03_sales_forecasting

October 23, 2025

1 Task 3: Sales Forecasting Using Time Series Analysis

Task Overview

Objective: Forecast the next 12 months of product sales using time series models.

Deliverables:

- Time series decomposition (trend, seasonality)
- ARIMA, Prophet or LSTM modeling
- Evaluation metrics (MAE, RMSE)
- Forecast visualizations

[41]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.model_selection import train_test_split
from statsmodels.tsa.seasonal import seasonal_decompose
```

[42]:
```
# Mock Data (Python):
date_range = pd.date_range(start='2020-01-01', periods=36, freq='M')
sales = np.random.poisson(lam=200, size=36) + np.linspace(0, 100, 36)
df = pd.DataFrame({'Date': date_range, 'Sales': sales.round(2)})
```

```
/tmp/ipykernel_478162/2065811994.py:2: FutureWarning:

'M' is deprecated and will be removed in a future version, please use 'ME'
instead.
```

[43]:
```
df.head(10)
```

[43]:

	Date	Sales
0	2020-01-31	182.00
1	2020-02-29	223.86
2	2020-03-31	200.71
3	2020-04-30	213.57
4	2020-05-31	220.43
5	2020-06-30	208.29

```
6 2020-07-31  214.14
7 2020-08-31  208.00
8 2020-09-30  219.86
9 2020-10-31  220.71
```

[44]:
```
df.info()
```

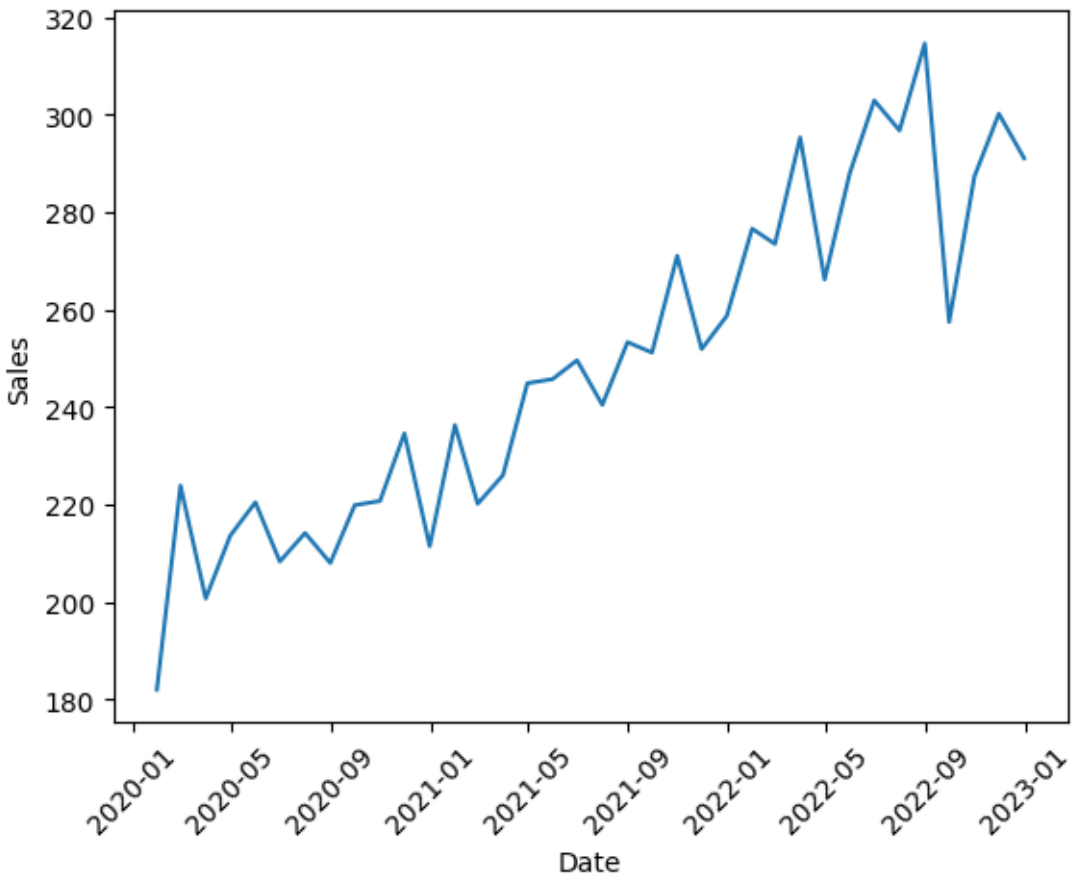
```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 36 entries, 0 to 35
Data columns (total 2 columns):
 #   Column  Non-Null Count  Dtype
---  ------  --------------  -----
 0   Date    36 non-null     datetime64[ns]
 1   Sales   36 non-null     float64
dtypes: datetime64[ns](1), float64(1)
memory usage: 704.0 bytes
```

[45]:
```
df.describe()
```

[45]:

	Date	Sales
count	36	36.000000
mean	2021-07-15 21:20:00	248.777778
min	2020-01-31 00:00:00	182.000000
25%	2020-10-23 06:00:00	220.357500
50%	2021-07-15 12:00:00	247.640000
75%	2022-04-07 12:00:00	274.215000
max	2022-12-31 00:00:00	314.570000
std	NaN	33.927472

[46]:
```
sns.lineplot(data=df, x="Date", y="Sales")
plt.xticks(rotation=45)
plt.show()
```



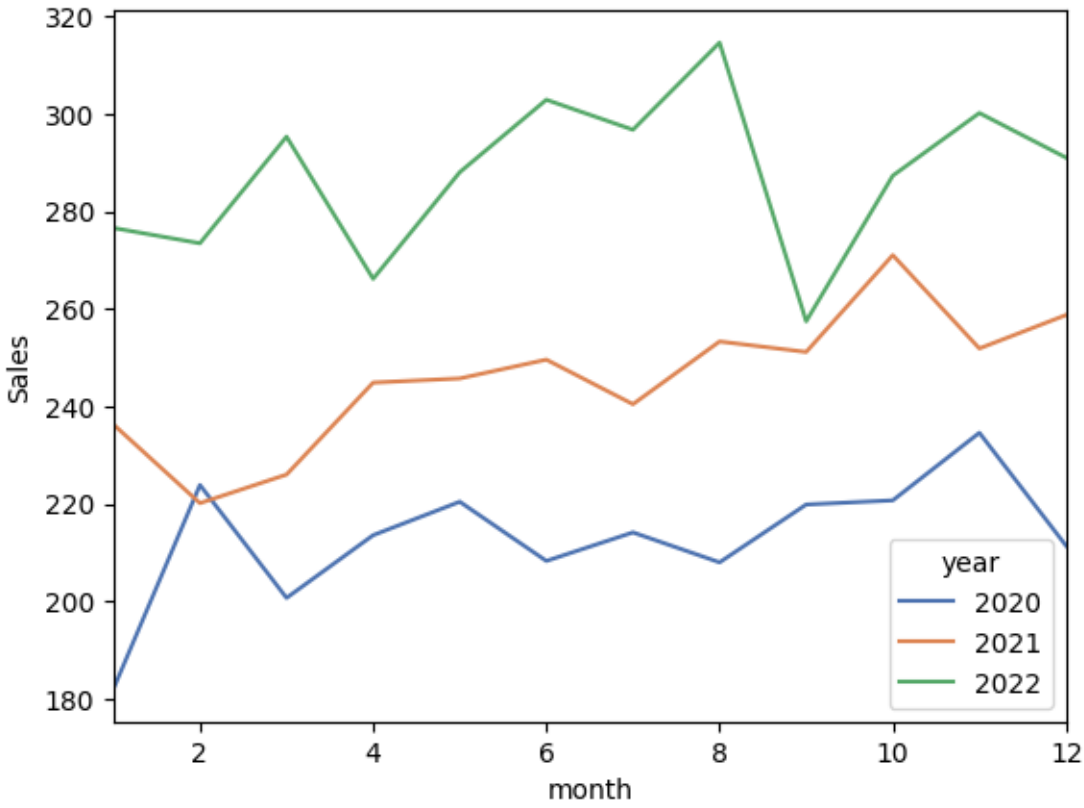
[47]:
```
df['year'] = df['Date'].dt.year
df['month'] = df['Date'].dt.month
```

[48]:
```
print(df['month'].unique())
print(df.year.unique())
```

```
[ 1  2  3  4  5  6  7  8  9 10 11 12]
[2020 2021 2022]
```

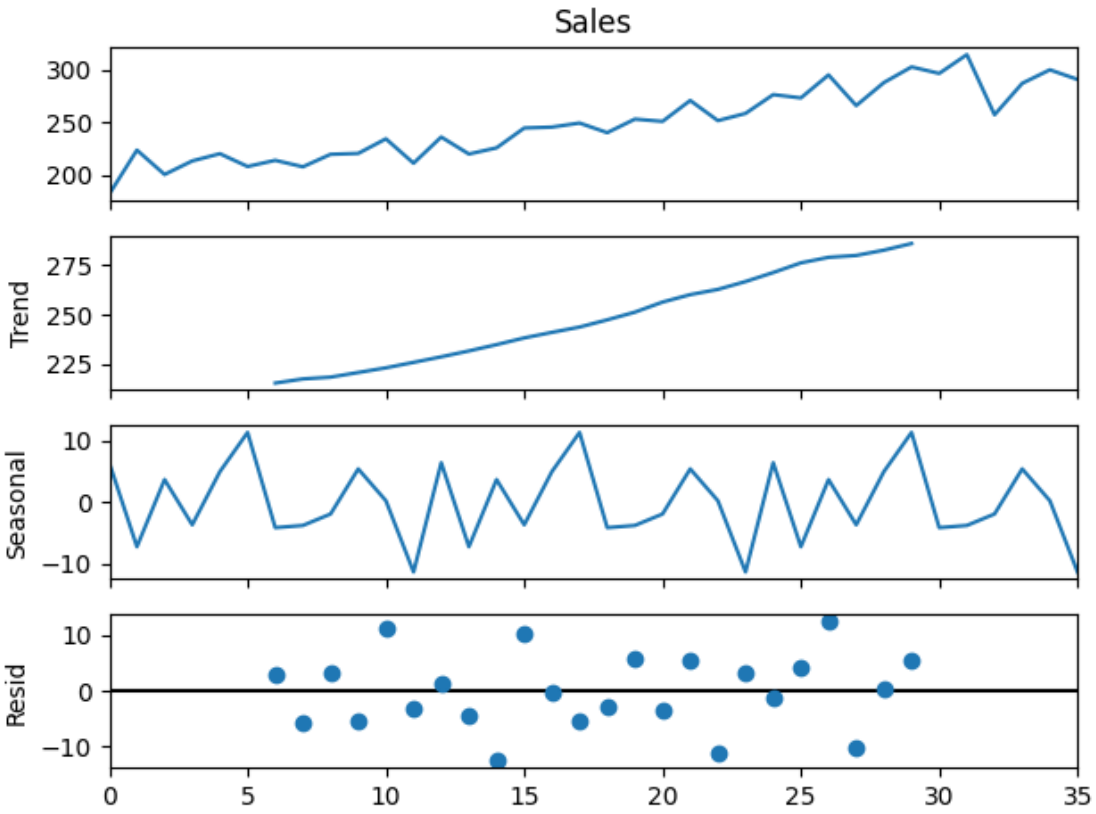
[49]:
```
# draw a line plot for each month
sns.lineplot(data=df, x="month", y="Sales", hue="year", palette='deep')
plt.xlim(1, 12)
```

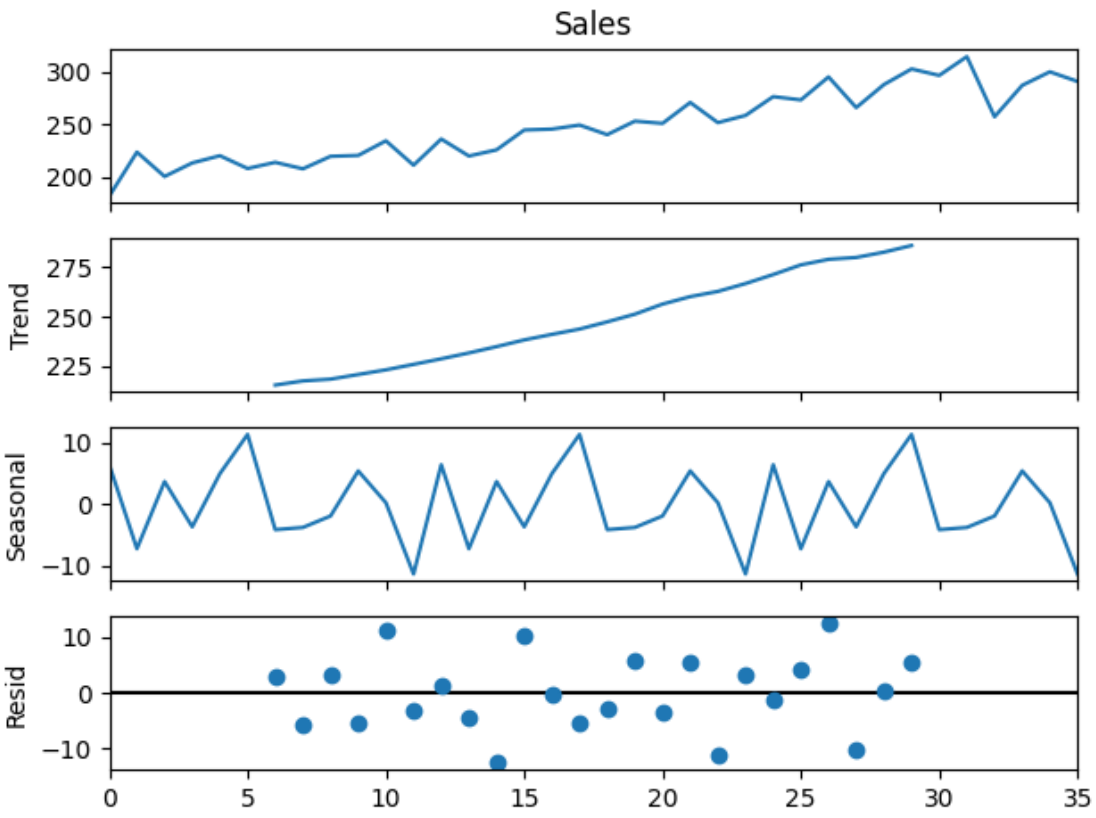
[49]: (1.0, 12.0)



[50]:
```
result = seasonal_decompose(df['Sales'], model='additive', period=12) # period for 1 year
result.plot()
```

[50]:


Sales
300
250
200
Trend
275
250
225
Seasonal
10
0
−10
Resid
10
0
−10
0
5
10
15
20
25
30
35



[51]:
```
# rename the columns
df = df.rename(columns={'Date':'ds', 'Sales': 'y'}) # prophet model take date as ds and target variable as y
df.head()
```

[51]:

	ds	y	year	month
0	2020-01-31	182.00	2020	1
1	2020-02-29	223.86	2020	2
2	2020-03-31	200.71	2020	3
3	2020-04-30	213.57	2020	4
4	2020-05-31	220.43	2020	5

[ ]:
```
from prophet import Prophet
from prophet.plot import plot_plotly

model = Prophet() # call the model
model.fit(df)

# make future dataframe and forecast
forecast = model.make_future_dataframe(periods=12, freq='M')  # forecast for 12 months
```

```
forecast = model.predict(forecast)
```

```
INFO    prophet:forecaster.py:parse_seasonality_args()- Disabling weekly
seasonality. Run prophet with weekly_seasonality=True to override this.
INFO    prophet:forecaster.py:parse_seasonality_args()- Disabling daily
seasonality. Run prophet with daily_seasonality=True to override this.
DEBUG   cmdstanpy:filesystem.py:_temp_single_json()- input tempfile:
/tmp/tmp56bic091/0dcoyy4r.json
DEBUG   cmdstanpy:filesystem.py:_temp_single_json()- input tempfile:
/tmp/tmp56bic091/6w4lfv28.json
DEBUG   cmdstanpy:model.py:_run_cmdstan()- idx 0
DEBUG   cmdstanpy:model.py:_run_cmdstan()- running CmdStan, num_threads: None
DEBUG   cmdstanpy:model.py:_run_cmdstan()- CmdStan args: ['/home/tk-
lpt-648/miniconda3/envs/data_analysis/lib/python3.10/site-
packages/prophet/stan_model/prophet_model.bin', 'random', 'seed=50775', 'data',
'file=/tmp/tmp56bic091/0dcoyy4r.json', 'init=/tmp/tmp56bic091/6w4lfv28.json',
'output',
'file=/tmp/tmp56bic091/prophet_modeli82mjpc1/prophet_model-20251001144505.csv',
'method=optimize', 'algorithm=newton', 'iter=10000']
14:45:05 - cmdstanpy - INFO - Chain [1] start processing
INFO    cmdstanpy:model.py:_run_cmdstan()- Chain [1] start processing
14:45:05 - cmdstanpy - INFO - Chain [1] done processing
INFO    cmdstanpy:model.py:_run_cmdstan()- Chain [1] done processing
/home/tk-lpt-648/miniconda3/envs/data_analysis/lib/python3.10/site-
packages/prophet/forecaster.py:1872: FutureWarning:

'M' is deprecated and will be removed in a future version, please use 'ME'
instead.
```

[66]:
```
forecast.tail()
```

[66]:

	ds	trend	yhat_lower	yhat_upper	trend_lower	trend_upper	\
43	2023-08-31	331.879207	350.776320	370.404424	331.663277	332.106804	
44	2023-09-30	334.956461	272.094432	291.079138	334.697064	335.229913	
45	2023-10-31	338.136291	324.271413	342.306453	337.822754	338.452744	
46	2023-11-30	341.213545	329.468711	349.015464	340.859587	341.579157	
47	2023-12-31	344.393375	336.810030	356.803024	343.992231	344.797360	

	additive_terms	additive_terms_lower	additive_terms_upper	yearly	\
43	28.792010	28.792010	28.792010	28.792010	
44	-53.785283	-53.785283	-53.785283	-53.785283	
45	-4.930613	-4.930613	-4.930613	-4.930613	
46	-1.755094	-1.755094	-1.755094	-1.755094	
47	2.892748	2.892748	2.892748	2.892748	

	yearly_lower	yearly_upper	multiplicative_terms	\

```
43     28.792010     28.792010                   0.0
44    -53.785283    -53.785283                   0.0
45     -4.930613     -4.930613                   0.0
46     -1.755094     -1.755094                   0.0
47      2.892748      2.892748                   0.0

    multiplicative_terms_lower  multiplicative_terms_upper        yhat
43                         0.0                         0.0  360.671217
44                         0.0                         0.0  281.171179
45                         0.0                         0.0  333.205678
46                         0.0                         0.0  339.458451
47                         0.0                         0.0  347.286123
```

[67]:
```
df.shape, forecast.shape # 36 + 12 = 48
```

[67]:
```
((36, 4), (48, 16))
```

[68]:
```
# calculate mean squared error
from sklearn.metrics import mean_squared_error, mean_absolute_error
y_true = df['y']
y_pred = forecast['yhat'][:len(y_true)]

print(f'Mean Squared Error: {mean_squared_error(y_true, y_pred):.2f}')
print("MAE: ", mean_absolute_error(y_true, y_pred))
print("RMSE: ", np.sqrt(mean_squared_error(y_true, y_pred)))
```

```
Mean Squared Error: 54.86
MAE:  6.100577729932693
RMSE:  7.406436716511218
```

[69]:
```
# plot the forecast
plot_plotly(model, forecast)
```