Stock Price Prediction Using LSTM, Bi-LSTM, GRU, and Bi-GRU

Introduction

The goal of this project is to predict stock prices of Reliance Industries Limited (RELIANCE) using historical stock data and technical indicators. This involves employing various recurrent neural network (RNN) architectures, specifically Long Short-Term Memory (LSTM), Bidirectional LSTM (Bi-LSTM), Gated Recurrent Unit (GRU), and Bidirectional GRU (Bi-GRU) to analyze and forecast future stock prices. This type of analysis is crucial for investors and analysts in making informed financial decisions.

Data Description

The dataset used in this project is sourced from the National Stock Exchange of India (NSE) via the `nsepy` library. It covers daily stock prices for Reliance Industries from January 1, 2007, to May 1, 2021. The dataset includes the following columns:

- **Date**: The trading date.
- **Open**: The opening price of the stock.
- **High**: The highest price of the stock during the trading day.
- **Low**: The lowest price of the stock during the trading day.
- **Close**: The closing price of the stock.
- **Volume**: The volume of shares traded.

In addition to the raw stock price data, three technical indicators are calculated:

1. **Exponential Moving Average (EMA)**: A trend-following indicator that gives more weight to recent prices.
2. **Average Directional Index (ADX)**: An indicator used to quantify the strength of a trend.
3. **Relative Strength Index (RSI)**: An oscillator that measures the speed and change of price movements to identify overbought or oversold conditions.

Steps Involved

1. **Data Retrieval**: Fetch historical stock price data using `nsepy`.
2. **Feature Engineering**: Add technical indicators (EMA, ADX, RSI) to the dataset.
3. **Data Preparation**:
    - **Normalization**: Standardize the dataset using `StandardScaler`.
    - **Sequencing**: Create sequences of past data to use as input for the RNN models.
4. **Model Building**:
    - **Unidirectional LSTM**: Implement a standard LSTM model.
    - **Bidirectional LSTM (Bi-LSTM)**: Implement a Bi-LSTM model to capture dependencies in both directions.
    - **Gated Recurrent Unit (GRU)**: Implement a GRU model for comparison.

    - **Bidirectional GRU (Bi-GRU)**: Implement a Bi-GRU model to capture dependencies in both directions.
5. **Model Training and Evaluation**: Train the models and evaluate their performance using metrics like Mean Squared Error (MSE), Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), and Explained Variance Score.
6. **Forecasting**: Predict future stock prices and visualize the forecasts alongside the historical data.

Methods

Data Retrieval

Historical stock data is retrieved using the `get_history` function from `nsepy`.

Feature Engineering

Technical indicators are calculated using the `TA-Lib` library:

- **EMA**: Exponential Moving Average.
- **ADX**: Average Directional Index.
- **RSI**: Relative Strength Index.

Data Preparation

1. **Normalization**: Standardize the features using `StandardScaler`.
2. **Sequencing**: Create sequences of past observations (14 days) to use as inputs for the models.

Model Building

1. **Unidirectional LSTM**:
    - Three LSTM layers with ReLU activation and dropout.
    - Dense layers for output.
2. **Bidirectional LSTM (Bi-LSTM)**:
    - Bidirectional LSTM layers to capture dependencies in both directions.
    - Pooling layers and dense layers for output.
3. **Gated Recurrent Unit (GRU)**:
    - GRU layers with dropout and dense layers for output.
4. **Bidirectional GRU (Bi-GRU)**:
    - Bidirectional GRU layers to capture dependencies in both directions.
    - Pooling layers and dense layers for output.

Model Training and Evaluation

Models are trained for 20 epochs with a batch size of 32. Performance is evaluated using MSE, RMSE, MAE, and Explained Variance Score. Forecasting is done for the next 20 days.

Forecasting

Future stock prices are predicted and compared with historical data.

Results

Unidirectional LSTM

- **Training Score**: MSE = [Training MSE]
- **Testing Score**: MSE = [Testing MSE]
- **Forecasting**: Visualizations of predicted vs. actual prices.

Bidirectional LSTM (Bi-LSTM)

- **Training Score**: MSE = [Training MSE]
- **Testing Score**: MSE = [Testing MSE]
- **Forecasting**: Visualizations of predicted vs. actual prices.

Gated Recurrent Unit (GRU)

- **Training Score**: MSE = [Training MSE]
- **Testing Score**: MSE = [Testing MSE]
- **Forecasting**: Visualizations of predicted vs. actual prices.

Bidirectional GRU (Bi-GRU)

- **Training Score**: MSE = [Training MSE]
- **Testing Score**: MSE = [Testing MSE]
- **Forecasting**: Visualizations of predicted vs. actual prices.

Conclusion

The comparison of different RNN architectures (LSTM, Bi-LSTM, GRU, and Bi-GRU) provides insights into their effectiveness in stock price prediction. The performance metrics and visualizations help in understanding the models' predictive capabilities. Future work could involve experimenting with other RNN variants, incorporating additional features, or applying these models to other financial instruments.

Future Work

1. **Model Enhancement**: Explore other advanced RNN variants or hybrid models for improved accuracy.
2. **Feature Engineering**: Include more technical indicators or external data sources (e.g., news sentiment) to enhance model performance.
3. **Real-Time Prediction**: Develop a real-time prediction system for stock prices.
4. **Extended Forecasting**: Extend the forecasting period beyond 20 days and validate the model on different timeframes.

Summary

This project successfully implements and compares various RNN architectures for stock price prediction using historical data and technical indicators. The results show the strengths and limitations of each model, providing valuable insights for future financial forecasting projects.