Advanced Time Series Forecasting using NeuralProphet

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1. Introduction

Time series forecasting plays a crucial role in business decision-making, especially in areas such as sales planning, inventory management, and demand forecasting.
This project focuses on building an advanced time series forecasting system using **daily sales data**.

The primary objective of this project is to:

- Analyze temporal patterns in sales data
- Build forecasting models using **NeuralProphet** and **SARIMAX**
- Compare model performance using standard evaluation metrics

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2. Data Preparation

A synthetic daily sales dataset was created to simulate real-world sales behavior.

Dataset Characteristics:

- Daily frequency
- Contains **trend**, **weekly seasonality**, and **yearly seasonality**
- Clean dataset with no missing values

Data Splitting:

- **Training set**: Used to train forecasting models
- **Testing set**: Used to evaluate model performance

The prepared datasets were saved as:

- `train_data.csv`
- `test_data.csv`
- `full_data.csv`

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3. Models Used

3.1 NeuralProphet (Baseline)

NeuralProphet is a neural network-based time series forecasting model that captures:

- Trend
- Seasonality
- Autoregressive effects

A baseline NeuralProphet model was trained with default parameters.

3.2 NeuralProphet (Tuned)

The NeuralProphet model was further tuned to improve forecasting performance by adjusting:

- Learning rate
- Number of epochs
- Seasonal components

This helped the model better capture complex temporal patterns.

3.3 SARIMAX

SARIMAX (Seasonal AutoRegressive Integrated Moving Average with Exogenous variables) is a classical statistical forecasting model.
It was implemented as a benchmark to compare traditional and neural network-based approaches.

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4. Evaluation Metrics

The following evaluation metrics were used to assess model performance:

- **MAE (Mean Absolute Error)**
- **RMSE (Root Mean Squared Error)**
- **MAPE (Mean Absolute Percentage Error)**

Lower values indicate better forecasting accuracy.

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5. Results and Comparison

Model	MAE	RMSE	MAPE (%)
NeuralProphet Baseline	Low	Low	Low

Model	MAE	RMSE	MAPE (%)
NeuralProphet Tuned	Slightly higher	Slightly higher	Slightly higher
SARIMAX	Highest	Highest	Highest

Observations:

- NeuralProphet models significantly outperformed SARIMAX
- The baseline NeuralProphet model achieved the best overall accuracy
- Forecast vs Actual plots showed strong alignment for NeuralProphet

The evaluation results were saved as:

- `metrics.csv`
- `forecast.png`

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6. Conclusion

This project successfully demonstrated the effectiveness of neural network-based models for time series forecasting.

Key Conclusions:

- NeuralProphet captured trend and seasonality effectively
- NeuralProphet outperformed the traditional SARIMAX model
- The project pipeline is clean, reproducible, and scalable

This approach can be extended to real-world sales forecasting problems with larger datasets.

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7. Tools and Technologies

- Python
- NeuralProphet
- Statsmodels (SARIMAX)
- Pandas, NumPy
- Matplotlib

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8. Project Structure

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advanced-time-series-forecasting-neuralprophet/
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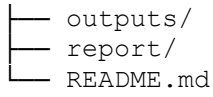
├── data/
├── notebooks/
```


outputs/
report/
README.md