Unobserverd_tsa

April 29, 2024

[67]:
```
import numpy as np
import statsmodels.api as sm
import matplotlib.pyplot as plt
from sklearn.metrics import r2_score
from sklearn.preprocessing import MinMaxScaler
from sklearn.impute import SimpleImputer
import matplotlib.pyplot as plt
import matplotlib.cm as cm
import math
from IPython.display import display
import os
import pandas as pd
```

[68]:
```
#
data_path = os.path.join("PEMS03_num31.npz")
data = np.load(data_path)['data']
```

[69]:
```
#
scaler = MinMaxScaler(feature_range=(0, 1))
data_normalized = scaler.fit_transform(data.reshape(-1, 1))
imp = SimpleImputer(missing_values=0, strategy='mean')
imp.fit(data_normalized)
data_normalized = imp.transform(data_normalized).reshape(-1)
```

[70]:
```
#
train_size = int(len(data_normalized) * 0.7)
valid_size = int(len(data_normalized) * 0.2)
test_size = len(data_normalized) - train_size - valid_size

train_data = data_normalized[:train_size]
valid_data = data_normalized[train_size:train_size+valid_size]
test_data = data_normalized[train_size+valid_size:]
```

[71]:
```
periodic = [12, 288]
k_range = 10

fits = [{
        k: sm.tsa.UnobservedComponents(
```

```
            train_data,
            level=True, trend=True,
            #cycle=True,
            freq_seasonal=[{'period':q,'harmonics':[1,k][p==q] } for q in␣
 ↪periodic]
            ).fit()
        for k in range(1, k_range+1)
    }
    for p in periodic
]
```

```
c:\Users\1213123\Documents\Scripts\CIVL7018\.venv\Lib\site-
packages\statsmodels\base\model.py:607: ConvergenceWarning: Maximum Likelihood
optimization failed to converge. Check mle_retvals
  warnings.warn("Maximum Likelihood optimization failed to "
c:\Users\1213123\Documents\Scripts\CIVL7018\.venv\Lib\site-
packages\statsmodels\base\model.py:607: ConvergenceWarning: Maximum Likelihood
optimization failed to converge. Check mle_retvals
  warnings.warn("Maximum Likelihood optimization failed to "
c:\Users\1213123\Documents\Scripts\CIVL7018\.venv\Lib\site-
packages\statsmodels\base\model.py:607: ConvergenceWarning: Maximum Likelihood
optimization failed to converge. Check mle_retvals
  warnings.warn("Maximum Likelihood optimization failed to "
c:\Users\1213123\Documents\Scripts\CIVL7018\.venv\Lib\site-
packages\statsmodels\base\model.py:607: ConvergenceWarning: Maximum Likelihood
optimization failed to converge. Check mle_retvals
  warnings.warn("Maximum Likelihood optimization failed to "
c:\Users\1213123\Documents\Scripts\CIVL7018\.venv\Lib\site-
packages\statsmodels\base\model.py:607: ConvergenceWarning: Maximum Likelihood
optimization failed to converge. Check mle_retvals
  warnings.warn("Maximum Likelihood optimization failed to "
```

[72]:

```
def mse_test_data (data):
    return ((data-test_data)**2).mean(axis=None)

def mae_test_data (data):
    return (np.absolute(data-test_data)).mean(axis=None)

def rsquared_test_data (data):
    return r2_score(test_data, data)

def iterating_k(i, models):
    index = pd.DataFrame(range(1,k_range+1), columns=['k'])
    data = [fit.get_forecast(valid_size+test_size).predicted_mean[valid_size:]␣
 ↪for _,fit in models.items()]
    index['mse'] = [mse_test_data(d) for d in data]
    index['mae'] = [mae_test_data(d) for d in data]
```

```
    index['rsquared'] = [rsquared_test_data(d) for d in data]
    display(f"periodicity = {periodic[i]}")
    display(index)
    return index

iter_k_fits = [iterating_k(i, f) for i,f in enumerate(fits)]
```

'periodicity = 12'

	k	mse	mae	rsquared
0	1	0.015978	0.094973	0.773105
1	2	0.015501	0.094228	0.779890
2	3	0.015518	0.094234	0.779639
3	4	0.015529	0.094245	0.779493
4	5	0.015565	0.094263	0.778970
5	6	0.015538	0.094242	0.779354
6	7	0.015539	0.094242	0.779350
7	8	0.015537	0.094241	0.779371
8	9	0.015542	0.094245	0.779301
9	10	0.015541	0.094244	0.779318

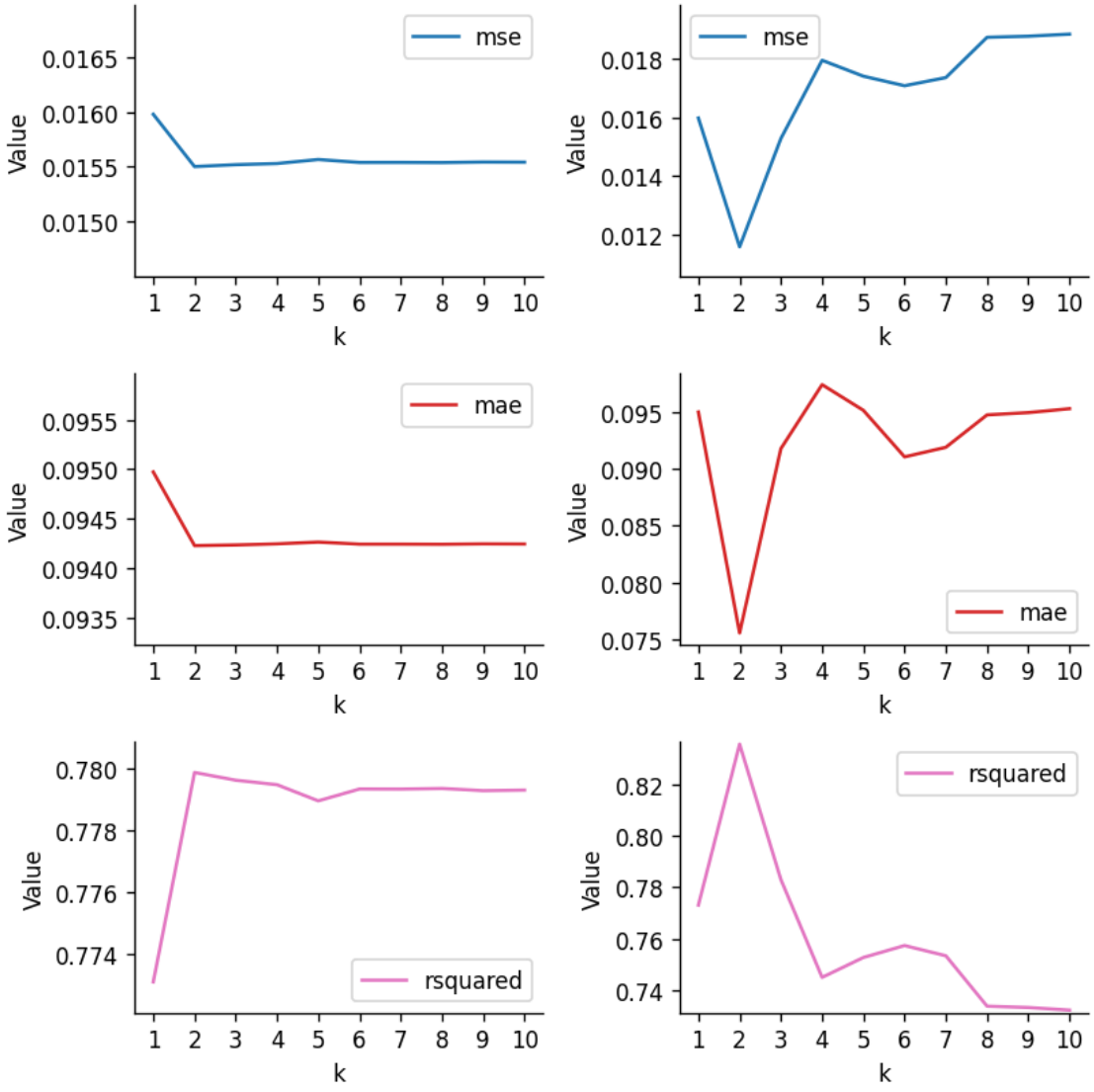
'periodicity = 288'

	k	mse	mae	rsquared
0	1	0.015978	0.094973	0.773105
1	2	0.011573	0.075569	0.835657
2	3	0.015277	0.091758	0.783063
3	4	0.017957	0.097383	0.745016
4	5	0.017412	0.095127	0.752742
5	6	0.017085	0.091037	0.757390
6	7	0.017364	0.091878	0.753425
7	8	0.018745	0.094727	0.733824
8	9	0.018780	0.094924	0.733320
9	10	0.018852	0.095268	0.732293

[73]:
```
fig, axs = plt.subplots(3, 2, figsize=(7,7), sharex=False, sharey=False,␣
 ↪dpi=120)
# plot mse, mae, rsquared of k
props = ['mse','mae','rsquared']
cmap = cm.get_cmap('tab10')

for i, p in enumerate(periodic):
    for j,p in enumerate(props):
        ax = axs[j,i]
        plot_data = iter_k_fits[i][p]
        ax.plot(np.arange(1, k_range+1, 1.0),plot_data, color = cmap(j/3),␣
 ↪label=p)
        ax.set_xticks(np.arange(1, k_range+1, 1.0))
        ax.set_ylim(plot_data.min()-0.001,plot_data.max()+0.001)
```

```
        ax.legend()
        ax.set_xlabel("k")
        ax.set_ylabel("Value")

plt.tight_layout()


plt.show()
```

```
C:\Users\1213123\AppData\Local\Temp\ipykernel_5440\827810264.py:4:
MatplotlibDeprecationWarning: The get_cmap function was deprecated in Matplotlib
3.7 and will be removed two minor releases later. Use
``matplotlib.colormaps[name]`` or ``matplotlib.colormaps.get_cmap(obj)``
instead.
  cmap = cm.get_cmap('tab10')
```



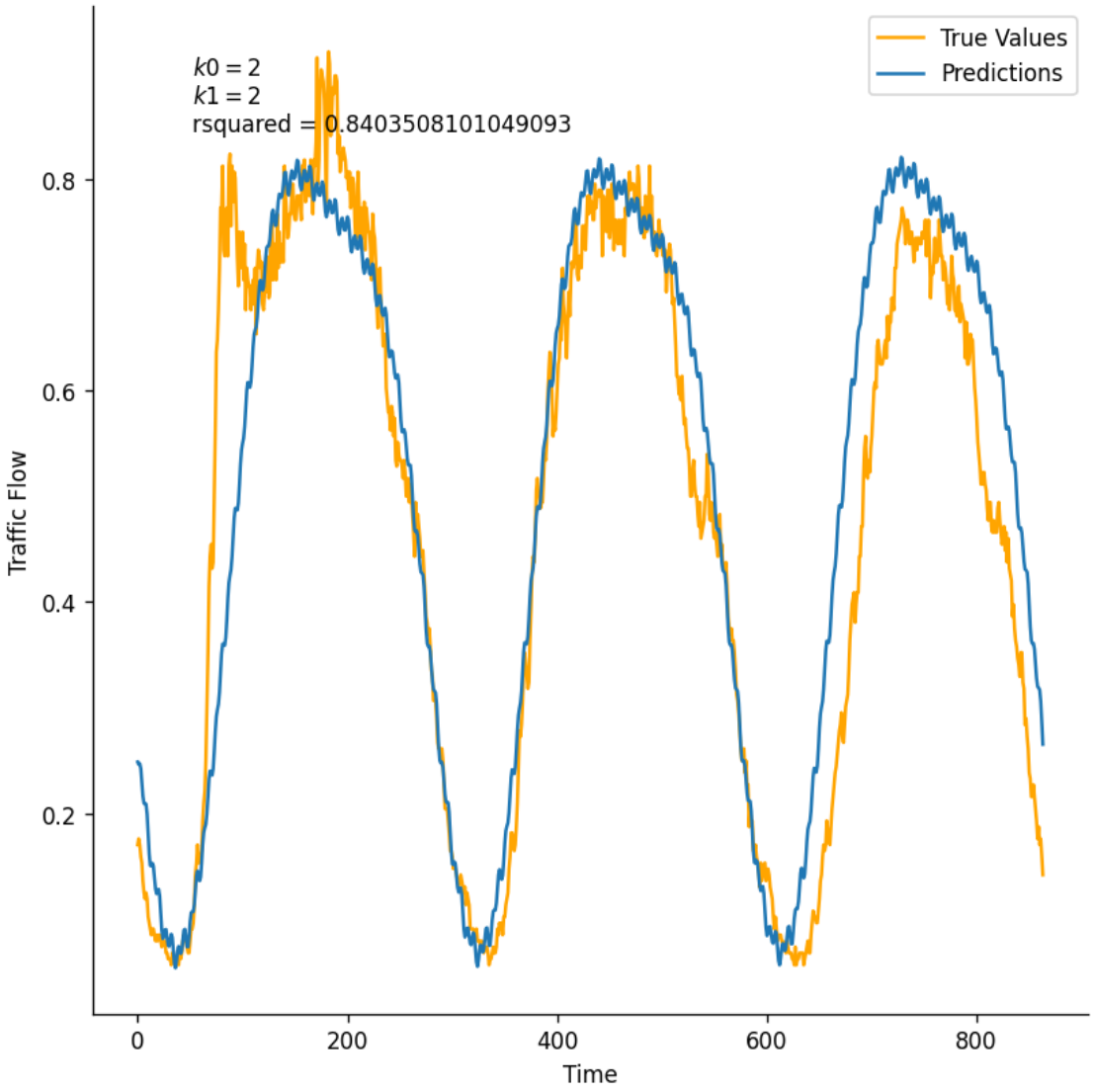
[74]:
```
# Obtains best k value base on the r squared performance
ks = [f[f.rsquared == f.rsquared.max()]['k'].values[0] for f in iter_k_fits]

best_fit = sm.tsa.UnobservedComponents(
        train_data,
        level=True, trend=True,
        #cycle=True,
        freq_seasonal=[{'period':p,'harmonics':k} for p,k in zip(periodic, ks)]
        ).fit()

best_fit_forecast = best_fit.get_forecast(valid_size+test_size).
 ↪predicted_mean[valid_size:]
rmse = math.sqrt(mse_test_data(best_fit_forecast))
mae = mae_test_data(best_fit_forecast)
r_squared = rsquared_test_data(best_fit_forecast)

print(*[rmse,mae,r_squared], sep=',')
```

```
0.10603218642700016,0.07415025129412875,0.8403508101049093
```

[76]:
```
def show1plot():
    fig, ax = plt.subplots(1, 1, figsize=(7,7), sharex=True, sharey=True,␣
 ↪dpi=120)

    # forecast
    ax.plot(test_data, 'orange', label='True Values')
    fc = best_fit.get_forecast(test_size)
    ax.plot(fc.predicted_mean, label='Predictions')

    ax.legend()
    plt.xlabel("Time")
    plt.ylabel("Traffic Flow")

    ks_text = '\n'.join([f'$k{i}={k}$' for i, k in enumerate(ks)])
    ax.text(.1, .95, f'{ks_text}\nrsquared = {r_squared}', va='top',␣
 ↪transform=ax.transAxes)
    plt.tight_layout()

show1plot()
print(best_fit.summary())

plt.show()
```

```
                            Unobserved Components Results
==============================================================================
```

```
==============
Dep. Variable:                                      y   No. Observations:
6048
Model:                                           None   Log Likelihood
13724.625
                    + stochastic freq_seasonal(12(2))   AIC
-27445.250
                   + stochastic freq_seasonal(288(2))   BIC
-27431.838
Date:                                Sun, 28 Apr 2024   HQIC
-27440.594
Time:                                        23:02:12
Sample:                                             0
                                                - 6048
Covariance Type:                                  opg
================================================================================
===============
                                   coef    std err          z      P>|z|
[0.025      0.975]
--------------------------------------------------------------------------------
---------------
sigma2.freq_seasonal_12(2)   2.026e-10      9e-10      0.225      0.822
-1.56e-09    1.97e-09
sigma2.freq_seasonal_288(2)     0.0003   4.01e-06     72.404      0.000
0.000       0.000
================================================================================
===
Ljung-Box (L1) (Q):                 607.19   Jarque-Bera (JB):
695.64
Prob(Q):                              0.00   Prob(JB):
0.00
Heteroskedasticity (H):               1.00   Skew:
-0.06
Prob(H) (two-sided):                  0.99   Kurtosis:
4.66
================================================================================
===

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-
step).
```


True Values
Predictions
k0 = 2
k1 = 2
rsquared = 0.8403508101049093
Traffic Flow
0.2
0.4
0.6
0.8
0
200
400
600
800
Time