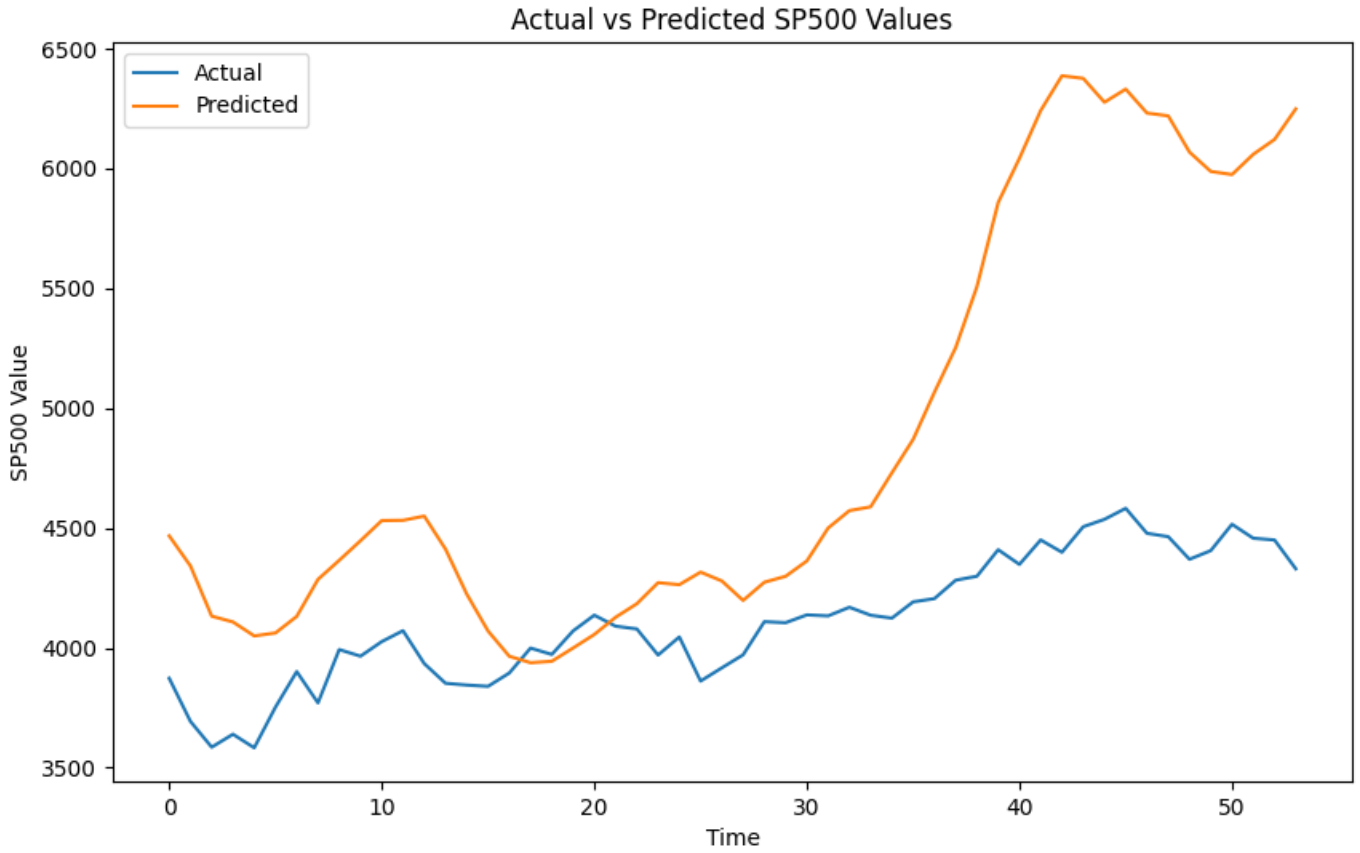
| | *SP500* | *DAX* | *CAC40* | *NI225* |
|---|---|---|---|---|
| Mean | 2899.3 | 12166.1 | 5349.3 | 21842.8 |
| Standard Error | 38.966 | 90.989 | 40.720 | 214.344 |
| Median | 2732.22 | 12210.55 | 5201.45 | 21374.83 |
| Standard Deviation | 902.9693 | 2108.5113 | 943.6193 | 4967.0580 |
| Sample Variance | 815353.6 | 4445819.8 | 890417.3 | 24671664.8 |
| Kurtosis | -1.085913 | -0.813946 | -0.591082 | -0.837505 |
| Skewness | 0.499968 | 0.165086 | 0.600821 | 0.302027 |
| Range | 3173.75 | 8680.51 | 3918.96 | 21019.56 |
| Minimum | 1592.43 | 7789.24 | 3658.04 | 12686.52 |
| Maximum | 4766.18 | 16469.75 | 7577 | 33706.08 |
| Sum | 1556932.42 | 6533199.95 | 2872562.48 | 11729556.79 |
| Count | 537 | 537 | 537 | 537 |

# LSTM




Metrics:
RMSE: 213.08615725428078
MAE: 168.15098623855218
MAPE: 4.122692327678075%
R-squared: 0.32940938072492776

# GRU




Metrics:

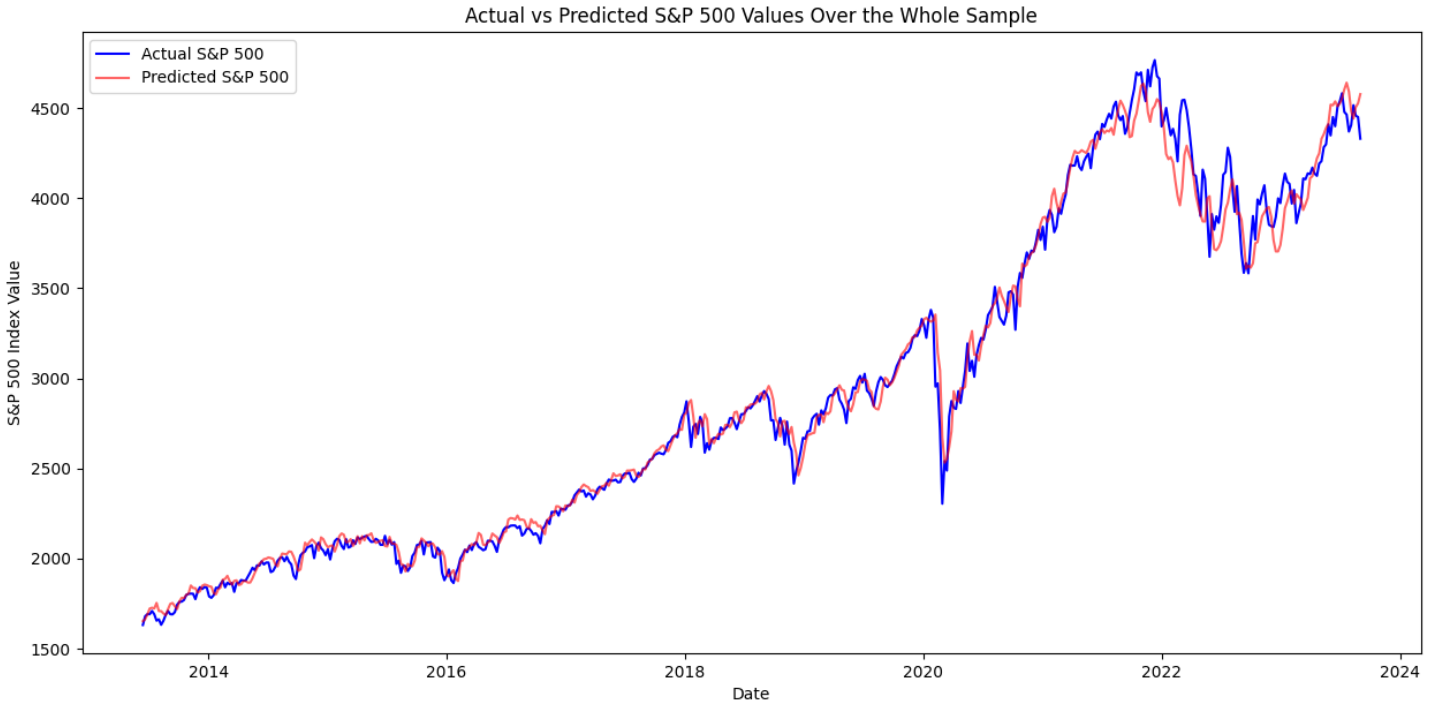
RMSE: 983.7988223290839

MAE: 807.5406781678946

MAPE: 19.131726398309983%

R-squared: -13.294191484324946

# CNN-LSTM Hybrid




Metrics:

Test RMSE: 167.53473096522842

Test MSE: 28067.88607959147

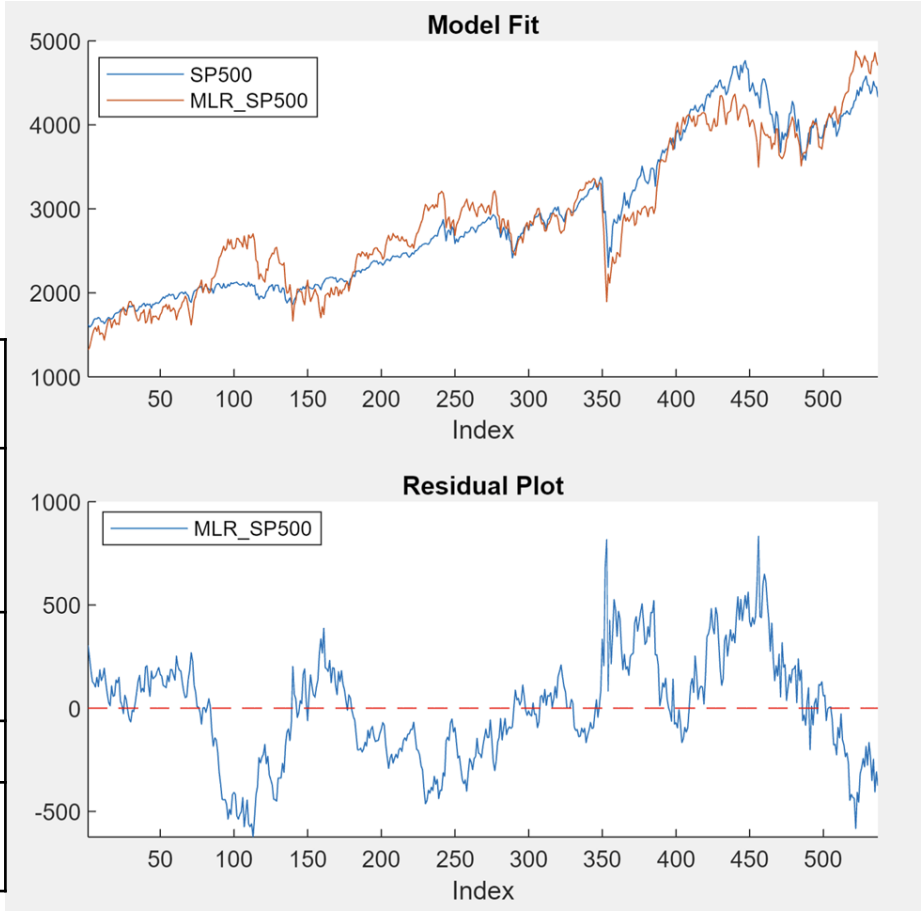
Test MAE: 137.97767620349052

Test MAPE: 3.2689335678620877

Test R^2: 0.6665272367519762

# Multiple Linear Regression (MLR)

| Parameter | Value | Standard Error | T stat | P Value |
|---|---|---|---|---|
| Intercept | -1.31E+03 | 76.0422 | -17.2211 | 3.63E-53 |
| Beta{CAC40} | 0.2385 | 0.0414 | 5.7643 | 1.39E-08 |
| Beta{DAX} | 0.0197 | 0.0212 | 0.9302 | 0.3527 |
| Beta{NI225} | 0.1233 | 0.007 | 17.5588 | 8.45E-55 |



# Comparison of Models

- - Best Performer: CNN-LSTM
- - Overall: AI models outperform MLR
- Comparison:
- - **LSTM**: Good accuracy with RMSE of 213.09 and MAE of 168.15.
- - **GRU**: Higher errors with RMSE of 983.80 and MAE of 807.54.
- - **CNN-LSTM**: Best performance with RMSE of 167.53 and MAE of 137.98.
- - **MLR**: Traditional model with RMSE of 259 and R-squared of 0.918.

# Policy Implications

Recommendation: Investors should use AI models for better predictions.

Benefits:

- Increased prediction accuracy

- Better risk management

- Improved investment strategies

Future Research: Explore more hybrid models and larger datasets to further enhance forecasting accuracy.

# Conclusion

- Finding: AI models, especially CNN-LSTM, provide better predictions.
- Impact: Helps investors make better decisions.
- Conclusion:
- - AI models significantly improve prediction accuracy over traditional methods.
- - The CNN-LSTM hybrid model shows the best performance among the tested models.
- - Implementing AI in stock market analysis can lead to more effective investment strategies.
- - Future work should focus on integrating more complex models and diverse datasets for even better results.

# Code

LSTM.txt

GRU.txt

CNN LSTM hybrid 2 whole sample predic