Bike Ride Sharing Project : Prophet

This project utilizes Facebook Prophet to forecast bike-sharing demand for the years 2011-2012 in Washington, DC. The model incorporates advanced techniques such as cross-validation, holiday adjustments, and hyperparameter tuning to ensure accurate and reliable predictions. By leveraging seasonal features, weather-based regressors, and robust evaluation metrics, the project aims to provide actionable insights into demand patterns for better resource planning and management.

Libraries and Data

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remount=True).
```

```
%cd /content/drive/MyDrive/Python - Time Series Forecasting/Modern Time Series Forecasting Techniques/Prophet
```

```
/content/drive/MyDrive/Python - Time Series Forecasting/Modern Time Series Forecasting Techniques/Prophet
```

```
# Libraries
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from statsmodels.graphics.tsaplots import month_plot, quarter_plot
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
from statsmodels.tsa.seasonal import seasonal_decompose
from sklearn.model_selection import ParameterGrid
```

```
# Loading the Data and Setting the Index
df = pd.read_csv("Daily Bike Sharing training.csv")
df.head()
```

	instant	dteday	season	yr	mnth	holiday	weekday	workingday	weathersit	temp	atemp	hum	windspeed	casual	regi
0	1	1/1/2011	1	0	1	0	6	0	2	0.344167	0.363625	0.805833	0.160446	331	
1	2	1/2/2011	1	0	1	0	0	0	2	0.363478	0.353739	0.696087	0.248539	131	
2	3	1/3/2011	1	0	1	0	1	1	1	0.196364	0.189405	0.437273	0.248309	120	
3	4	1/4/2011	1	0	1	0	2	1	1	0.200000	0.212122	0.590435	0.160296	108	
4	5	1/5/2011	1	0	1	0	3	1	1	0.226957	0.229270	0.436957	0.186900	82	

In Prophet, we don't convert date into index, but considers it as a column.

```
# Information about the Dataframe
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 701 entries, 0 to 700
Data columns (total 16 columns):
 #   Column      Non-Null Count  Dtype  
---  ------      --------------  -----  
 0   instant     701 non-null    int64  
 1   dteday      701 non-null    object 
 2   season      701 non-null    int64  
 3   yr          701 non-null    int64  
 4   mnth        701 non-null    int64  
 5   holiday     701 non-null    int64  
 6   weekday     701 non-null    int64  
 7   workingday  701 non-null    int64  
 8   weathersit  701 non-null    int64  
 9   temp        701 non-null    float64
 10  atemp       701 non-null    float64
 11  hum         701 non-null    float64
 12  windspeed   701 non-null    float64
 13  casual      701 non-null    int64  
 14  registered  701 non-null    int64  
 15  cnt         701 non-null    int64  
dtypes: float64(4), int64(11), object(1)
memory usage: 87.8+ KB
```

```
df = df.rename(columns = {'cnt' : 'y', 'dteday' : 'ds'})
df.head()
```

	instant	ds	season	yr	mnth	holiday	weekday	workingday	weathersit	temp	atemp	hum	windspeed	casual	regi
0	1	1/1/2011	1	0	1	0	6	0	2	0.344167	0.363625	0.805833	0.160446	331	
1	2	1/2/2011	1	0	1	0	0	0	2	0.363478	0.353739	0.696087	0.248539	131	
2	3	1/3/2011	1	0	1	0	1	1	1	0.196364	0.189405	0.437273	0.248309	120	
3	4	1/4/2011	1	0	1	0	2	1	1	0.200000	0.212122	0.590435	0.160296	108	
4	5	1/5/2011	1	0	1	0	3	1	1	0.226957	0.229270	0.436957	0.186900	82	

```
df['ds'] = pd.to_datetime(df['ds'])
```

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 701 entries, 0 to 700
Data columns (total 16 columns):
 #   Column      Non-Null Count  Dtype
---  ------      --------------  -----
 0   instant     701 non-null    int64
 1   ds          701 non-null    datetime64[ns]
 2   season      701 non-null    int64
 3   yr          701 non-null    int64
 4   mnth        701 non-null    int64
 5   holiday     701 non-null    int64
 6   weekday     701 non-null    int64
 7   workingday  701 non-null    int64
 8   weathersit  701 non-null    int64
 9   temp        701 non-null    float64
 10  atemp       701 non-null    float64
 11  hum         701 non-null    float64
 12  windspeed   701 non-null    float64
 13  casual      701 non-null    int64
 14  registered  701 non-null    int64
 15  y           701 non-null    int64
dtypes: datetime64[ns](1), float64(4), int64(11)
memory usage: 87.8 KB
```

```
# Prepare the weather situation Variable
weather_sit = pd.get_dummies(df['weathersit'], drop_first=True)
```

```
df = pd.concat([df,weather_sit], axis=1)
```

```
df.head()
```

	instant	ds	season	yr	mnth	holiday	weekday	workingday	weathersit	temp	atemp	hum	windspeed	casual	registe
0	1	2011-01-01	1	0	1	0	6	0	2	0.344167	0.363625	0.805833	0.160446	331	
1	2	2011-01-02	1	0	1	0	0	0	2	0.363478	0.353739	0.696087	0.248539	131	
2	3	2011-01-03	1	0	1	0	1	1	1	0.196364	0.189405	0.437273	0.248309	120	1
3	4	2011-01-04	1	0	1	0	2	1	1	0.200000	0.212122	0.590435	0.160296	108	1
4	5	2011-01-05	1	0	1	0	3	1	1	0.226957	0.229270	0.436957	0.186900	82	1

```
df = df.rename(columns = {2: 'weather_sit_2', 3 : 'weather_sit_3'})
```

```
df.drop(columns = ['instant', 'season','yr', 'mnth', 'weekday','casual','registered','weathersit', 'weekday'], inplace = True)
```

```
# Replace the value of 29th October 2012 with 28th October
to_replace = df.loc[df['ds'] == '2012-10-28'].y.values[0]
```

```
df[df.ds == '2012-10-29'].y.values[0] == to_replace
```

```
False
```

```
df.loc[df['ds'] == '2012-10-29','y'] = to_replace
df.loc[df['ds'] == '2012-10-30','y'] = to_replace
```

We are replacing the y value of 29th and 30th October, 2012, with the value on 28th October, to take care of the unusual event(Hurricane) on the 29th Oct, 2012.

```
df.loc[df.ds == '2012-10-30']
```

	ds	holiday	workingday	temp	atemp	hum	windspeed	y	weather_sit_2	weather_sit_3
668	2012-10-30	0	1	0.318182	0.309909	0.825455	0.213009	4459	True	False

Exploratory Data Analysis

[ ] ↳ 12 cells hidden

Holidays

```
df.head()
```

	ds	holiday	workingday	temp	atemp	hum	windspeed	y	weather_sit_2	weather_sit_3
0	2011-01-01	0	0	0.344167	0.363625	0.805833	0.160446	985	True	False
1	2011-01-02	0	0	0.363478	0.353739	0.696087	0.248539	801	True	False
2	2011-01-03	0	1	0.196364	0.189405	0.437273	0.248309	1349	False	False
3	2011-01-04	0	1	0.200000	0.212122	0.590435	0.160296	1562	False	False
4	2011-01-05	0	1	0.226957	0.229270	0.436957	0.186900	1600	False	False

```
# Check the holidays in our df
df[df['holiday'] == 1].ds
```

```
      ds
16    2011-01-17
51    2011-02-21
104   2011-04-15
149   2011-05-30
184   2011-07-04
247   2011-09-05
282   2011-10-10
314   2011-11-11
327   2011-11-24
359   2011-12-26
366   2012-01-02
380   2012-01-16
415   2012-02-20
471   2012-04-16
513   2012-05-28
550   2012-07-04
611   2012-09-03
646   2012-10-08
681   2012-11-12
691   2012-11-22

dtype: datetime64[ns]
```

```
gen_holidays = pd.DataFrame({'holiday' : 'gen_holi',
                             'ds' : df[df['holiday'] == 1].ds,
                             'lower_window' : -2,
                             'upper_window' : 2})

xmas = pd.DataFrame({'holiday': 'Christmas',
                     'ds' : pd.to_datetime(['2011-12-24','2012-12-24']),
                     'lower_window' : -5,
                     'upper_window' : 3})

nye = pd.DataFrame({'holiday': 'New Year',
                     'ds' : pd.to_datetime(['2011-12-31','2012-12-31']),
                     'lower_window' : -3,
                     'upper_window': 3})

easter = pd.DataFrame({'holiday': 'Easter',
                     'ds' : pd.to_datetime(['2011-04-24','2012-04-08']),
                      'lower_window' : -3,
                      'upper_window': 3})

holidays = pd.concat([gen_holidays, xmas, nye, easter])
```

```
holidays
```

	holiday	ds	lower_window	upper_window
16	gen_holi	2011-01-17	-2	2
51	gen_holi	2011-02-21	-2	2
104	gen_holi	2011-04-15	-2	2
149	gen_holi	2011-05-30	-2	2
184	gen_holi	2011-07-04	-2	2
247	gen_holi	2011-09-05	-2	2
282	gen_holi	2011-10-10	-2	2
314	gen_holi	2011-11-11	-2	2
327	gen_holi	2011-11-24	-2	2
359	gen_holi	2011-12-26	-2	2
366	gen_holi	2012-01-02	-2	2
380	gen_holi	2012-01-16	-2	2
415	gen_holi	2012-02-20	-2	2
471	gen_holi	2012-04-16	-2	2
513	gen_holi	2012-05-28	-2	2
550	gen_holi	2012-07-04	-2	2
611	gen_holi	2012-09-03	-2	2
646	gen_holi	2012-10-08	-2	2
681	gen_holi	2012-11-12	-2	2
691	gen_holi	2012-11-22	-2	2
0	Christmas	2011-12-24	-5	3
1	Christmas	2012-12-24	-5	3
0	New Year	2011-12-31	-3	3
1	New Year	2012-12-31	-3	3
0	Easter	2011-04-24	-3	3
1	Easter	2012-04-08	-3	3

Feature Engineering

```
# Thought process
# A person might take decision of renting a bike tomorrow, based on today's  weather.
```

```
for lag in [1,2,3,4,5,6,7]:
  df[f'temp_lag_{lag}'] = df['temp'].shift(lag)
  df[f'atemp_lag_{lag}'] = df['atemp'].shift(lag)
```

```
df.corr()
```

Show hidden output

```
df = df.iloc[:,:11]
df.head()
```

	ds	holiday	workingday	temp	atemp	hum	windspeed	y	weather_sit_2	weather_sit_3	temp_lag_1
0	2011-01-01	0	0	0.344167	0.363625	0.805833	0.160446	985	True	False	NaN
1	2011-01-02	0	0	0.363478	0.353739	0.696087	0.248539	801	True	False	0.344167
2	2011-01-03	0	1	0.196364	0.189405	0.437273	0.248309	1349	False	False	0.363478
3	2011-01-04	0	1	0.200000	0.212122	0.590435	0.160296	1562	False	False	0.196364
4	2011-01-05	0	1	0.226957	0.229270	0.436957	0.186900	1600	False	False	0.200000

Prophet Model

```
df.head(1)
```

	ds	holiday	workingday	temp	atemp	hum	windspeed	y	weather_sit_2	weather_sit_3	temp_lag_1
0	2011-01-01	0	0	0.344167	0.363625	0.805833	0.160446	985	True	False	NaN

```
# Remove any NAs
df = df.dropna()
```

```
from prophet import Prophet
```

```
# Building the Prophet Model
m = Prophet(yearly_seasonality=True,
            weekly_seasonality=True,
            daily_seasonality=True,
            holidays = holidays,
            seasonality_mode='multiplicative',
            seasonality_prior_scale= 10,
            holidays_prior_scale= 10,
            changepoint_prior_scale= 0.05)

m.add_regressor('workingday')
m.add_regressor('temp')
m.add_regressor('atemp')
m.add_regressor('hum')
m.add_regressor('windspeed')
m.add_regressor('weather_sit_2')
m.add_regressor('weather_sit_3')
m.add_regressor('temp_lag_1')

m.fit(df)
```

```
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/kiv1co7n.json
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/lki05ncw.json
DEBUG:cmdstanpy:idx 0
DEBUG:cmdstanpy:running CmdStan, num_threads: None
DEBUG:cmdstanpy:CmdStan args: ['/usr/local/lib/python3.11/dist-packages/prophet/stan_model/prophet_model.bin', 'random', 'seed=7941
12:37:38 - cmdstanpy - INFO - Chain [1] start processing
INFO:cmdstanpy:Chain [1] start processing
12:37:38 - cmdstanpy - INFO - Chain [1] done processing
INFO:cmdstanpy:Chain [1] done processing
<prophet.forecaster.Prophet at 0x78f2651564d0>
```

```
# Regressor Coefficients

from prophet.utilities import regressor_coefficients
regressor_coefficients(m)
```

	regressor	regressor_mode	center	coef_lower	coef	coef_upper
0	workingday	multiplicative	0.000000	0.142201	0.142201	0.142201
1	temp	multiplicative	0.502959	1.561403	1.561403	1.561403
2	atemp	multiplicative	0.481015	0.604339	0.604339	0.604339
3	hum	multiplicative	0.625459	-0.609555	-0.609555	-0.609555
4	windspeed	multiplicative	0.190577	-0.846086	-0.846086	-0.846086
5	weather_sit_2	multiplicative	0.000000	-0.157436	-0.157436	-0.157436
6	weather_sit_3	multiplicative	0.000000	-0.622127	-0.622127	-0.622127
7	temp_lag_1	multiplicative	0.503024	-0.838133	-0.838133	-0.838133

```
# Function to interpret the coefficient results
def interpret_prophet_coefficients(df):
    interpretations = []

    # Iterate through each row in the DataFrame 'df'
    for _, row in df.iterrows():
        regressor = row['regressor']  # Get the regressor name
        mode = row['regressor_mode']  # Get the regressor mode (multiplicative or additive)
        coef = row['coef']  # Get the coefficient value
        effect_type = 'increase' if coef > 0 else 'decrease'  # Determine if the effect is an increase or decrease

        # Generate interpretation based on the regressor mode
        if mode == 'multiplicative':
            interpretation = f"For each unit increase in {regressor}, the target variable is expected to {effect_type} by {abs(coef) * 1
        elif mode == 'additive':
            interpretation = f"For each unit increase in {regressor}, the target variable changes by {coef:.2f} units (additively)."
        else:
            interpretation = f"Regressor {regressor} has an unrecognized mode '{mode}'."

        interpretations.append(interpretation)

    return interpretations

coefs = pd.DataFrame(regressor_coefficients(m))  # Get regressor coefficients from the Prophet model
interpretations = interpret_prophet_coefficients(coefs) # Generate interpretations based on coefficients

# Print each interpretation
for interpretation in interpretations:
    print(interpretation)
```

```
For each unit increase in workingday, the target variable is expected to increase by 14.22% (multiplicatively).
For each unit increase in temp, the target variable is expected to increase by 156.14% (multiplicatively).
For each unit increase in atemp, the target variable is expected to increase by 60.43% (multiplicatively).
For each unit increase in hum, the target variable is expected to decrease by 60.96% (multiplicatively).
For each unit increase in windspeed, the target variable is expected to decrease by 84.61% (multiplicatively).
For each unit increase in weather_sit_2, the target variable is expected to decrease by 15.74% (multiplicatively).
For each unit increase in weather_sit_3, the target variable is expected to decrease by 62.21% (multiplicatively).
For each unit increase in temp_lag_1, the target variable is expected to decrease by 83.81% (multiplicatively).
```

Cross Validation

```
from prophet.diagnostics import cross_validation
```

```
df.shape[0] - 180
```

```
520
```

```
# Apply CV to the Model
df_cv = cross_validation(model=m,
                         horizon = '30 days',
                         period = '15 days',
                         initial = '521 days',
                         parallel = 'processes')

df_cv.head()
```

```
INFO:prophet:Making 10 forecasts with cutoffs between 2012-06-19 00:00:00 and 2012-11-01 00:00:00
INFO:prophet:Applying in parallel with <concurrent.futures.process.ProcessPoolExecutor object at 0x78f26534f3d0>
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/cfld6p96.json
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/d6daw3yn.json
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/xw6wb7z1.json
DEBUG:cmdstanpy:idx 0
DEBUG:cmdstanpy:running CmdStan, num_threads: None
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/7i3ju91g.json
DEBUG:cmdstanpy:CmdStan args: ['/usr/local/lib/python3.11/dist-packages/prophet/stan_model/prophet_model.bin', 'random', 'seed=5173
DEBUG:cmdstanpy:idx 0
12:37:39 - cmdstanpy - INFO - Chain [1] start processing
DEBUG:cmdstanpy:running CmdStan, num_threads: None
INFO:cmdstanpy:Chain [1] start processing
DEBUG:cmdstanpy:CmdStan args: ['/usr/local/lib/python3.11/dist-packages/prophet/stan_model/prophet_model.bin', 'random', 'seed=7435
12:37:39 - cmdstanpy - INFO - Chain [1] start processing
INFO:cmdstanpy:Chain [1] start processing
12:37:39 - cmdstanpy - INFO - Chain [1] done processing
INFO:cmdstanpy:Chain [1] done processing
12:37:39 - cmdstanpy - INFO - Chain [1] done processing
INFO:cmdstanpy:Chain [1] done processing
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/hbfiov33.json
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/cmfmvxqu.json
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/97v5sw3x.json
DEBUG:cmdstanpy:idx 0
DEBUG:cmdstanpy:running CmdStan, num_threads: None
DEBUG:cmdstanpy:CmdStan args: ['/usr/local/lib/python3.11/dist-packages/prophet/stan_model/prophet_model.bin', 'random', 'seed=2288
12:37:39 - cmdstanpy - INFO - Chain [1] start processing
INFO:cmdstanpy:Chain [1] start processing
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/an8o5pj_.json
DEBUG:cmdstanpy:idx 0
DEBUG:cmdstanpy:running CmdStan, num_threads: None
DEBUG:cmdstanpy:CmdStan args: ['/usr/local/lib/python3.11/dist-packages/prophet/stan_model/prophet_model.bin', 'random', 'seed=7039
12:37:40 - cmdstanpy - INFO - Chain [1] start processing
INFO:cmdstanpy:Chain [1] start processing
12:37:40 - cmdstanpy - INFO - Chain [1] done processing
INFO:cmdstanpy:Chain [1] done processing
12:37:40 - cmdstanpy - INFO - Chain [1] done processing
INFO:cmdstanpy:Chain [1] done processing
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/96l0ybqv.json
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/4jsmo0pp.json
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/t9ye1qpy.json
DEBUG:cmdstanpy:idx 0
DEBUG:cmdstanpy:running CmdStan, num_threads: None
DEBUG:cmdstanpy:CmdStan args: ['/usr/local/lib/python3.11/dist-packages/prophet/stan_model/prophet_model.bin', 'random', 'seed=5983
12:37:40 - cmdstanpy - INFO - Chain [1] start processing
INFO:cmdstanpy:Chain [1] start processing
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/x2xnm80p.json
DEBUG:cmdstanpy:idx 0
DEBUG:cmdstanpy:running CmdStan, num_threads: None
DEBUG:cmdstanpy:CmdStan args: ['/usr/local/lib/python3.11/dist-packages/prophet/stan_model/prophet_model.bin', 'random', 'seed=4984
12:37:40 - cmdstanpy - INFO - Chain [1] start processing
INFO:cmdstanpy:Chain [1] start processing
12:37:41 - cmdstanpy - INFO - Chain [1] done processing
INFO:cmdstanpy:Chain [1] done processing
12:37:41 - cmdstanpy - INFO - Chain [1] done processing
INFO:cmdstanpy:Chain [1] done processing
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/gawq_km5.json
```

```python
# Look at the CV output
df_cv.head()
```

```
DEBUG:cmdstanpy:running CmdStan, num_threads: None
DEBUG:cmdstanpy:CmdStan args: ['/usr/local/lib/python3.11/dist-packages/prophet/stan_model/prophet_model.bin', 'random', 'seed=4003
12:37:41 - cmdstanpy - INFO - Chain [1] start processing
DEBUG:cmdstanpy:idx 0
DEBUG:cmdstanpy:running CmdStan, num_threads: None
ges/prophet/stan_model/prophet_model.bin', 'random', 'seed=1953
12:37:41 - cmdstanpy - INFO - Chain [1] start processing
INFO:cmdstanpy:Chain [1] start processing
12:37:42 - cmdstanpy - INFO - Chain [1] done processing
```

	ds	yhat	yhat_lower	yhat_upper	y	cutoff
0	2012-06-20	8203.392863	7525.190257	8847.238097	6211	2012-06-19
1	2012-06-21	8484.764223	7763.428546	9241.957433	5905	2012-06-19
2	2012-06-22	8112.815958	7368.109625	8797.406645	5823	2012-06-19
3	2012-06-23	7718.436442	7018.882716	8399.984570	7458	2012-06-19
4	2012-06-24	7868.306390	7166.928654	8529.135921	6891	2012-06-19

```python
from prophet.diagnostics import performance_metrics
```

```
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/5m_0fpmf.json
```

```python
performance_metrics(df_cv)
```

```
DEBUG:cmdstanpy:running CmdStan, num_threads: None
DEBUG:cmdstanpy:CmdStan args: ['/usr/local/lib/python3.11/dist-packages/prophet/stan_model/prophet_model.bin', 'random', 'seed=6272
12:37:42 - cmdstanpy - INFO - Chain [1] start processing
INFO:cmdstanpy:Chain [1] start processing
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/qjl7s34r.json
DEBUG:cmdstanpy:idx 0
DEBUG:cmdstanpy:running CmdStan, num_threads: None
DEBUG:cmdstanpy:CmdStan args: ['/usr/local/lib/python3.11/dist-packages/prophet/stan_model/prophet_model.bin', 'random', 'seed=6682
12:37:42 - cmdstanpy - INFO - Chain [1] start processing
INFO:cmdstanpy:Chain [1] start processing
12:37:42 - cmdstanpy - INFO - Chain [1] done processing
INFO:cmdstanpy:Chain [1] done processing
```

```
12:37:42 - cmdstanpy - INFO - Chain [1] done processing
INFO:cmdstanpy:Chain [1] done processing
```

```
0  2012-06-20  8203.392863  7525.190257  8847.238097  6211  2012-06-19
2  2012-06-22  8112.815958  7368.109625  8797.406645  5823  2012-06-19
4  2012-06-24  7868.306390  7166.928654  8529.125921  6891  2012-06-19
```

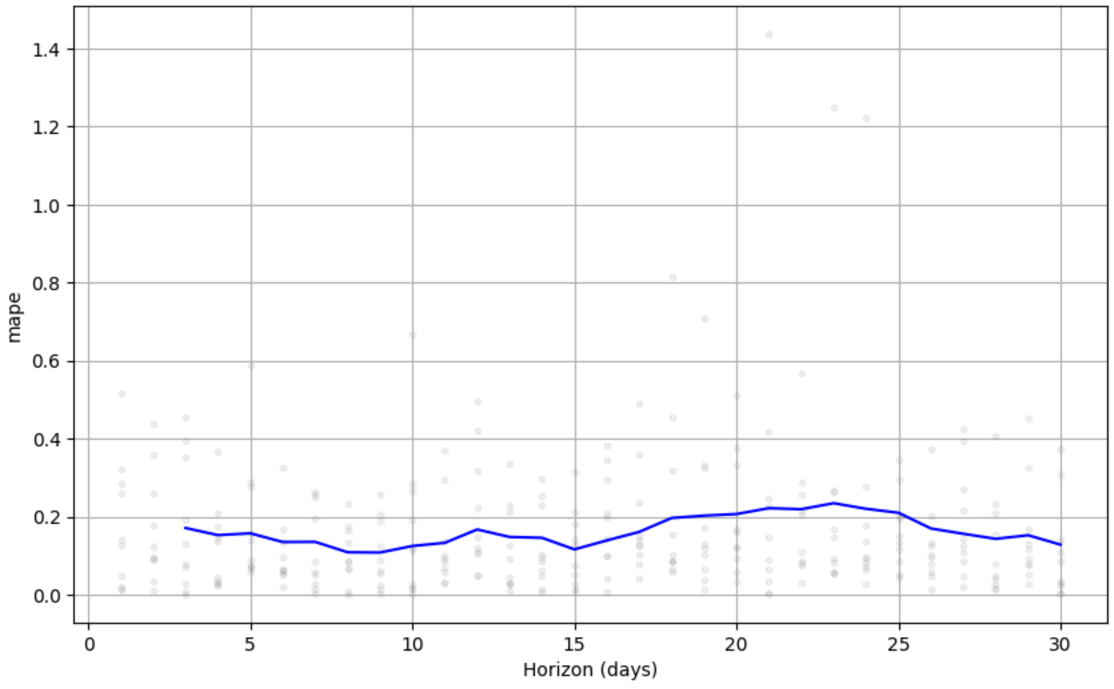
	horizon	mse	rmse	mae	mape	mdape	smape	coverage
0	3 days	1.573677e+06	1254.462721	969.389523	0.171172	0.125322	0.162184	0.500000
1	4 days	1.388489e+06	1178.341516	906.660100	0.152929	0.109979	0.148148	0.533333
2	5 days	1.473163e+06	1213.739133	958.955343	0.157498	0.109521	0.153140	0.500000
3	6 days	1.180663e+06	1086.583053	863.924277	0.135286	0.081196	0.136659	0.566667
4	7 days	1.301757e+06	1140.945611	894.008085	0.135583	0.081180	0.140020	0.600000
5	8 days	1.029205e+06	1014.497408	773.447326	0.109022	0.075934	0.116939	0.633333
6	9 days	9.722975e+05	986.051449	765.225859	0.108304	0.085255	0.114686	0.600000
7	10 days	1.370797e+06	1170.810336	856.152994	0.125013	0.088142	0.127640	0.566667
8	11 days	1.475688e+06	1214.778792	885.325590	0.133176	0.091222	0.133814	0.566667
9	12 days	1.920275e+06	1385.739982	1062.168952	0.167342	0.111737	0.170757	0.466667
10	13 days	1.559523e+06	1248.808806	965.826694	0.148161	0.102608	0.155738	0.500000
11	14 days	1.581995e+06	1257.774005	969.057523	0.146019	0.104937	0.155484	0.533333
12	15 days	1.200756e+06	1095.790002	809.993844	0.116330	0.089214	0.124780	0.633333
13	16 days	1.261055e+06	1122.967207	883.399028	0.139345	0.101834	0.145314	0.566667
14	17 days	1.371567e+06	1171.139074	957.653437	0.161188	0.133430	0.168358	0.500000
15	18 days	2.166931e+06	1472.049779	1157.018586	0.196822	0.133724	0.199518	0.533333
16	19 days	2.527280e+06	1589.742101	1225.718956	0.202810	0.126800	0.204160	0.566667
17	20 days	2.772082e+06	1664.957165	1290.907463	0.206924	0.122046	0.207115	0.500000
18	21 days	2.682781e+06	1637.919867	1256.139227	0.221912	0.127223	0.209482	0.433333
19	22 days	2.405493e+06	1550.965048	1218.461413	0.219295	0.135178	0.207292	0.433333
20	23 days	2.265223e+06	1505.065893	1173.829661	0.234702	0.127327	0.208278	0.466667
21	24 days	1.746259e+06	1321.461107	1087.733061	0.220342	0.101923	0.195105	0.500000
22	25 days	1.663743e+06	1289.861702	1074.238667	0.210141	0.125205	0.189394	0.433333
23	26 days	1.458049e+06	1207.497150	983.736184	0.169947	0.110960	0.165658	0.500000
24	27 days	1.610601e+06	1269.094507	1036.502805	0.156305	0.126050	0.174236	0.466667
25	28 days	1.678686e+06	1295.641102	971.679026	0.143358	0.106755	0.162417	0.600000
26	29 days	1.915873e+06	1384.150520	1033.672523	0.152601	0.112158	0.173430	0.600000
27	30 days	1.708436e+06	1307.071533	901.569447	0.128441	0.082003	0.144500	0.666667

```python
rmse = round(performance_metrics(df_cv)['rmse'].mean(),2)
print(f'RMSE : {rmse}')
mape = round(performance_metrics(df_cv)['mape'].mean()*100,3)
print(f'MAPE : {mape}%')
```

```
RMSE : 1287.07
MAPE : 16.321%
```

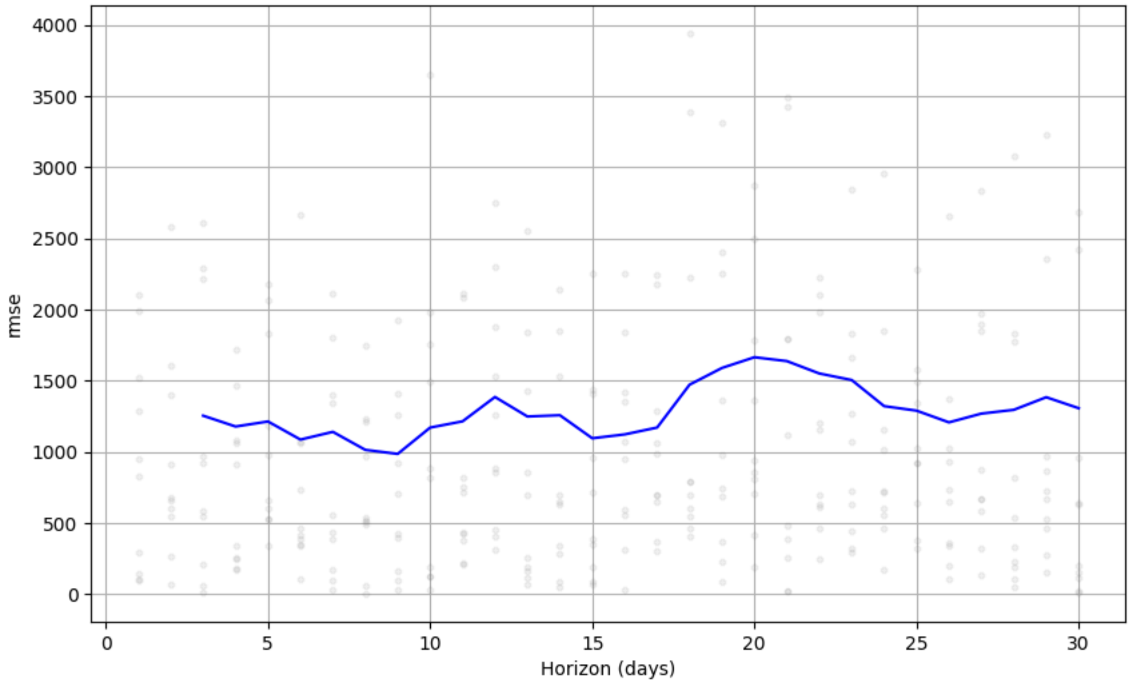
```python
# Plotting the metrics over time
from prophet.plot import plot_cross_validation_metric
fig = plot_cross_validation_metric(df_cv, metric='mape')
fig.show()
```

```
/usr/local/lib/python3.11/dist-packages/prophet/plot.py:546: FutureWarning: Series.view is deprecated and will be removed in a futur
  x_plt = df_none['horizon'].astype('timedelta64[ns]').view(np.int64) / float(dt_conversions[i])
/usr/local/lib/python3.11/dist-packages/prophet/plot.py:547: FutureWarning: Series.view is deprecated and will be removed in a futur
  x_plt_h = df_h['horizon'].astype('timedelta64[ns]').view(np.int64) / float(dt_conversions[i])
```



```
# Plotting the metrics over time
from prophet.plot import plot_cross_validation_metric
fig = plot_cross_validation_metric(df_cv, metric='rmse')
fig.show()
```

```
/usr/local/lib/python3.11/dist-packages/prophet/plot.py:546: FutureWarning: Series.view is deprecated and will be removed in a futur
  x_plt = df_none['horizon'].astype('timedelta64[ns]').view(np.int64) / float(dt_conversions[i])
/usr/local/lib/python3.11/dist-packages/prophet/plot.py:547: FutureWarning: Series.view is deprecated and will be removed in a futur
  x_plt_h = df_h['horizon'].astype('timedelta64[ns]').view(np.int64) / float(dt_conversions[i])
```



Exploring the Error

```
df_cv['deviation'] = df_cv['yhat'] - df_cv['y']
df_cv['deviation%'] = (df_cv['deviation'] / df_cv['y'] - 1)*100
```

```
df_cv.sort_values(by = 'deviation%', ascending = False).head(10)
```

	ds	yhat	yhat_lower	yhat_upper	y	cutoff	deviation	deviation%
290	2012-11-22	5912.573506	5124.330978	6757.046756	2425	2012-11-01	3487.573506	43.817464
292	2012-11-24	5122.346211	4292.348905	5899.621466	2277	2012-11-01	2845.346211	24.960308
293	2012-11-25	5381.559704	4588.507096	6227.299682	2424	2012-11-01	2957.559704	22.011539
17	2012-07-07	8782.396220	8098.628905	9507.379331	4840	2012-06-19	3942.396220	-18.545533
18	2012-07-08	7987.885432	7344.396128	8692.483357	4672	2012-06-19	3315.885432	-29.026425
9	2012-06-29	9113.938217	8455.959744	9814.678539	5463	2012-06-19	3650.938217	-33.169720
214	2012-10-07	5578.202053	4806.171230	6376.454385	3510	2012-10-02	2068.202053	-41.076865
291	2012-11-23	6136.910990	5391.363873	6932.500086	3910	2012-11-01	2226.910990	-43.045755
180	2012-09-18	6179.586725	5419.394910	6967.456884	4073	2012-09-17	2106.586725	-48.279236
199	2012-10-07	5298.043962	4512.508565	6068.623166	3510	2012-09-17	1788.043962	-49.058577

```
df_cv.sort_values(by = 'deviation%', ascending = True).head(10)
```

Show hidden output

Paramter Tuning

```
# Define the paramter grid to search
param_grid = {
    'changepoint_prior_scale': [0.05, 0.1, 0.5],
    'seasonality_prior_scale':[5,10, 20],
    'holidays_prior_scale':[5, 10, 20],
    'seasonality_mode': ['additive', 'multiplicative']
}


# Generate all combinations of Parameter
all_params = list(ParameterGrid(param_grid))


# Placeholder for storing the results
tuning_results = []

# Build a pipeline for parameter tuning
for params in all_params:
  # Build the model
  m = Prophet(yearly_seasonality=True,
              weekly_seasonality=True,
              daily_seasonality=True,
              holidays = holidays,
              **params)

  m.add_regressor('workingday')
  m.add_regressor('temp')
  m.add_regressor('atemp')
  m.add_regressor('hum')
  m.add_regressor('windspeed')
  m.add_regressor('weather_sit_2')
  m.add_regressor('weather_sit_3')
  m.add_regressor('temp_lag_1')

  m.fit(df)

  # Cross Validation

  df_cv = cross_validation(model=m,
                           initial = '521 days',
                           horizon = '15 days',
                           period = '30 days',
                           parallel = 'processes')

  # Compute and store the error

  rmse = performance_metrics(df_cv)['rmse'].mean()
  tuning_results.append(rmse)
```

```
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/n56td3td.json
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/1mp5lmh7.json
DEBUG:cmdstanpy:idx 0
DEBUG:cmdstanpy:running CmdStan, num_threads: None
```

```
DEBUG:cmdstanpy:CmdStan args: ['/usr/local/lib/python3.11/dist-packages/prophet/stan_model/prophet_model.bin', 'random', 'seed=82
12:37:44 - cmdstanpy - INFO - Chain [1] start processing
INFO:cmdstanpy:Chain [1] start processing
12:37:44 - cmdstanpy - INFO - Chain [1] done processing
INFO:cmdstanpy:Chain [1] done processing
INFO:prophet:Making 6 forecasts with cutoffs between 2012-06-19 00:00:00 and 2012-11-16 00:00:00
INFO:prophet:Applying in parallel with <concurrent.futures.process.ProcessPoolExecutor object at 0x78f26181a590>
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/6nrq4oyt.json
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/zpucwob_.json
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/esd92ibh.json
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/jevz94sh.json
DEBUG:cmdstanpy:idx 0
DEBUG:cmdstanpy:running CmdStan, num_threads: None
DEBUG:cmdstanpy:CmdStan args: ['/usr/local/lib/python3.11/dist-packages/prophet/stan_model/prophet_model.bin', 'random', 'seed=26
12:37:44 - cmdstanpy - INFO - Chain [1] start processing
INFO:cmdstanpy:Chain [1] start processing
DEBUG:cmdstanpy:idx 0
DEBUG:cmdstanpy:running CmdStan, num_threads: None
DEBUG:cmdstanpy:CmdStan args: ['/usr/local/lib/python3.11/dist-packages/prophet/stan_model/prophet_model.bin', 'random', 'seed=37
12:37:44 - cmdstanpy - INFO - Chain [1] start processing
INFO:cmdstanpy:Chain [1] start processing
12:37:44 - cmdstanpy - INFO - Chain [1] done processing
INFO:cmdstanpy:Chain [1] done processing
12:37:44 - cmdstanpy - INFO - Chain [1] done processing
INFO:cmdstanpy:Chain [1] done processing
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/4yeffv8d.json
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/zmwvgp1u.json
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/z6qim1ny.json
DEBUG:cmdstanpy:idx 0
DEBUG:cmdstanpy:running CmdStan, num_threads: None
DEBUG:cmdstanpy:CmdStan args: ['/usr/local/lib/python3.11/dist-packages/prophet/stan_model/prophet_model.bin', 'random', 'seed=48
12:37:45 - cmdstanpy - INFO - Chain [1] start processing
INFO:cmdstanpy:Chain [1] start processing
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/htdbn7ks.json
DEBUG:cmdstanpy:idx 0
DEBUG:cmdstanpy:running CmdStan, num_threads: None
DEBUG:cmdstanpy:CmdStan args: ['/usr/local/lib/python3.11/dist-packages/prophet/stan_model/prophet_model.bin', 'random', 'seed=97
12:37:45 - cmdstanpy - INFO - Chain [1] start processing
INFO:cmdstanpy:Chain [1] start processing
12:37:45 - cmdstanpy - INFO - Chain [1] done processing
INFO:cmdstanpy:Chain [1] done processing
12:37:45 - cmdstanpy - INFO - Chain [1] done processing
INFO:cmdstanpy:Chain [1] done processing
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/reg0si1p.json
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/r_lz_tq1.json
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/48yk4zfg.json
DEBUG:cmdstanpy:idx 0
DEBUG:cmdstanpy:running CmdStan, num_threads: None
DEBUG:cmdstanpy:CmdStan args: ['/usr/local/lib/python3.11/dist-packages/prophet/stan_model/prophet_model.bin', 'random', 'seed=59
12:37:46 - cmdstanpy - INFO - Chain [1] start processing
INFO:cmdstanpy:Chain [1] start processing
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/7fqmei3q.json
DEBUG:cmdstanpy:idx 0
```

```
# Outcome of the Parameter Tuning
outcome = pd.DataFrame(all_params)
outcome.head()
```

	changepoint_prior_scale	holidays_prior_scale	seasonality_mode	seasonality_prior_scale
0	0.05	5	additive	5
1	0.05	5	additive	10
2	0.05	5	additive	20
3	0.05	5	multiplicative	5
4	0.05	5	multiplicative	10

```
outcome['tuning_results'] = tuning_results
```

```
outcome.sort_values(by = 'tuning_results', ascending = True).head(10)
```

	changepoint_prior_scale	holidays_prior_scale	seasonality_mode	seasonality_prior_scale	tuning_results
12	0.05	20	additive	5	1103.756959
6	0.05	10	additive	5	1104.748261
0	0.05	5	additive	5	1105.384277
1	0.05	5	additive	10	1106.076239
7	0.05	10	additive	10	1107.431737
8	0.05	10	additive	20	1108.131706
13	0.05	20	additive	10	1111.029155
2	0.05	5	additive	20	1111.166837
14	0.05	20	additive	20	1111.227858
24	0.10	10	additive	5	1154.809691

```
# Fetch the best Parameters
best_params = outcome.sort_values(by = 'tuning_results', ascending = True).iloc[0]
```

```
best_params = all_params[tuning_results.index(min(tuning_results))]
```

Predicting the Future

Data Preparation

```
# Loading the Data and Setting the Index
df_train = pd.read_csv("Daily Bike Sharing training.csv")
df_future = pd.read_csv("Daily Bike Sharing future.csv")
df = pd.concat([df_train, df_future])
df.reset_index(drop = True, inplace = True)
df.tail()
```

	instant	dteday	season	yr	mnth	holiday	weekday	workingday	weathersit	temp	atemp	hum	windspeed	casual
726	727	12/27/2012	1	1	12	0	4	1	2	0.254167	0.226642	0.652917	0.350133	NaN
727	728	12/28/2012	1	1	12	0	5	1	2	0.253333	0.255046	0.590000	0.155471	NaN
728	729	12/29/2012	1	1	12	0	6	0	2	0.253333	0.242400	0.752917	0.124383	NaN
729	730	12/30/2012	1	1	12	0	0	0	1	0.255833	0.231700	0.483333	0.350754	NaN
730	731	12/31/2012	1	1	12	0	1	1	2	0.215833	0.223487	0.577500	0.154846	NaN

```
# Information about the Dataframe
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 731 entries, 0 to 730
Data columns (total 16 columns):
 #   Column      Non-Null Count  Dtype
---  ------      --------------  -----
 0   instant     731 non-null    int64
 1   dteday      731 non-null    object
 2   season      731 non-null    int64
 3   yr          731 non-null    int64
 4   mnth        731 non-null    int64
 5   holiday     731 non-null    int64
 6   weekday     731 non-null    int64
 7   workingday  731 non-null    int64
 8   weathersit  731 non-null    int64
 9   temp        731 non-null    float64
 10  atemp       731 non-null    float64
 11  hum         731 non-null    float64
 12  windspeed   731 non-null    float64
 13  casual      701 non-null    float64
 14  registered  701 non-null    float64
 15  cnt         701 non-null    float64
dtypes: float64(7), int64(8), object(1)
memory usage: 91.5+ KB
```

```
# Changing the Columns Names
df = df.rename(columns = {'cnt' : 'y', 'dteday' : 'ds'})
```

```
df.head()
```

	instant	ds	season	yr	mnth	holiday	weekday	workingday	weathersit	temp	atemp	hum	windspeed	casual	regi
0	1	1/1/2011	1	0	1	0	6	0	2	0.344167	0.363625	0.805833	0.160446	331.0	
1	2	1/2/2011	1	0	1	0	0	0	2	0.363478	0.353739	0.696087	0.248539	131.0	
2	3	1/3/2011	1	0	1	0	1	1	1	0.196364	0.189405	0.437273	0.248309	120.0	
3	4	1/4/2011	1	0	1	0	2	1	1	0.200000	0.212122	0.590435	0.160296	108.0	
4	5	1/5/2011	1	0	1	0	3	1	1	0.226957	0.229270	0.436957	0.186900	82.0	

```
# Changing 'ds' column into format YYYY-MM_DD
df['ds'] = pd.to_datetime(df['ds'])
```

```
# Prepare the weather situation Variable
weather_sit = pd.get_dummies(df['weathersit'], drop_first=True)
df = pd.concat([df,weather_sit], axis=1)
df.head(1)
```

	instant	ds	season	yr	mnth	holiday	weekday	workingday	weathersit	temp	atemp	hum	windspeed	casual	registe
0	1	2011-01-01	1	0	1	0	6	0	2	0.344167	0.363625	0.805833	0.160446	331.0	

```
# Renaming variables 2 and 3
df = df.rename(columns = {2: 'weather_sit_2', 3 : 'weather_sit_3'})
```

```
# Dropping unnecassary Variables
df.drop(columns = ['instant', 'season','yr', 'mnth', 'weekday','casual','registered','weathersit', 'weekday'], inplace = True)
```

```
# Look at date '2012-10-29'
df[df.ds == '2012-10-29']
```

	ds	holiday	workingday	temp	atemp	hum	windspeed	y	weather_sit_2	weather_sit_3
667	2012-10-29	0	1	0.44	0.4394	0.88	0.3582	22.0	False	True

```
# Replace the value of 29th October 2012 with 28th October, because during EDA, no sign of Weekly Seasonality,
# hence using the previous day value for the unusaul event(Huricane) on 29th October, 2012
to_replace = df.loc[df['ds'] == '2012-10-28'].y.values[0]
df.loc[df['ds'] == '2012-10-29','y'] = to_replace
df.loc[df['ds'] == '2012-10-30','y'] = to_replace
```

```
gen_holidays = pd.DataFrame({'holiday' : 'gen_holi',
                             'ds' : df[df['holiday'] == 1].ds,
                             'lower_window' : -2,
                             'upper_window' : 2})

xmas = pd.DataFrame({'holiday': 'Christmas',
                     'ds' : pd.to_datetime(['2011-12-24','2012-12-24']),
                     'lower_window' : -5,
                     'upper_window' : 3})

nye = pd.DataFrame({'holiday': 'New Year',
                    'ds' : pd.to_datetime(['2011-12-31','2012-12-31']),
                    'lower_window' : -3,
                    'upper_window': 3})

easter = pd.DataFrame({'holiday': 'Easter',
                       'ds' : pd.to_datetime(['2011-04-24','2012-04-08']),
                        'lower_window' : -3,
                        'upper_window': 3})

holidays = pd.concat([gen_holidays, xmas, nye, easter])
```

```
# Creating the lagged temperature variable
lag =1
df[f'temp_lag_{lag}'] = df['temp'].shift(lag)
df.head()
```

	ds	holiday	workingday	temp	atemp	hum	windspeed	y	weather_sit_2	weather_sit_3	temp_lag_1
0	2011-01-01	0	0	0.344167	0.363625	0.805833	0.160446	985.0	True	False	NaN
1	2011-01-02	0	0	0.363478	0.353739	0.696087	0.248539	801.0	True	False	0.344167
2	2011-01-03	0	1	0.196364	0.189405	0.437273	0.248309	1349.0	False	False	0.363478
3	2011-01-04	0	1	0.200000	0.212122	0.590435	0.160296	1562.0	False	False	0.196364
4	2011-01-05	0	1	0.226957	0.229270	0.436957	0.186900	1600.0	False	False	0.200000

Prophet Forecasting Model

```
# Separating the training data for final model
train = df[:-30]
train.tail()
```

	ds	holiday	workingday	temp	atemp	hum	windspeed	y	weather_sit_2	weather_sit_3	temp_lag_1
696	2012-11-27	0	1	0.291667	0.281558	0.786667	0.237562	3959.0	True	False	0.313333
697	2012-11-28	0	1	0.296667	0.289762	0.506250	0.210821	5260.0	False	False	0.291667
698	2012-11-29	0	1	0.280870	0.298422	0.555652	0.115522	5323.0	False	False	0.296667
699	2012-11-30	0	1	0.298333	0.323867	0.649583	0.058471	5668.0	False	False	0.280870
700	2012-12-01	0	0	0.298333	0.316904	0.806667	0.059704	5191.0	True	False	0.298333

```
# Remove any NAs
train = train.dropna()
```

```
from prophet import Prophet
```

```
# Building the Prophet Model
m = Prophet(yearly_seasonality=True,
            weekly_seasonality=True,
            daily_seasonality=True,
            holidays = holidays,
            **best_params)

m.add_regressor('workingday')
m.add_regressor('temp')
m.add_regressor('atemp')
m.add_regressor('hum')
m.add_regressor('windspeed')
m.add_regressor('weather_sit_2')
m.add_regressor('weather_sit_3')
m.add_regressor('temp_lag_1')

m.fit(train)
```

```
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/32ke3er_.json
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/2k22czoe.json
DEBUG:cmdstanpy:idx 0
DEBUG:cmdstanpy:running CmdStan, num_threads: None
DEBUG:cmdstanpy:CmdStan args: ['/usr/local/lib/python3.11/dist-packages/prophet/stan_model/prophet_model.bin', 'random', 'seed=9166
12:42:32 - cmdstanpy - INFO - Chain [1] start processing
INFO:cmdstanpy:Chain [1] start processing
12:42:32 - cmdstanpy - INFO - Chain [1] done processing
INFO:cmdstanpy:Chain [1] done processing
<prophet.forecaster.Prophet at 0x78f260b1ebd0>
```

Forecasting

```
# Future Regressors
future_regressors = df.drop(columns =['y', 'ds'])
future_regressors = future_regressors.dropna()
future_regressors.reset_index(drop = True, inplace = True)
future_regressors
```

	holiday	workingday	temp	atemp	hum	windspeed	weather_sit_2	weather_sit_3	temp_lag_1
0	0	0	0.363478	0.353739	0.696087	0.248539	True	False	0.344167
1	0	1	0.196364	0.189405	0.437273	0.248309	False	False	0.363478
2	0	1	0.200000	0.212122	0.590435	0.160296	False	False	0.196364
3	0	1	0.226957	0.229270	0.436957	0.186900	False	False	0.200000
4	0	1	0.204348	0.233209	0.518261	0.089565	False	False	0.226957
...	...	...	...	...	...	...	...	...	...
725	0	1	0.254167	0.226642	0.652917	0.350133	True	False	0.243333
726	0	1	0.253333	0.255046	0.590000	0.155471	True	False	0.254167
727	0	0	0.253333	0.242400	0.752917	0.124383	True	False	0.253333
728	0	0	0.255833	0.231700	0.483333	0.350754	False	False	0.253333
729	0	1	0.215833	0.223487	0.577500	0.154846	True	False	0.255833

730 rows × 9 columns

```
# Create a future Dataframe
future = m.make_future_dataframe(periods = 30, freq = 'D')
future = pd.concat([future, future_regressors], axis = 1)
future.tail()
```

	ds	holiday	workingday	temp	atemp	hum	windspeed	weather_sit_2	weather_sit_3	temp_lag_1
725	2012-12-27	0	1	0.254167	0.226642	0.652917	0.350133	True	False	0.243333
726	2012-12-28	0	1	0.253333	0.255046	0.590000	0.155471	True	False	0.254167
727	2012-12-29	0	0	0.253333	0.242400	0.752917	0.124383	True	False	0.253333
728	2012-12-30	0	0	0.255833	0.231700	0.483333	0.350754	False	False	0.253333
729	2012-12-31	0	1	0.215833	0.223487	0.577500	0.154846	True	False	0.255833

Results

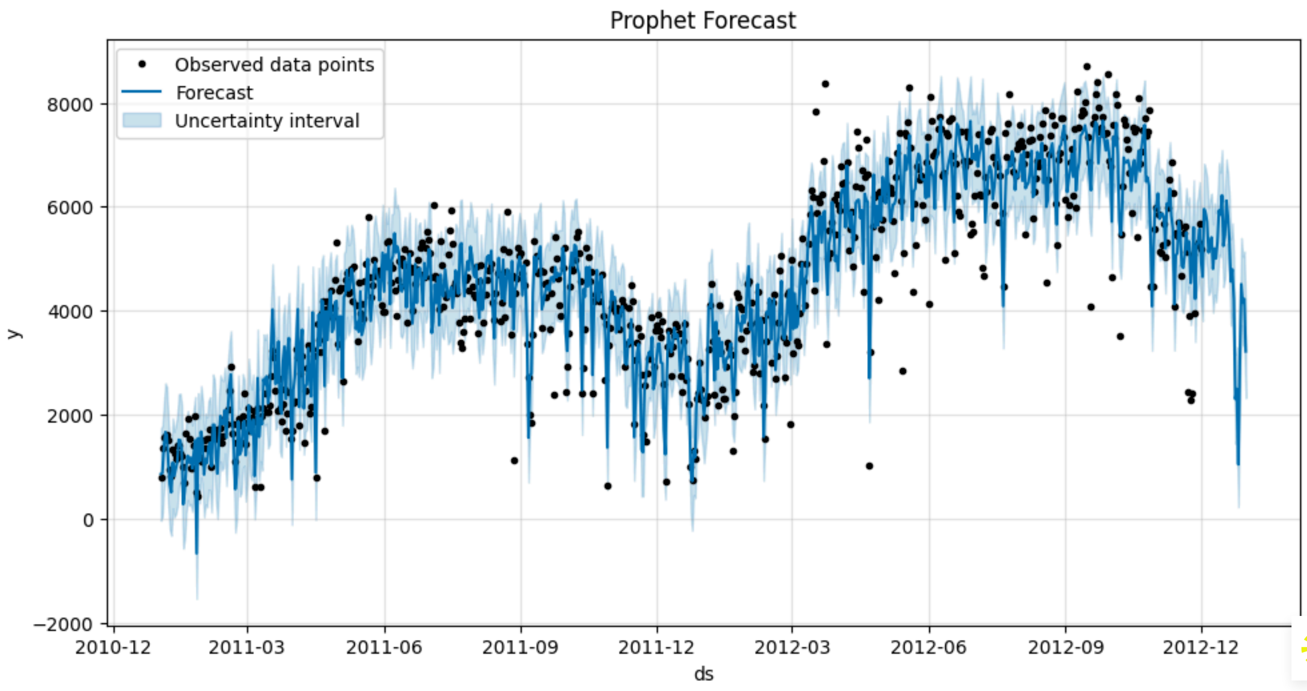
```
# Make the Forecast
forecast = m.predict(future)
forecast.tail()
```

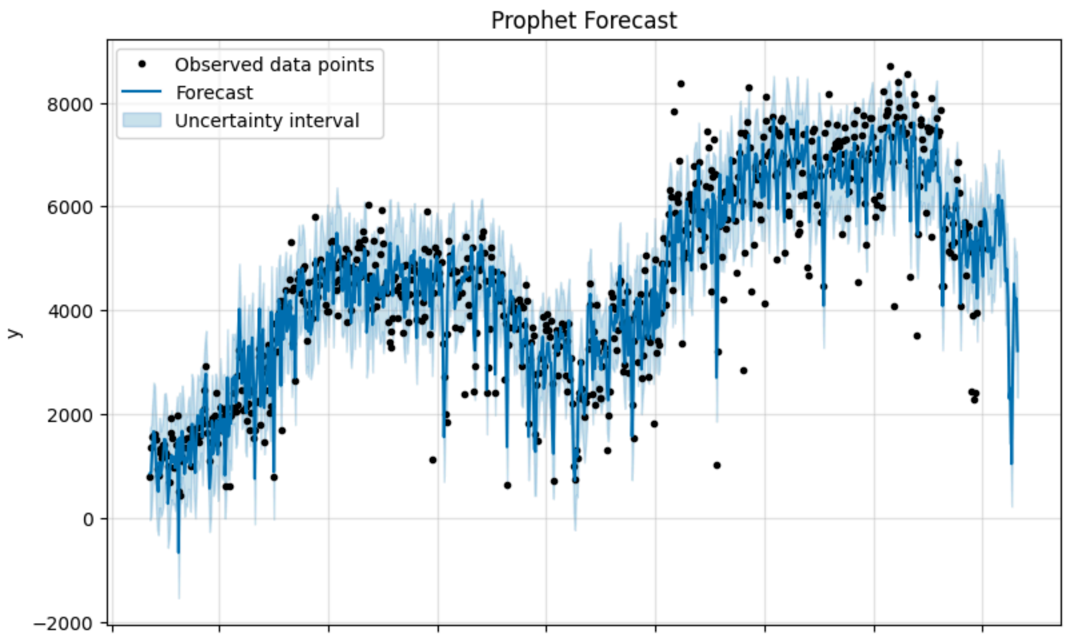
	ds	trend	yhat_lower	yhat_upper	trend_lower	trend_upper	Christmas	Christmas_lower	Christmas_upper	Easter	..
725	2012-12-27	5345.523562	2150.765533	3827.780766	5345.009949	5346.241699	-1606.966168	-1606.966168	-1606.966168	0.0	
726	2012-12-28	5351.587913	3729.437579	5397.458117	5351.024279	5352.383858	0.000000	0.000000	0.000000	0.0	
727	2012-12-29	5357.652264	3347.901192	5047.732428	5357.055728	5358.499222	0.000000	0.000000	0.000000	0.0	
728	2012-12-30	5363.716615	3301.462254	5137.553208	5363.078240	5364.620736	0.000000	0.000000	0.000000	0.0	
729	2012-12-31	5369.780966	2321.345981	4074.878039	5369.104941	5370.744529	0.000000	0.000000	0.000000	0.0	

5 rows × 64 columns

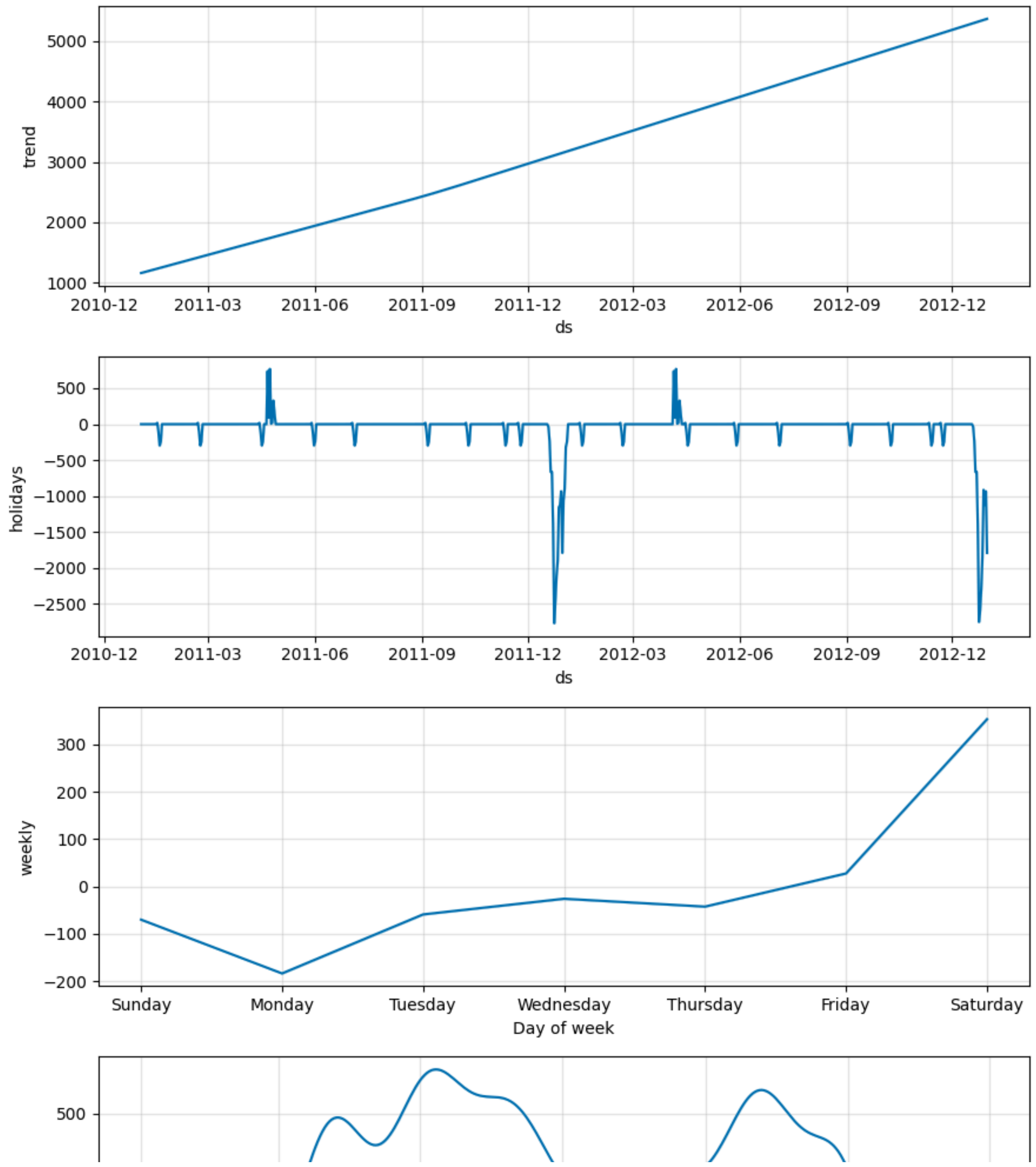
Forecasted Visualization

```
# 1. Visualize the overall forecast
fig = m.plot(forecast)
plt.title("Prophet Forecast")
fig.set_size_inches(8, 5)
plt.legend()
plt.show()
```

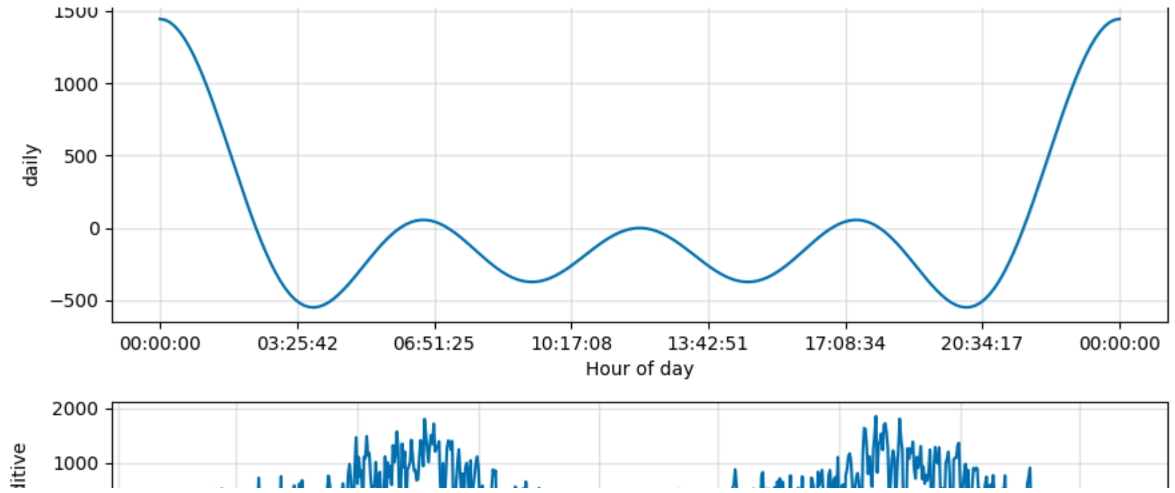


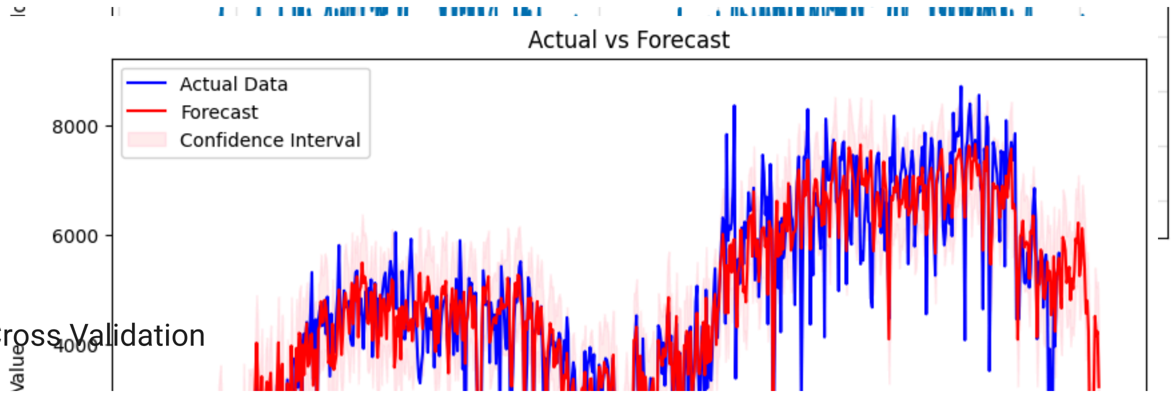


```
# 2. Visualize the forecast components (trend, weekly seasonality, yearly seasonality, etc.)
fig2 = m.plot_components(forecast)
plt.show()
```



```
# 3. Plot actual vs predicted values
plt.figure(figsize=(10, 6))
plt.plot(df['ds'], df['y'], label='Actual Data', color='blue')
plt.plot(forecast['ds'], forecast['yhat'], label='Forecast', color='red')
plt.fill_between(forecast['ds'], forecast['yhat_lower'], forecast['yhat_upper'], color='pink', alpha=0.3, label='Confidence Interval')
plt.title("Actual vs Forecast")
plt.xlabel("Date")
plt.ylabel("Value")
plt.legend()
plt.show()
```





Cross Validation

```
from prophet.diagnostics import cross_validation, performance_metrics
import seaborn as sns

# Perform cross-validation
df_cv = cross_validation(model=m,
                         horizon='30 days',
                         period='15 days',
                         initial='521 days')

# Calculate performance metrics
df_metrics = performance_metrics(df_cv)

# Display the metrics
print(df_metrics)
```

```
INFO:prophet:Making 10 forecasts with cutoffs between 2012-06-19 00:00:00 and 2012-11-01 00:00:00
100%                                          10/10 [00:03<00:00,  2.49it/s]
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/v1a2ohpd.json
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/n4wdl107.json
DEBUG:cmdstanpy:idx 0
DEBUG:cmdstanpy:running CmdStan, num_threads: None
DEBUG:cmdstanpy:CmdStan args: ['/usr/local/lib/python3.11/dist-packages/prophet/stan_model/prophet_model.bin', 'random', 'seed=5811
12:42:35 - cmdstanpy - INFO - Chain [1] start processing
INFO:cmdstanpy:Chain [1] start processing
12:42:36 - cmdstanpy - INFO - Chain [1] done processing
INFO:cmdstanpy:Chain [1] done processing
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/12fq2pg3.json
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/erg67yjg.json
DEBUG:cmdstanpy:idx 0
DEBUG:cmdstanpy:running CmdStan, num_threads: None
DEBUG:cmdstanpy:CmdStan args: ['/usr/local/lib/python3.11/dist-packages/prophet/stan_model/prophet_model.bin', 'random', 'seed=4627
12:42:36 - cmdstanpy - INFO - Chain [1] start processing
INFO:cmdstanpy:Chain [1] start processing
12:42:36 - cmdstanpy - INFO - Chain [1] done processing
INFO:cmdstanpy:Chain [1] done processing
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/pktan_mw.json
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/piwdq2u6.json
DEBUG:cmdstanpy:idx 0
DEBUG:cmdstanpy:running CmdStan, num_threads: None
DEBUG:cmdstanpy:CmdStan args: ['/usr/local/lib/python3.11/dist-packages/prophet/stan_model/prophet_model.bin', 'random', 'seed=3304
12:42:36 - cmdstanpy - INFO - Chain [1] start processing
INFO:cmdstanpy:Chain [1] start processing
12:42:36 - cmdstanpy - INFO - Chain [1] done processing
INFO:cmdstanpy:Chain [1] done processing
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/5c663f4l.json
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/kqs8gupi.json
DEBUG:cmdstanpy:idx 0
DEBUG:cmdstanpy:running CmdStan, num_threads: None
DEBUG:cmdstanpy:CmdStan args: ['/usr/local/lib/python3.11/dist-packages/prophet/stan_model/prophet_model.bin', 'random', 'seed=8707
12:42:37 - cmdstanpy - INFO - Chain [1] start processing
INFO:cmdstanpy:Chain [1] start processing
12:42:37 - cmdstanpy - INFO - Chain [1] done processing
INFO:cmdstanpy:Chain [1] done processing
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/eftlmli5.json
DEBUG:cmdstanpy:input tempfile: /tmp/tmp6gs6f14f/qiess9af.json
DEBUG:cmdstanpy:idx 0
DEBUG:cmdstanpy:running CmdStan, num_threads: None
```