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Stock Market Price Prediction

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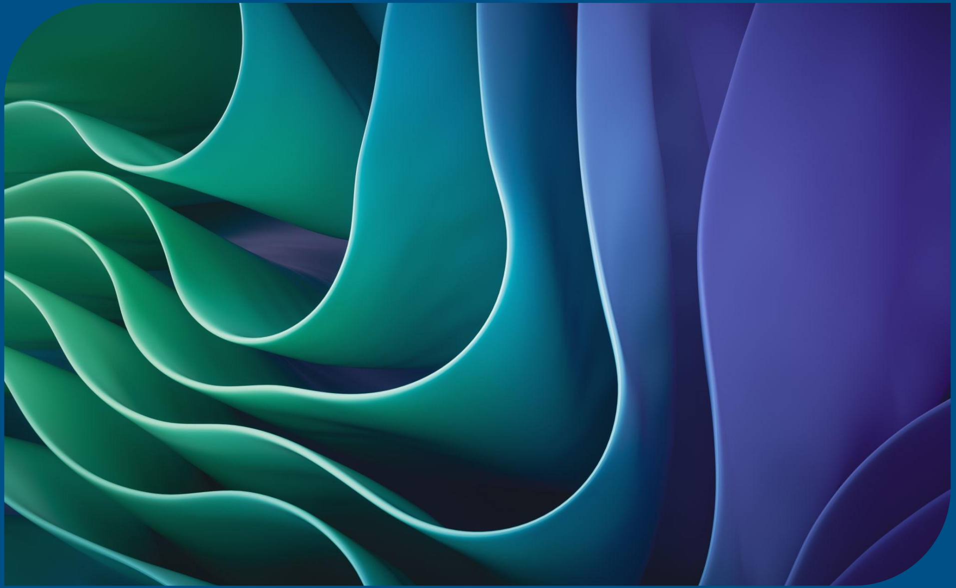

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2. Related Works and Alg. Selection
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Our Project's Focus

- **Our Objective**
  - Evaluate how well algorithms handle the complexities of financial data to inform better stock market forecasting
  - Compare/contrast two machine learning algorithms:
    - *Linear Regression*
    - *Long Short-Term Memory (LSTM)*

- **Important Distinction**
  - Only evaluating on a day to day basis
  - Given an opening price, what is the predicted closing price?

- **Real-World Implication**
  - Understand which algorithm provides more reliable predictions for short-term trading decisions

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Linear Regression

Overview:

- A fundamental statistical technique modeling relationships between dependent and independent variables.
- Represents the relationship as a straight line: $y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_2 x_2 + \epsilon$

Advantages:

- Computationally efficient and interpretable.

Limitations:

- Struggles with capturing non-linear and dynamic trends in financial data.
- Performance deteriorates in volatile market conditions.

LSTM

Overview:

- LSTM networks, a subtype of RNNs, use memory cells to retain relevant information over extended time periods.
- Designed to model sequential data, capturing long-term dependencies and complex temporal patterns.

Advantages:

- Handles noisy and non-linear data effectively.
- Flexible integration of input features like technical indicators and macroeconomic variables.

Challenges:

- Computationally intensive and requires extensive training.
- Performance depends on effective feature engineering and hyperparameter tuning

Similar Studies

- **Overview**
  - Multiple studies confirmed our rationale for choosing these specific algorithms

- **Why Linear Regression?**
  - Emioma and Edeki (2021) successfully applied linear regression for short-term stock price prediction using factors like opening and closing prices

- **Why LSTM?**
  - Bhandari et al. (2022) demonstrated that LSTMs outperform traditional methods like ARIMA and linear regression for forecasting indices like S&P 500
  - Saboor et al. (2020): Achieved high accuracy in predicting indices like S&P 500 and NIFTY 50

Data and Preprocessing

100 Stocks

- 50 large cap
- 50 mid cap

Historical stock data

- Date
- Opening price
- Closing price
- Daily high
- Daily low

Partition into input and output

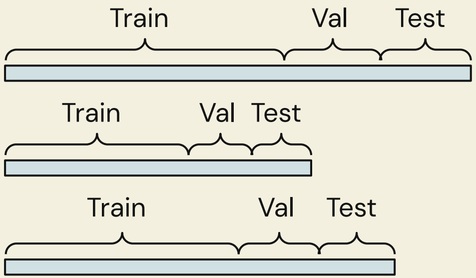
- Input: open, low, and high
- Output: close

Scaling

- Scale prices to a value between 0 and 1
- Improves model efficiency

Training/Validation/Testing Sets

- Training: 70%
- Validation: 15%
- Testing: 15%



- Aggregate training and validation data sets

Training and Validation

Training

- Train both models using aggregate training set

Validation

- Fine-tune LSTM hyper-parameters using aggregate validation set
- Number of units in LSTM layer: 100
- Recurrent dropout rate: 0.1
- Dropout layer rate: 0.3
- Learning rate: 0.005

Testing

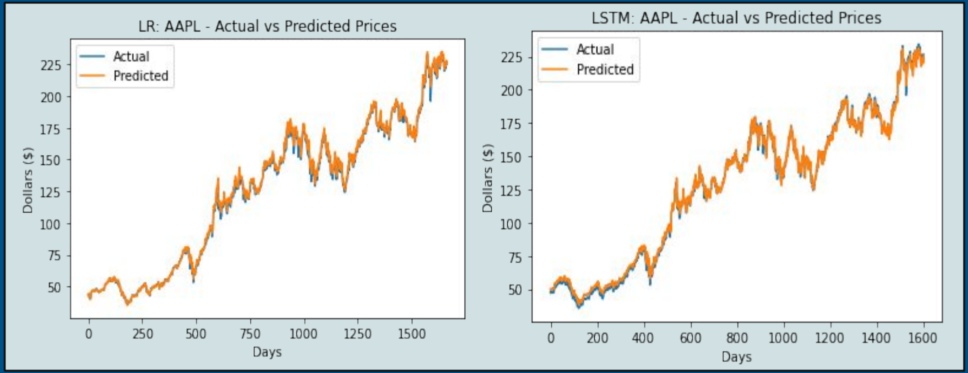
Test on testing sets for each individual stock

- Mean squared error
- Mean absolute error
- R^2 value
- Linear regression coefficients/correlations

Day trading simulation

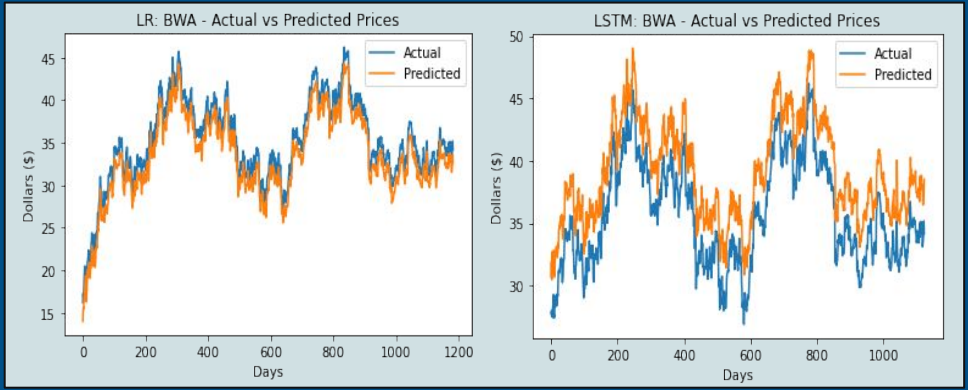
- Randomly select stocks
- For a random day, make a prediction about which stock would produce greatest yield
- Compare predicted to actual

Model Comparison



High Market Cap (AAPL):

- Both models perform well with clear trends
- Shows stability in predictions for established stocks



Mid Market Cap (BWA):

- More volatility and complex patterns
- LR shows surprisingly competitive performance despite simplicity

Performance Metrics

Metric (Average)	Linear Regression	LSTM
R squared	0.977	0.935
MSE	1.45e-8	3.89e-08
MAE	0.000076	0.000110
Training time	Less than 1 second	1.17 hours

- **Both models perform well.**
  - Linear regression performs slightly better.
- **Big trade-off on model complexity**
  - LSTM takes a significantly higher computation power.

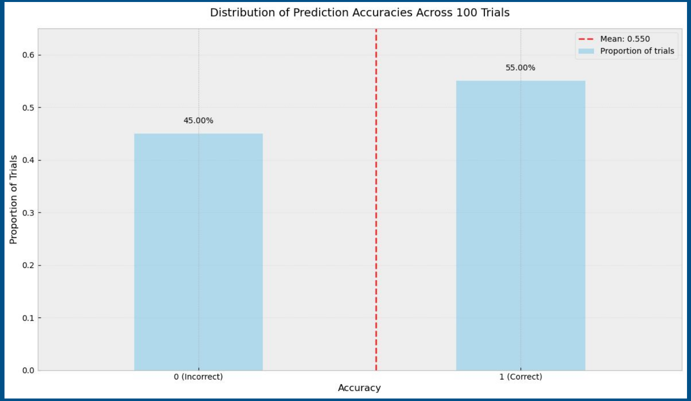
➔ Linear Regression: Simple, assumes linear relationships between features and target

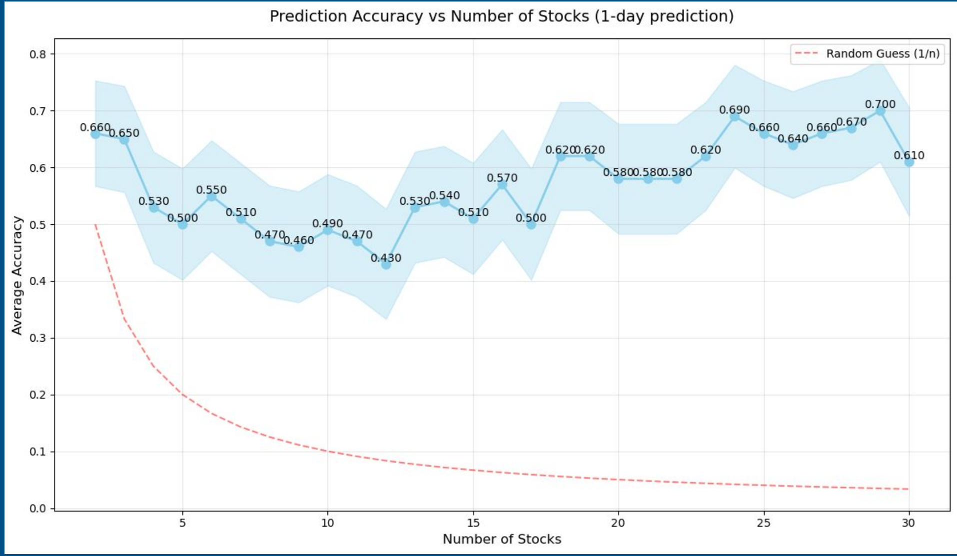
➔ LSTM: More complex, capable of learning sequential patterns and dependencies in time series data

Implication

- **Two Stocks Prediction Accuracy:**
  - Tested over 100 different trials
  - Success = Correctly identifying the stock with highest price increase
  - Model achieves 55.0% accuracy in picking best performer

- **Multiple Stock Comparison (100 trials):**
  - Compares predicted vs actual daily closing prices for N stocks (N = 2 to 30).
  - Particularly valuable for day traders comparing multiple options.
  - Performance stays stable choosing between a high number of stocks.





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Conclusion

Both models performed well, showcasing their strengths in stock price prediction.

Linear Regression:

- Competitive performance, especially for high-market-cap stocks.
- Surprising edge in **stability**.
- Achieved a higher **R^2 value (0.977)** compared to LSTM.
- Significantly shorter training time (**less than 1 second**).

LSTM:

- Demonstrated the ability to learn **complex temporal patterns**.
- Achieved a strong **R^2 value (0.935)** despite the complexity.
- Training time was significantly longer (**1.17 hours**), reflecting its higher computational requirements.

Key Takeaway:

- Trade-offs between accuracy and complexity quantified.

Future Work

1. **Future Price Prediction**: Extend the model to predict the closing price of future dates, evaluating the algorithms' ability to handle longer-term forecasts and adapt to temporal patterns over multiple days.

2. **Dataset Expansion**: Increase the size and diversity of the dataset to evaluate the models' performance across a broader range of stocks and market conditions.

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