Explainable Stock Price Forecasting: A Comparative Exploration of Prophet and Mamdani Fuzzy System based on Accuracy and Interpretability

Ranjith Ramaswamy

INTRODUCTION

- In the dynamic realm of finance, accurately predicting stock prices is vital yet challenging due to the influence of diverse global events and local factors.

- Advanced computational models powered by machine learning offer remarkable capabilities in stock forecasting but pose concerns regarding interpretability.

- This research aims to strike a balance between predictive precision and model transparency by conducting a comparative analysis of Prophet and Mamdani models on Nifty 50 data, thereby illuminating their individual strengths , weakness and suitability for stock price forecasting, considering both accuracy and interpretability.

Dataset

- Source: Nifty 50 data from National Stock Exchange of India
- Timespan: Historical daily data from 2012-2022
- Contents:

  Nifty 50 closing prices, Traded volumes, Technical indicators (RSI, MACD, Bollinger Bands), Macroeconomic indicators (GDP, inflation, unemployment), Market sentiment data, Global market data (Dow Jones, Shanghai index)

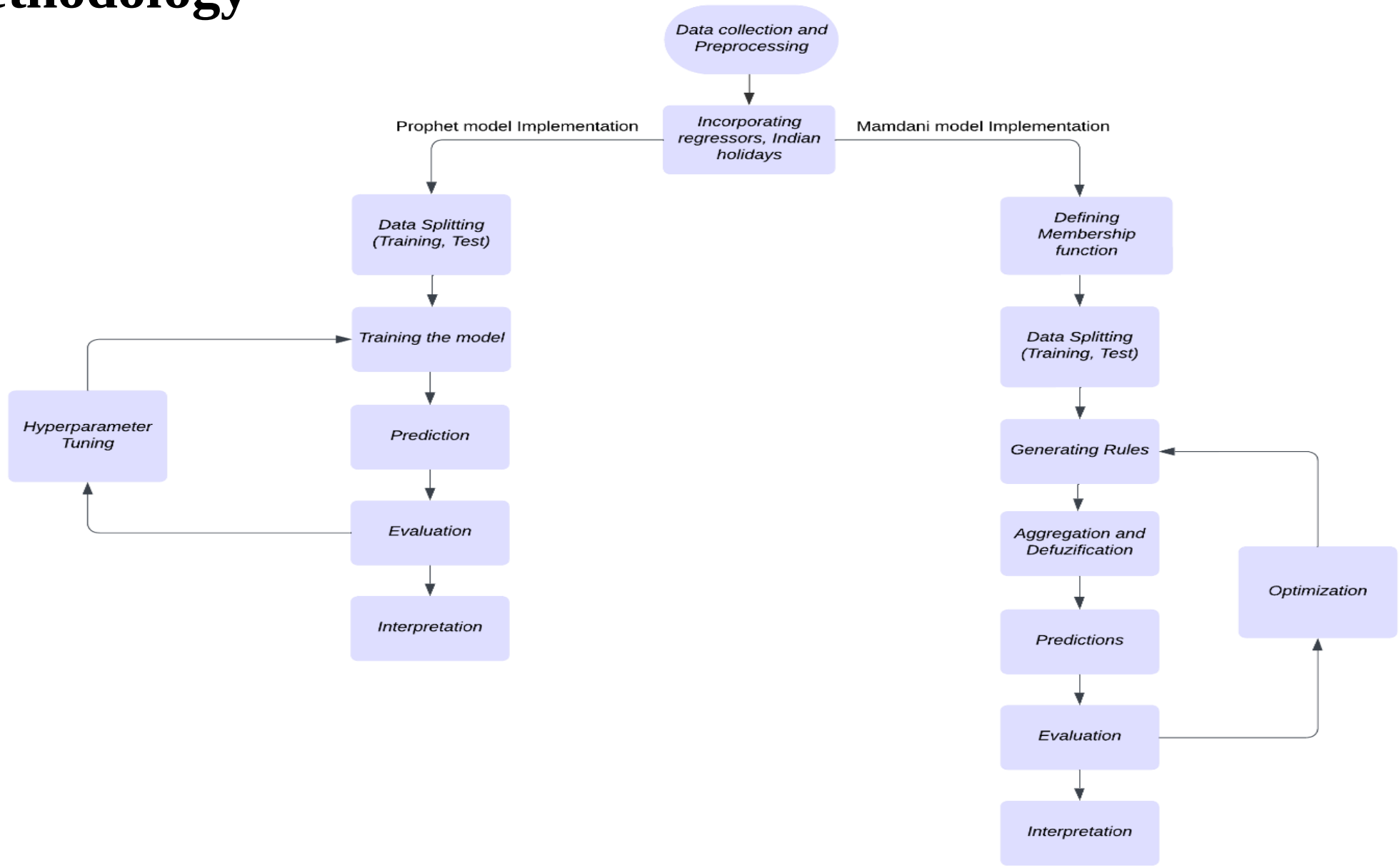
- Preprocessing:

  Data cleaning, Handling of missing values, Outlier assessment, Feature engineering

- Partitioning:

  Training data: 2012-2020, Test data: 2021-2022

Methodology

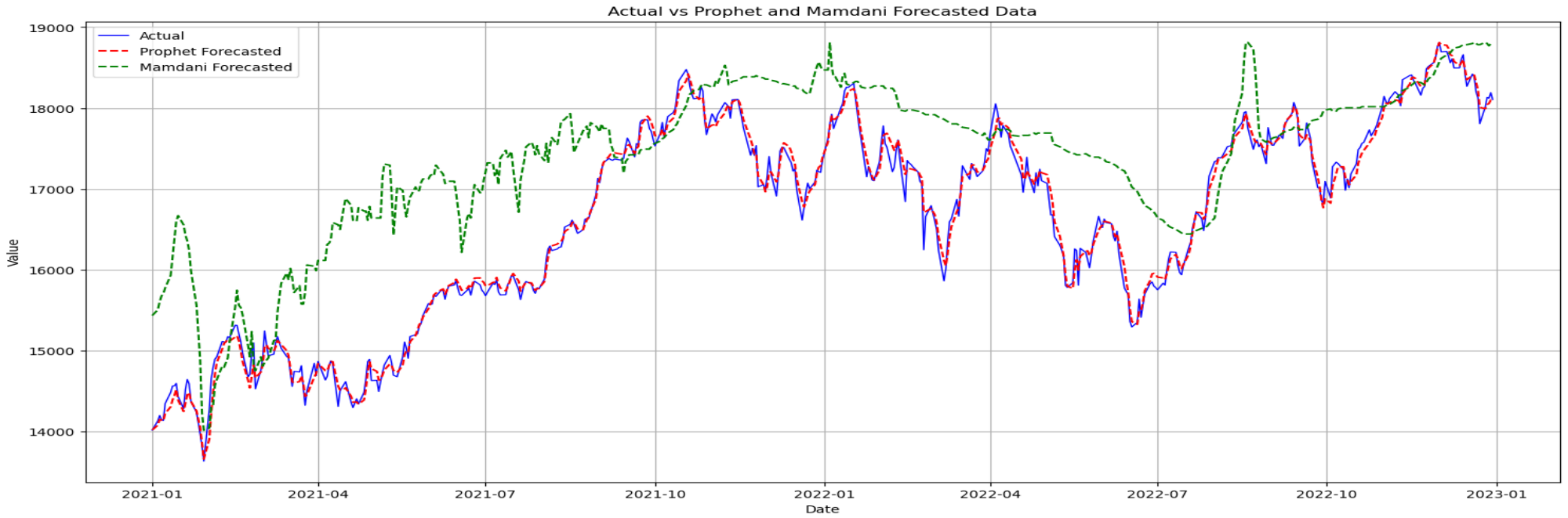


RESULTS

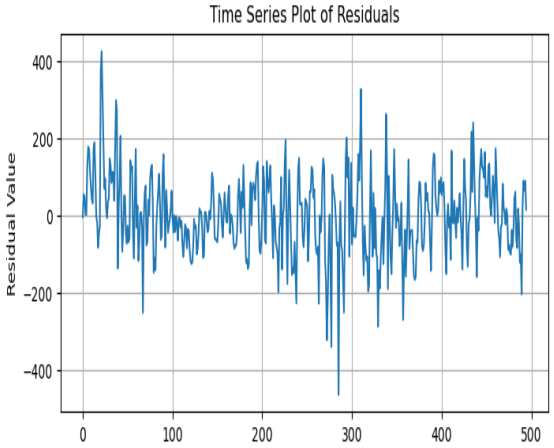
- Accuracy metrics comparison:

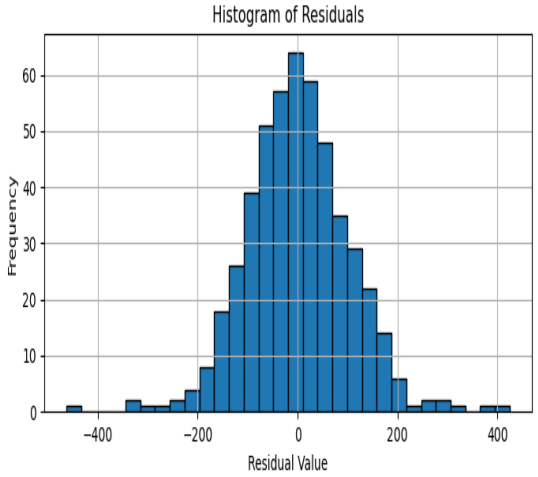
Model	SMAPE	MPE
Prophet	0.48%	0.01%
Mamdani	2.51%	4.82%

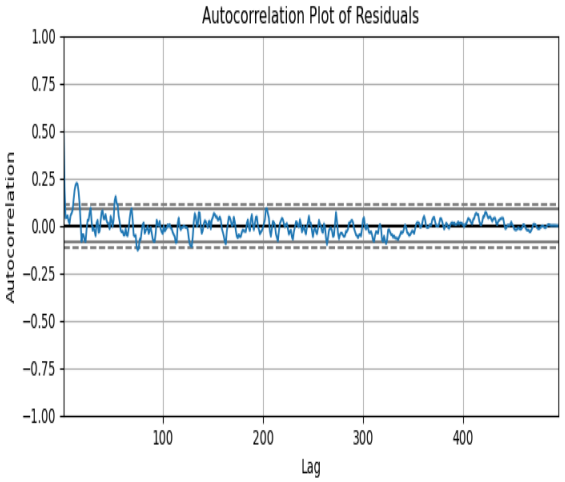
- Comparison visual forecast fit:



➢ Residual Analysis:

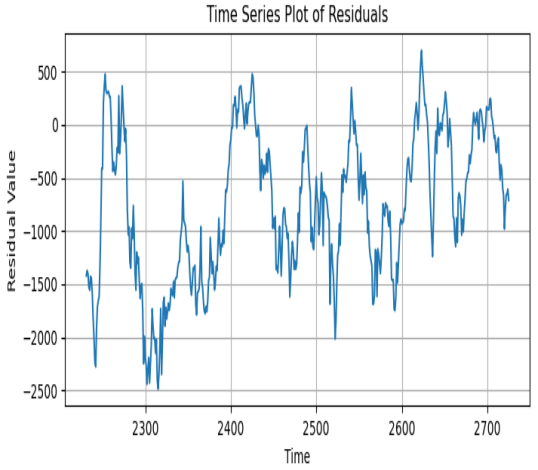


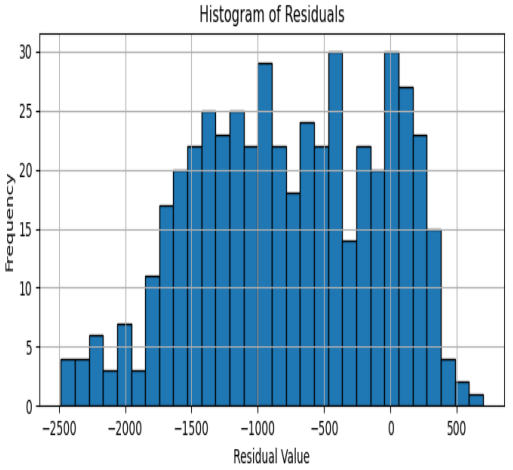


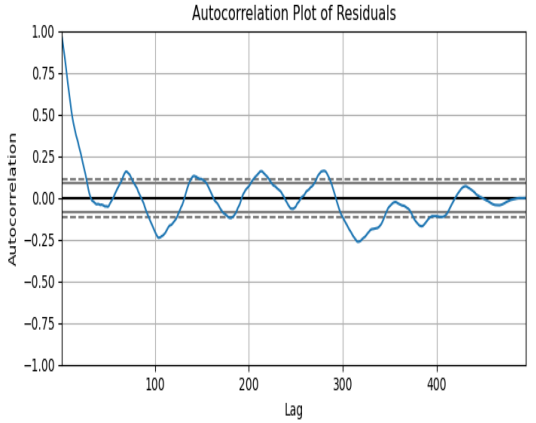


Count	495
Mean	0.60
Std	103.31
Min	-462.91
25%	-67.24
50%	-2.41
75%	61.62
Max	424.73

Residuals statistics.







count	495
mean	-763.78
std	698.58
min	-2485.21
25%	-1310.74
50%	-762.67
75%	-154.26
Max	698.61

Residuals statistics.

➢ Comparison of instance level prediction:

Variable	Prophet Coefficient	Mamdani Linguistic Term
Date	21-01-05	21-01-05
Dow Jones Industrial Average	77.70	Low
GDP Growth	-1.05	Medium
Inflation	-4.78	High
MACD	86.20	Medium
MACD Histogram	64.22	Medium
MACD Signal	-40.12	Medium
Moving Average 50	-1363	Low
RSI 14	79.12	High
Sentiment	-0.03	Medium
Shanghai Stock Exchange	10.27	Low
Shares Traded	-10.70	Medium
Unemployment	0.25	Medium
Lower Band 20	2298.49	Low
Middle Band 20	2221.52	Low
Upper Band 20	2101.88	Low
Output	14149.69	Low: 15605.57

➢ Interpretability comparison:

Interpretability Aspect	Mamdani	Prophet
Transparency into components	High	Medium
Granularity of insights	High	Low
Traceability of reasoning	High	Low
Quantifying uncertainty	High	Low
Localized insights	High	Medium
Temporal adaptability	High	Medium

➢ SWOT Analysis:

MODEL	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Mamdani	Interpretability through transparent linguistic rules and reasoning traceability	Lower quantitative accuracy	Hybrid ensembling with Prophet	Overfitting from excessive localization
	Localized learning adapts to regime changes	Overprediction bias	Regularization to improve bias-accuracy tradeoff	Difficulty generalizing across regimes
	Aligns well with domain knowledge	Insufficient volatility encoding	Expanding rule base and membership functions	Comprehension overhead from complexity
Prophet	Excellent numerical forecasting accuracy	Black-box nature limits interpretability	Incorporating localized modeling to capture regime changes	Overfitting and temporal over-generalization
	Minimal errors highlight adaptability	Lacks granularity into model workings	Advanced functional approximations	Changing market conditions
	Broad conformity with domain principles	Smooths temporal nuances	Ensembling with Mamdani for transparency	New data may violate assumptions

Conclusion:

- The analysis revealed a trade-off between numerical accuracy favoring Prophet versus transparency favoring Mamdani.
- The strengths and weaknesses highlight the value of developing accurate yet interpretable forecasting systems. Future work should explore ensembling Prophet with enhanced Mamdani models to combine strengths and advance explanation interfaces.
- Testing on diverse datasets can reveal additional comparative insights into navigating the accuracy-interpretability balance.