COMPARISON BETWEEN ARIMA AND DEEP LEARNING MODELS FOR FORECASTING

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OBJECTIVE

- Project Focus: Comprehensive comparison of AutoRegressive Integrated Moving Average (ARIMA) versus deep-learning models: Long Short-Term Memory (LSTM), and Convolutional Neural Networks (CNN).
- Beyond Comparison: Exploration of how each model interacts with diverse dataset characteristics, including window size, seasonality, trends, and the choice between one-step and multi-step forecasting.
- Evaluation Metrics: Utilization of essential metrics—Root Mean Square Error (RMSE), Mean Absolute Percentage Error (MAPE), and Mean Absolute Error (MAE) for rigorous performance assessment.
- Investigating how tuning hyperparameters, such as step size, prediction window, and regularization, affects the accuracy of models while forecasting

METHODOLOGY

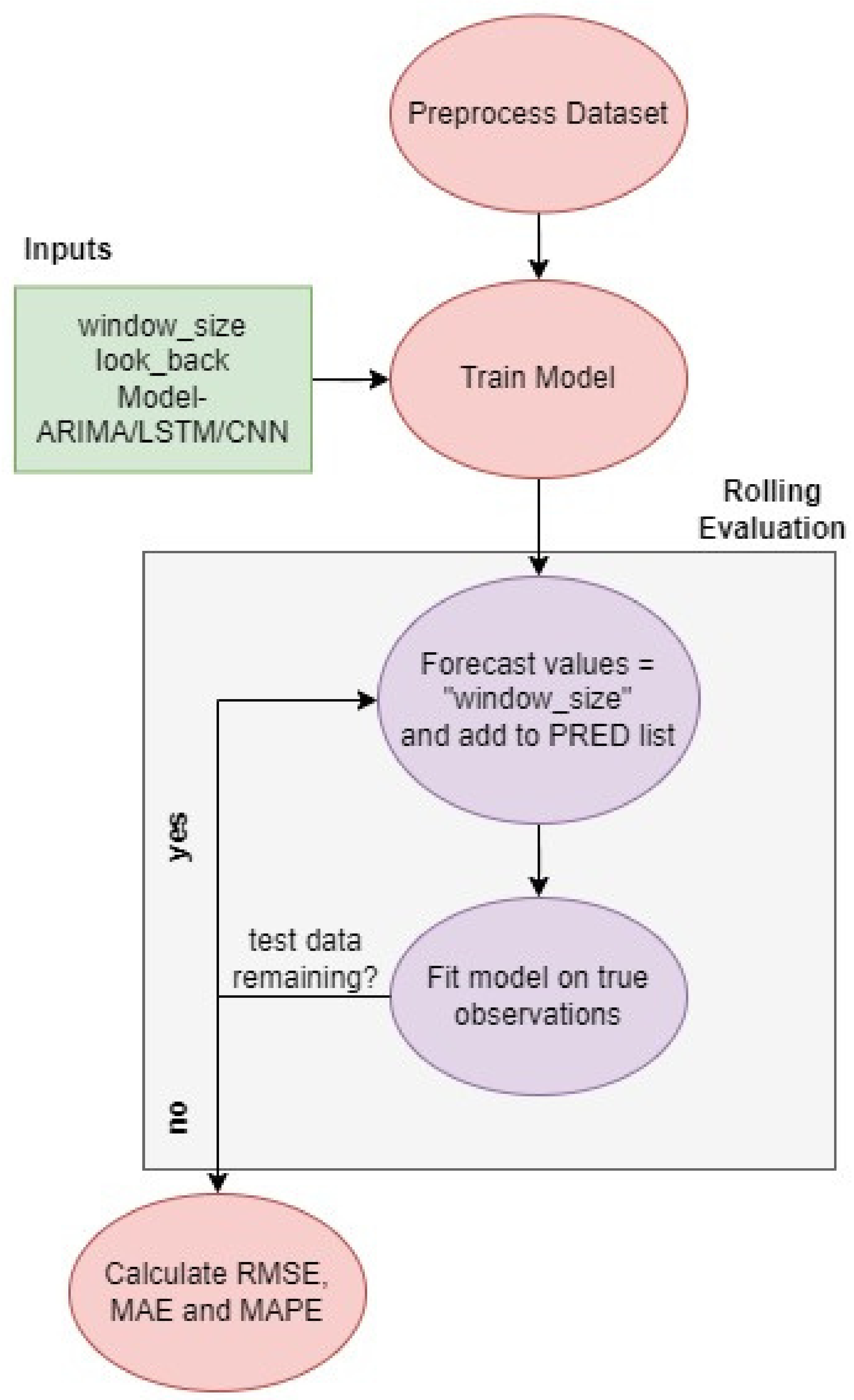


FIGURE 1: ROLLING EVALUATION

DATASET

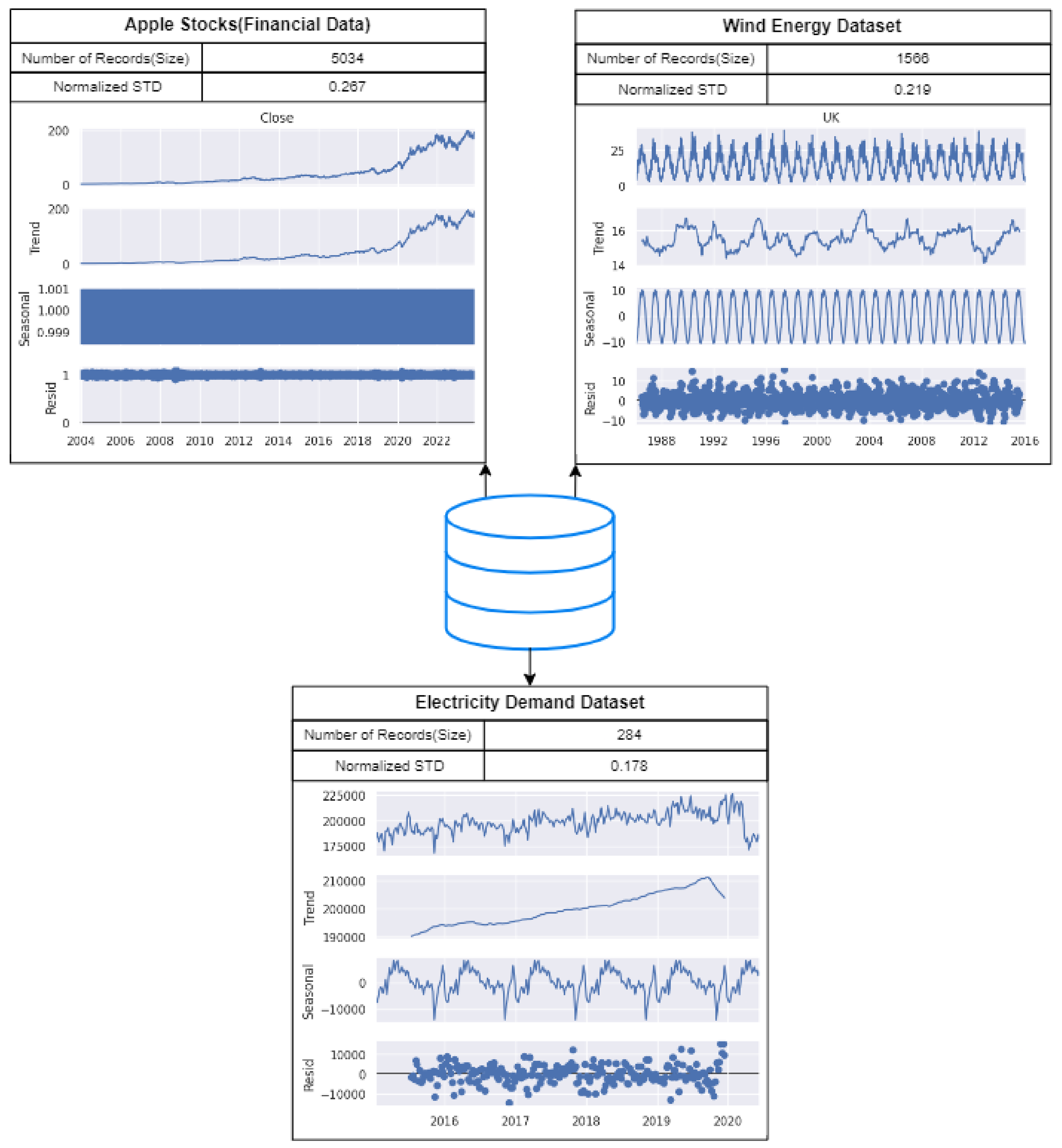


FIGURE 2: DATASET

RESULTS

1. Results on Electricity Dataset

Properties: Trend: Linear, Seasonal: True

DATASET : ELECTRICITY LOOKBACK = 1

Models	RMSE		MAE		MAPE	
	1step	3step	1step	3step	1step	3step
ARIMA	8258.929	-	6534.281	-	0.032	-
LSTM	9936.293	-	8210.613	-	0.04	-
CNN	12779.624	-	9603.25	-	0.047	-

DATASET : ELECTRICITY LOOKBACK = 5

Models	RMSE		MAE		MAPE	
	1step	3step	1step	3step	1step	3step
ARIMA	8164.112	9115.779	6477.497	7200.061	0.032	0.057
LSTM	9725.179	14620.289	8021.952	11504.041	0.04	0.06
CNN	13285.55	18647.398	10534.019	13679.973	0.052	0.067

DATASET : ELECTRICITY LOOKBACK = 10

Models	RMSE		MAE		MAPE	
	1step	3step	1step	3step	1step	3step
ARIMA	8131.122	9169.76	6538.924	7284.423	0.032	0.036
LSTM	9250.669	13849.569	7590.978	10728.728	0.037	0.053
CNN	14023.304	14820.829	10247.94	11580.361	0.05	0.057

TABLE 1 : EVALUATION ON ELECTRICITY DATASET

ARIMA consistently outperformed CNN and LSTM across various metrics (RMSE, MAPE, MSE) and prediction horizons for the dataset with linear trend and seasonality.

2. Results on Wind Energy Dataset

Properties: Trend: Non Linear, Seasonal: True

DATASET: WIND LOOKBACK=1

Models	RMSE		MAE		MAPE	
	1step	3step	1step	3step	1step	3step
ARIMA	4.362	-	3.2	-	0.229	-
LSTM	4.712	-	3.444	-	0.245	-
CNN	4.846	-	3.52	-	0.251	-

DATASET: WIND LOOKBACK=5

Models	RMSE		MAE		MAPE	
	1step	3step	1step	3step	1step	3step
ARIMA	4.246	4.726	3.142	3.579	0.219	0.257
LSTM	4.702	5.495	3.397	4.147	0.235	0.308
CNN	9.813	7.336	6.67	5.48	0.432	0.377

DATASET: WIND LOOKBACK=10

Models	RMSE		MAE		MAPE	
	1step	3step	1step	3step	1step	3step
ARIMA	4.272	4.722	3.168	3.59	0.222	0.259
LSTM	4.69	5.212	3.373	3.929	0.237	0.295
CNN	7.286	7.643	5.301	5.762	0.373	0.416

TABLE 2 : EVALUATION ON WIND ENERGY DATASET

ARIMA consistently outperformed CNN and LSTM across various metrics (RMSE, MAPE, MSE) and prediction horizons for the dataset with nonlinear trend and seasonality.

3. Results on Financial Dataset

Properties: Trend: Random, Seasonal: False

DATASET: FINANCIAL LOOKBACK=1

Models	RMSE		MAE		MAPE	
	1step	3step	1step	3step	1step	3step
ARIMA	2.348	-	1.597	-	0.023	-
LSTM	3.127	-	2.33	-	0.019	-
CNN	3.828	-	2.874	-	0.031	-

DATASET: FINANCIAL LOOKBACK=5

Models	RMSE		MAE		MAPE	
	1step	3step	1step	3step	1step	3step
ARIMA	2.376	3.075	1.597	2.164	0.023	0.032
LSTM	2.812	3.68	2.109	2.737	0.017	0.02
CNN	3.25	4.2	2.272	2.963	0.033	0.043

DATASET: FINANCIAL LOOKBACK=10

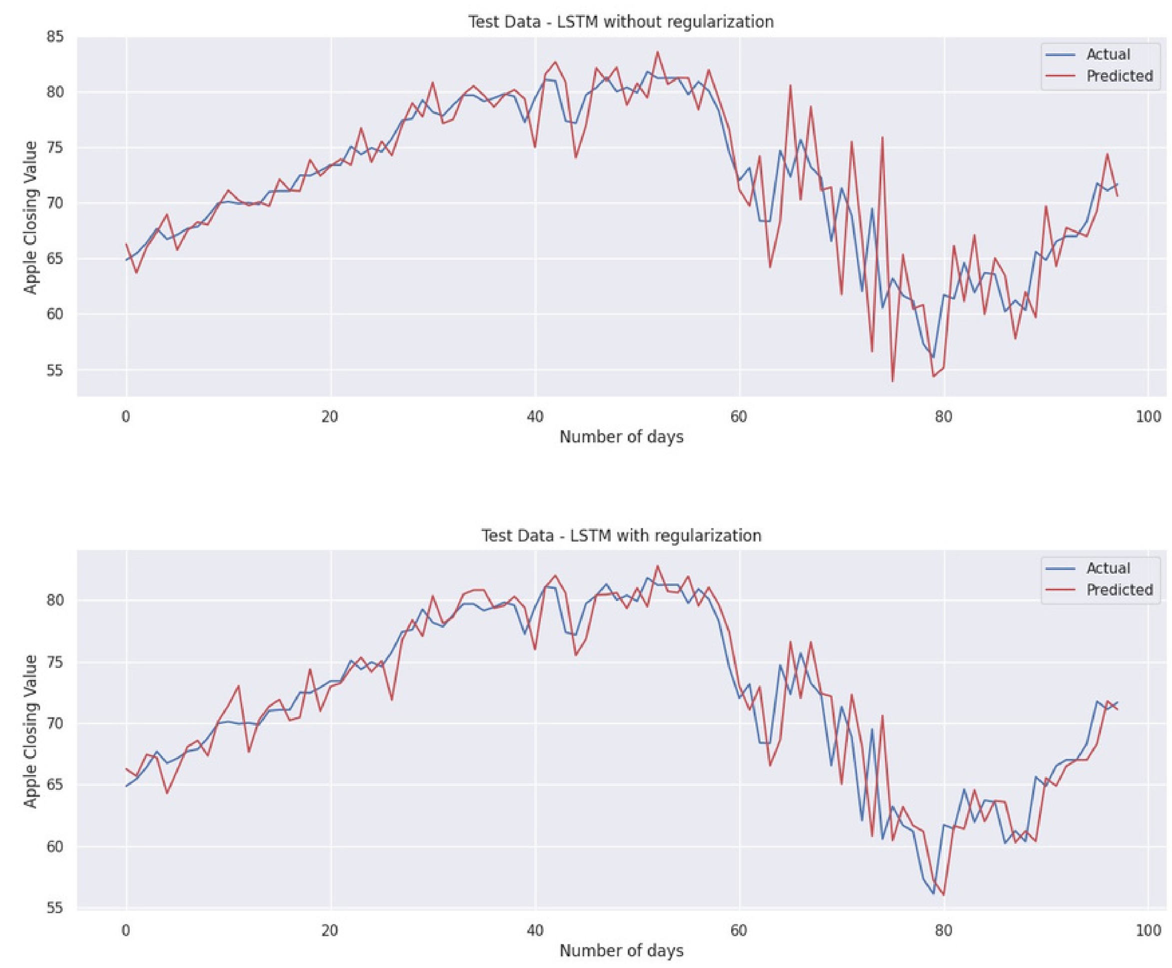
Models	RMSE		MAE		MAPE	
	1step	3step	1step	3step	1step	3step
ARIMA	2.277	2.967	1.562	2.164	0.023	0.032
LSTM	2.769	3.895	2.079	2.915	0.016	0.022
CNN	3.444	4.457	2.466	3.332	0.035	0.048

TABLE 3 : EVALUATION ON FINANCIAL DATASET

ARIMA outperformed LSTM and CNN in RMSE and MAE, yet, interestingly, LSTM exhibited a better MAPE score . This suggests that while LSTM produces predictions with a smaller average percentage error, occasional larger errors contribute to its higher RMSE.

Observation:

LSTM exhibits a better MAPE compared to ARIMA, but a poorer RMSE, suggesting potential overfitting. To address this, regularization is introduced for improved model stability



DATASET : FINANCIAL LOOKBACK = 1 FORECAST WINDOW = 1 STEP

	RMSE	MAE	MAPE
LSTM - Without Regularization	3.127	2.33	0.019
LSTM - With Regularization	2.636	1.883	0.018

TABLE 4: REGULARIZATION IN LSTM

CONCLUSION & FUTURE SCOPE

- ARIMA excelled in diverse datasets (linear, non-linear, random), consistently outperforming LSTM and CNN.
- CNNs excel at local patterns but struggle with time series' temporal nature, leading to inferior performance.
- LSTM surprisingly surpassed ARIMA in MAPE for random data, indicating occasional significant errors.
- Regularizing LSTM enhanced forecasting accuracy, mitigating substantial errors.
- Findings highlight the importance of selecting models tailored to specific data characteristics.
- Model refinement, such as regularization, proves crucial for improving predictive capabilities.
- Assess the influence of incorporating external factors on predictive accuracy in time series forecasting.