AlexNguyen_ElectricityForecasting

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0.1 Time Series Forecasting - Electricity

0.1.1 Alex Nguyen

0.1.2 1. Read the dataset

[ ]:
```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.dates as mdates
import matplotlib.pyplot as plt
import statsmodels.api as sm

from datetime import datetime
from pmdarima import preprocessing as AutoARIMA
from pmdarima.preprocessing import FourierFeaturizer
from sklearn.metrics import mean_absolute_error, root_mean_squared_error
from sklearn.model_selection import train_test_split
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
from statsmodels.tsa.arima.model import ARIMA
from statsmodels.tsa.seasonal import seasonal_decompose
from sklearn.preprocessing import StandardScaler, MinMaxScaler
from statsmodels.tsa.stattools import adfuller
from pmdarima import pipeline
```

[ ]:
```
data = pd.read_csv('energydata_complete.csv')
data
```

[ ]:
```
                       date  Appliances  lights         T1       RH_1  \
0      2016-01-11 17:00:00          60      30  19.890000  47.596667
1      2016-01-11 17:10:00          60      30  19.890000  46.693333
2      2016-01-11 17:20:00          50      30  19.890000  46.300000
3      2016-01-11 17:30:00          50      40  19.890000  46.066667
4      2016-01-11 17:40:00          60      40  19.890000  46.333333
…                        …         …       …        …          …
19730  2016-05-27 17:20:00         100       0  25.566667  46.560000
19731  2016-05-27 17:30:00          90       0  25.500000  46.500000
19732  2016-05-27 17:40:00         270      10  25.500000  46.596667
19733  2016-05-27 17:50:00         420      10  25.500000  46.990000
```

```
19734  2016-05-27 18:00:00         430      10  25.500000  46.600000

              T2       RH_2         T3       RH_3         T4  …         T9  \
0      19.200000  44.790000  19.790000  44.730000  19.000000  …  17.033333
1      19.200000  44.722500  19.790000  44.790000  19.000000  …  17.066667
2      19.200000  44.626667  19.790000  44.933333  18.926667  …  17.000000
3      19.200000  44.590000  19.790000  45.000000  18.890000  …  17.000000
4      19.200000  44.530000  19.790000  45.000000  18.890000  …  17.000000
…            …          …          …          …          …  …          …
19730  25.890000  42.025714  27.200000  41.163333  24.700000  …  23.200000
19731  25.754000  42.080000  27.133333  41.223333  24.700000  …  23.200000
19732  25.628571  42.768571  27.050000  41.690000  24.700000  …  23.200000
19733  25.414000  43.036000  26.890000  41.290000  24.700000  …  23.200000
19734  25.264286  42.971429  26.823333  41.156667  24.700000  …  23.200000

          RH_9      T_out  Press_mm_hg     RH_out  Windspeed  Visibility  \
0      45.5300   6.600000        733.5  92.000000   7.000000   63.000000
1      45.5600   6.483333        733.6  92.000000   6.666667   59.166667
2      45.5000   6.366667        733.7  92.000000   6.333333   55.333333
3      45.4000   6.250000        733.8  92.000000   6.000000   51.500000
4      45.4000   6.133333        733.9  92.000000   5.666667   47.666667
…          …          …          …          …          …           …
19730  46.7900  22.733333        755.2  55.666667   3.333333   23.666667
19731  46.7900  22.600000        755.2  56.000000   3.500000   24.500000
19732  46.7900  22.466667        755.2  56.333333   3.666667   25.333333
19733  46.8175  22.333333        755.2  56.666667   3.833333   26.166667
19734  46.8450  22.200000        755.2  57.000000   4.000000   27.000000

       Tdewpoint        rv1        rv2
0       5.300000  13.275433  13.275433
1       5.200000  18.606195  18.606195
2       5.100000  28.642668  28.642668
3       5.000000  45.410389  45.410389
4       4.900000  10.084097  10.084097
…            …          …          …
19730  13.333333  43.096812  43.096812
19731  13.300000  49.282940  49.282940
19732  13.266667  29.199117  29.199117
19733  13.233333   6.322784   6.322784
19734  13.200000  34.118851  34.118851

[19735 rows x 29 columns]
```

0.1.3 2. Analyse and visualise the data

2.1 Skimming data

[ ]:
```
# check data type and NA
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 19735 entries, 0 to 19734
Data columns (total 29 columns):
 #   Column       Non-Null Count  Dtype
---  ------       --------------  -----
 0   date         19735 non-null  object
 1   Appliances   19735 non-null  int64
 2   lights       19735 non-null  int64
 3   T1           19735 non-null  float64
 4   RH_1         19735 non-null  float64
 5   T2           19735 non-null  float64
 6   RH_2         19735 non-null  float64
 7   T3           19735 non-null  float64
 8   RH_3         19735 non-null  float64
 9   T4           19735 non-null  float64
 10  RH_4         19735 non-null  float64
 11  T5           19735 non-null  float64
 12  RH_5         19735 non-null  float64
 13  T6           19735 non-null  float64
 14  RH_6         19735 non-null  float64
 15  T7           19735 non-null  float64
 16  RH_7         19735 non-null  float64
 17  T8           19735 non-null  float64
 18  RH_8         19735 non-null  float64
 19  T9           19735 non-null  float64
 20  RH_9         19735 non-null  float64
 21  T_out        19735 non-null  float64
 22  Press_mm_hg  19735 non-null  float64
 23  RH_out       19735 non-null  float64
 24  Windspeed    19735 non-null  float64
 25  Visibility   19735 non-null  float64
 26  Tdewpoint    19735 non-null  float64
 27  rv1          19735 non-null  float64
 28  rv2          19735 non-null  float64
dtypes: float64(26), int64(2), object(1)
memory usage: 4.4+ MB
```

[ ]:
```
data.columns
```

[ ]:
```
Index(['date', 'Appliances', 'lights', 'T1', 'RH_1', 'T2', 'RH_2', 'T3',
       'RH_3', 'T4', 'RH_4', 'T5', 'RH_5', 'T6', 'RH_6', 'T7', 'RH_7', 'T8',
       'RH_8', 'T9', 'RH_9', 'T_out', 'Press_mm_hg', 'RH_out', 'Windspeed',
       'Visibility', 'Tdewpoint', 'rv1', 'rv2'],
      dtype='object')
```

```
[ ]: # Rv1 and rv2 are introduced to dataset to reduce features from initial dataset␣
     ↪to test Boruta algorithm [1]. We don't need them anymore, so drop.
     data = data.drop(['rv1', 'rv2'], axis = 1)
     data.columns
```

```
[ ]: Index(['date', 'Appliances', 'lights', 'T1', 'RH_1', 'T2', 'RH_2', 'T3',
            'RH_3', 'T4', 'RH_4', 'T5', 'RH_5', 'T6', 'RH_6', 'T7', 'RH_7', 'T8',
            'RH_8', 'T9', 'RH_9', 'T_out', 'Press_mm_hg', 'RH_out', 'Windspeed',
            'Visibility', 'Tdewpoint'],
           dtype='object')
```

```
[ ]: # rename variables
     rename_dict = {
         'Appliances': 'appliance',
         'lights': 'light',
         'T1': 'temp_kitchen',
         'RH_1': 'humid_kitchen',
         'T2': 'temp_living',
         'RH_2': 'humid_living',
         'T3': 'temp_laundry',
         'RH_3': 'humid_laundry',
         'T4': 'temp_office',
         'RH_4': 'humid_office',
         'T5': 'temp_bath',
         'RH_5': 'humid_bath',
         'T6': 'temp_outbuilding',
         'RH_6': 'humid_outbuilding',
         'T7': 'temp_iron',
         'RH_7': 'humid_iron',
         'T8': 'temp_kid',
         'RH_8': 'humid_kid',
         'T9': 'temp_parent',
         'RH_9': 'humid_parent',
         'T_out': 'tempt_weather',
         'Press_mm_hg': 'pressure_weather',
         'RH_out': 'humid_weather',
         'Windspeed': 'wind_weather',
         'Visibility': 'vis_weather',
         'Tdewpoint': 'tdew_weather',
         'rv1': 'random_1',
         'rv2': 'random_2'
     }

     data.rename(columns=rename_dict, inplace=True)
     data.columns
```

```
[ ]: Index(['date', 'appliance', 'light', 'temp_kitchen', 'humid_kitchen',
            'temp_living', 'humid_living', 'temp_laundry', 'humid_laundry',
            'temp_office', 'humid_office', 'temp_bath', 'humid_bath',
            'temp_outbuilding', 'humid_outbuilding', 'temp_iron', 'humid_iron',
            'temp_kid', 'humid_kid', 'temp_parent', 'humid_parent', 'tempt_weather',
            'pressure_weather', 'humid_weather', 'wind_weather', 'vis_weather',
            'tdew_weather'],
           dtype='object')
```

```
[ ]: # as [1, p. 93], time information is the most important feature to appliance's
     ↪energy consumption, we create this variable as well
     data['date'] = pd.to_datetime(data['date'], format='%Y-%m-%d %H:%M:%S',
     ↪utc=True)

     def convert_to_seconds(x):
         return x.hour * 3600 + x.minute * 60 + x.second

     data['sec_midnight'] = data['date'].apply(convert_to_seconds)
     data['sec_midnight'].describe()
```

```
[ ]: count    19735.000000
     mean     42907.129465
     std      24940.020831
     min          0.000000
     25%      21600.000000
     50%      43200.000000
     75%      64200.000000
     max      85800.000000
     Name: sec_midnight, dtype: float64
```

```
[ ]: #convert date to index
     data.index = pd.to_datetime(data.date)
     data.drop('date', axis=1, inplace=True)
     data.sort_index(inplace=True)
     data.head()
```

```
[ ]:                            appliance  light  temp_kitchen  humid_kitchen  \
     date
     2016-01-11 17:00:00+00:00         60     30         19.89      47.596667
     2016-01-11 17:10:00+00:00         60     30         19.89      46.693333
     2016-01-11 17:20:00+00:00         50     30         19.89      46.300000
     2016-01-11 17:30:00+00:00         50     40         19.89      46.066667
     2016-01-11 17:40:00+00:00         60     40         19.89      46.333333

                                temp_living  humid_living  temp_laundry  \
     date
     2016-01-11 17:00:00+00:00         19.2     44.790000         19.79
```

```
2016-01-11 17:10:00+00:00         19.2     44.722500         19.79
2016-01-11 17:20:00+00:00         19.2     44.626667         19.79
2016-01-11 17:30:00+00:00         19.2     44.590000         19.79
2016-01-11 17:40:00+00:00         19.2     44.530000         19.79

                           humid_laundry  temp_office  humid_office  …  \
date                                                                 …
2016-01-11 17:00:00+00:00      44.730000    19.000000     45.566667  …
2016-01-11 17:10:00+00:00      44.790000    19.000000     45.992500  …
2016-01-11 17:20:00+00:00      44.933333    18.926667     45.890000  …
2016-01-11 17:30:00+00:00      45.000000    18.890000     45.723333  …
2016-01-11 17:40:00+00:00      45.000000    18.890000     45.530000  …

                           humid_kid  temp_parent  humid_parent  \
date
2016-01-11 17:00:00+00:00  48.900000    17.033333         45.53
2016-01-11 17:10:00+00:00  48.863333    17.066667         45.56
2016-01-11 17:20:00+00:00  48.730000    17.000000         45.50
2016-01-11 17:30:00+00:00  48.590000    17.000000         45.40
2016-01-11 17:40:00+00:00  48.590000    17.000000         45.40

                           tempt_weather  pressure_weather  humid_weather  \
date
2016-01-11 17:00:00+00:00       6.600000             733.5           92.0
2016-01-11 17:10:00+00:00       6.483333             733.6           92.0
2016-01-11 17:20:00+00:00       6.366667             733.7           92.0
2016-01-11 17:30:00+00:00       6.250000             733.8           92.0
2016-01-11 17:40:00+00:00       6.133333             733.9           92.0

                           wind_weather  vis_weather  tdew_weather  \
date
2016-01-11 17:00:00+00:00      7.000000    63.000000           5.3
2016-01-11 17:10:00+00:00      6.666667    59.166667           5.2
2016-01-11 17:20:00+00:00      6.333333    55.333333           5.1
2016-01-11 17:30:00+00:00      6.000000    51.500000           5.0
2016-01-11 17:40:00+00:00      5.666667    47.666667           4.9

                           sec_midnight
date
2016-01-11 17:00:00+00:00         61200
2016-01-11 17:10:00+00:00         61800
2016-01-11 17:20:00+00:00         62400
2016-01-11 17:30:00+00:00         63000
2016-01-11 17:40:00+00:00         63600

[5 rows x 27 columns]
```

2.2 Analyse and visualise data

[ ]:
```
# summary nummeric
data.describe()
```

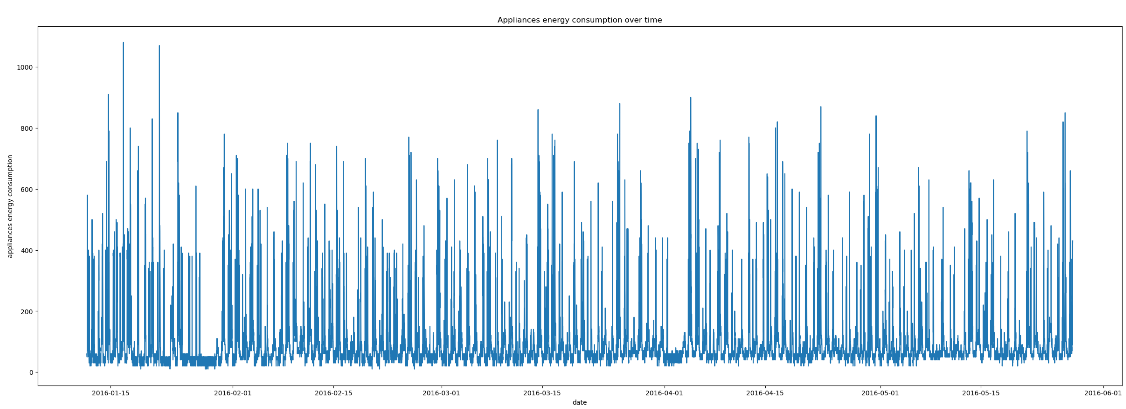
[ ]:
```
           appliance         light  temp_kitchen  humid_kitchen   temp_living  \
count   19735.000000  19735.000000  19735.000000   19735.000000  19735.000000
mean       97.694958      3.801875     21.686571      40.259739     20.341219
std       102.524891      7.935988      1.606066       3.979299      2.192974
min        10.000000      0.000000     16.790000      27.023333     16.100000
25%        50.000000      0.000000     20.760000      37.333333     18.790000
50%        60.000000      0.000000     21.600000      39.656667     20.000000
75%       100.000000      0.000000     22.600000      43.066667     21.500000
max      1080.000000     70.000000     26.260000      63.360000     29.856667

        humid_living  temp_laundry  humid_laundry   temp_office  humid_office  \
count   19735.000000  19735.000000   19735.000000  19735.000000  19735.000000
mean       40.420420     22.267611      39.242500     20.855335     39.026904
std         4.069813      2.006111       3.254576      2.042884      4.341321
min        20.463333     17.200000      28.766667     15.100000     27.660000
25%        37.900000     20.790000      36.900000     19.530000     35.530000
50%        40.500000     22.100000      38.530000     20.666667     38.400000
75%        43.260000     23.290000      41.760000     22.100000     42.156667
max        56.026667     29.236000      50.163333     26.200000     51.090000

        …     humid_kid   temp_parent  humid_parent  tempt_weather  \
count   …  19735.000000  19735.000000  19735.000000   19735.000000
mean    …     42.936165     19.485828     41.552401       7.411665
std     …      5.224361      2.014712      4.151497       5.317409
min     …     29.600000     14.890000     29.166667      -5.000000
25%     …     39.066667     18.000000     38.500000       3.666667
50%     …     42.375000     19.390000     40.900000       6.916667
75%     …     46.536000     20.600000     44.338095      10.408333
max     …     58.780000     24.500000     53.326667      26.100000

        pressure_weather  humid_weather  wind_weather   vis_weather  \
count       19735.000000   19735.000000  19735.000000  19735.000000
mean          755.522602      79.750418      4.039752     38.330834
std             7.399441      14.901088      2.451221     11.794719
min           729.300000      24.000000      0.000000      1.000000
25%           750.933333      70.333333      2.000000     29.000000
50%           756.100000      83.666667      3.666667     40.000000
75%           760.933333      91.666667      5.500000     40.000000
max           772.300000     100.000000     14.000000     66.000000

        tdew_weather  sec_midnight
count   19735.000000  19735.000000
mean        3.760707  42907.129465
```

```
std        4.194648  24940.020831
min       -6.600000      0.000000
25%        0.900000  21600.000000
50%        3.433333  43200.000000
75%        6.566667  64200.000000
max       15.500000  85800.000000

[8 rows x 27 columns]
```

[ ]:
```
# define sensor and weather feature variables
sensor = ['light', 'sec_midnight', 'temp_kitchen', 'humid_kitchen',␣
 ↪'temp_living', 'humid_living', 'temp_laundry',
          'humid_laundry','temp_office', 'humid_office', 'temp_bath',␣
 ↪'humid_bath', 'temp_outbuilding', 'humid_outbuilding',
          'temp_iron', 'humid_iron', 'temp_kid', 'humid_kid', 'temp_parent',␣
 ↪'humid_parent']

weather = ['tempt_weather','pressure_weather', 'humid_weather', 'wind_weather',␣
 ↪'vis_weather', 'tdew_weather']
```

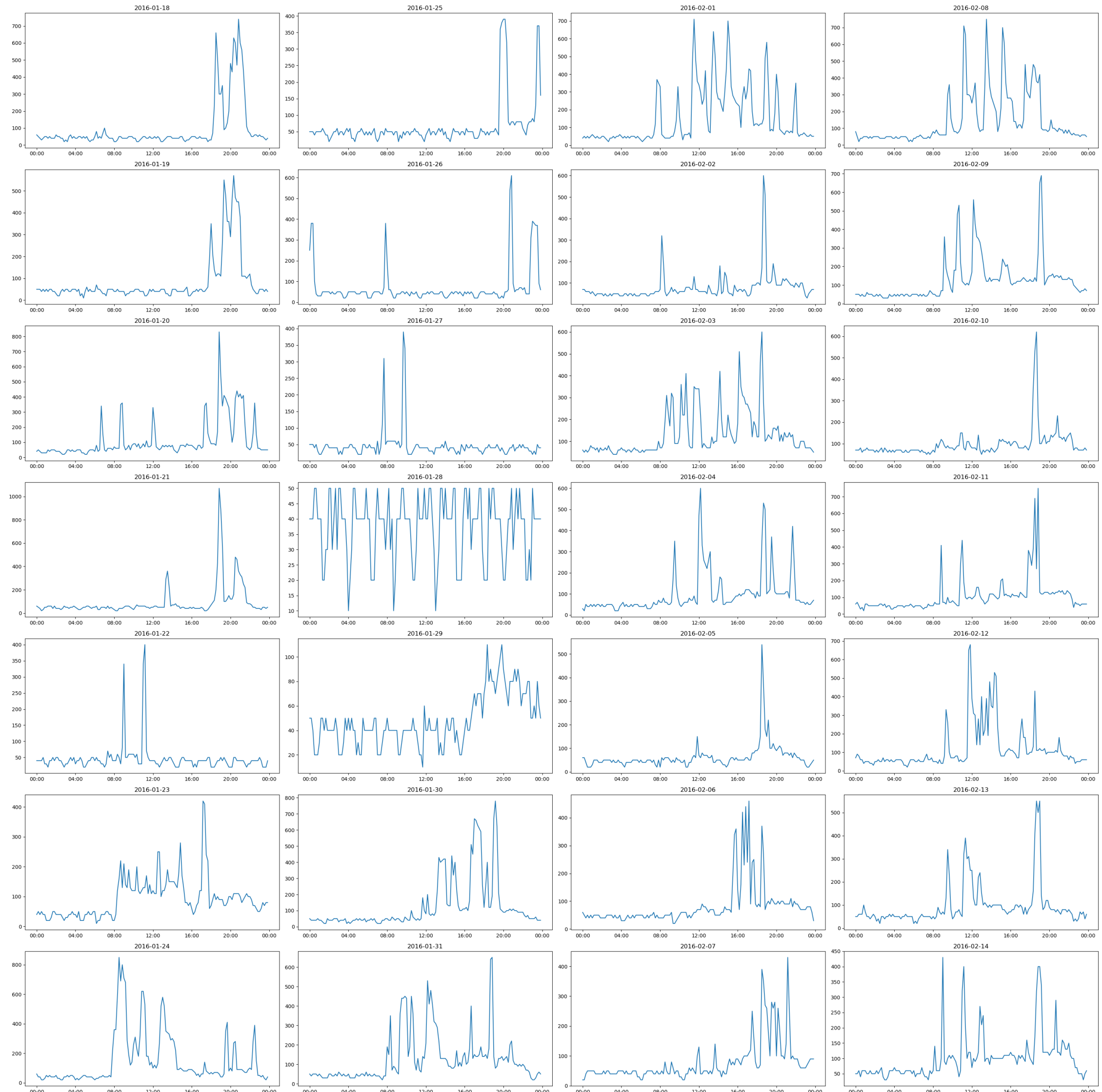
2.2.1 Target visualisation

[ ]:
```
# visualise target
import warnings
warnings.filterwarnings("ignore")

plt.figure(figsize=(30, 10))
sns.lineplot(data['appliance'])
plt.title('Appliances energy consumption over time')
plt.xlabel('date')
plt.ylabel('appliances energy consumption')
plt.show()
```

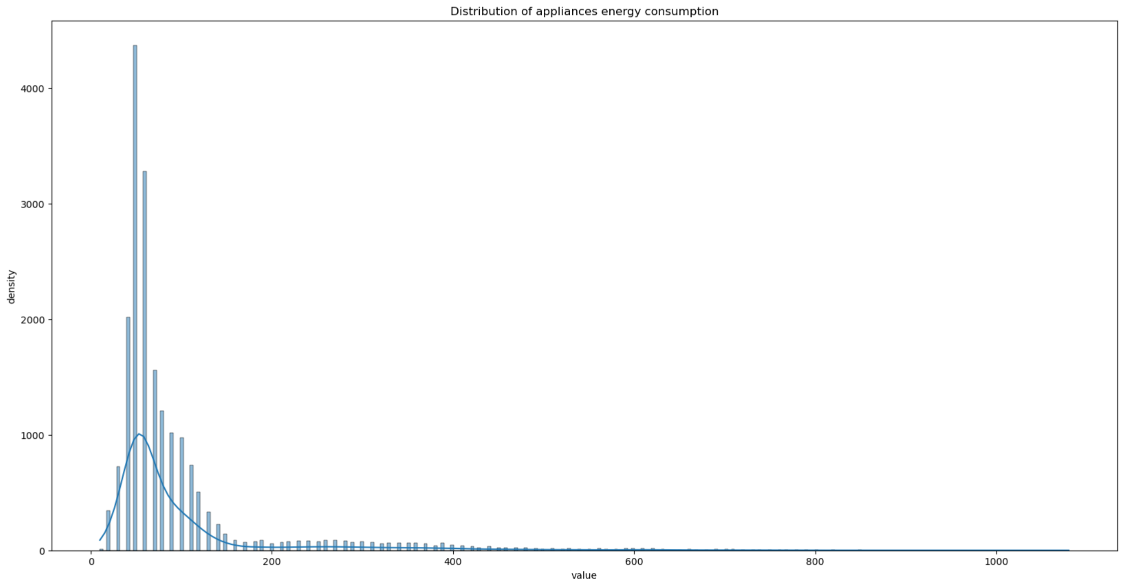


[ ]:

```
# have a closer look for 4 weeks data
start_date = '2016-01-18'
end_date = pd.to_datetime(start_date) + pd.DateOffset(days=27)

fig, axes = plt.subplots(nrows=7, ncols=4, figsize=(30, 30))

for i, day in enumerate(pd.date_range(start=start_date, end=end_date)):
    daily_data = data.loc[day.strftime('%Y-%m-%d')]
    ax = axes[i % 7, i // 7]
    ax.plot(daily_data.index, daily_data['appliance'])
    ax.xaxis.set_major_locator(mdates.HourLocator(interval=4))
    ax.xaxis.set_major_formatter(mdates.DateFormatter('%H:%M'))
    ax.set_title(day.strftime('%Y-%m-%d'))

plt.tight_layout()
plt.show()
```

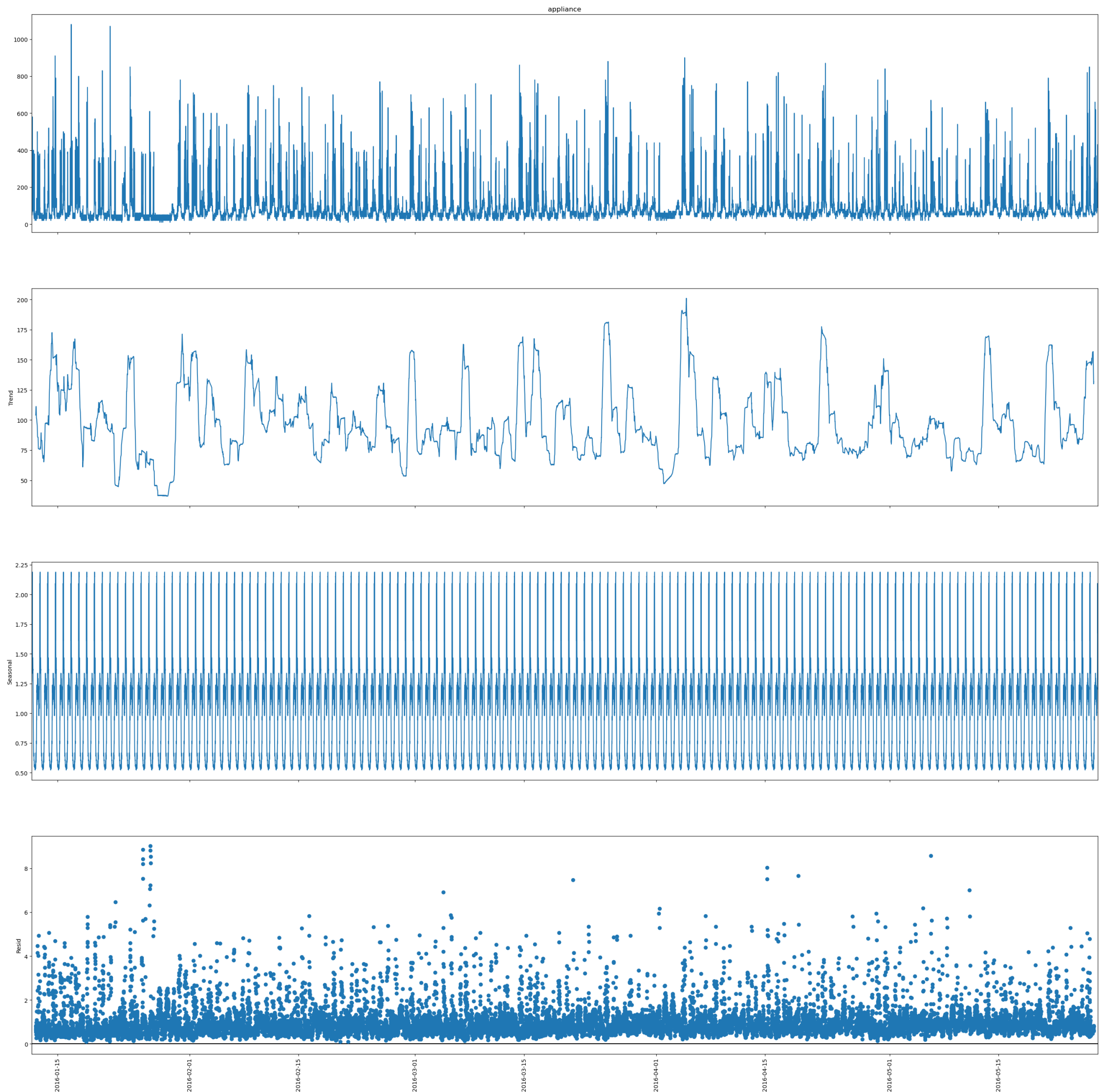


[ ]:
```
# distribution of target
plt.figure(figsize=(20, 10))
sns.histplot(data['appliance'], kde=True)
plt.title('Distribution of appliances energy consumption')
plt.xlabel('value')
plt.ylabel('density')
plt.show()
```



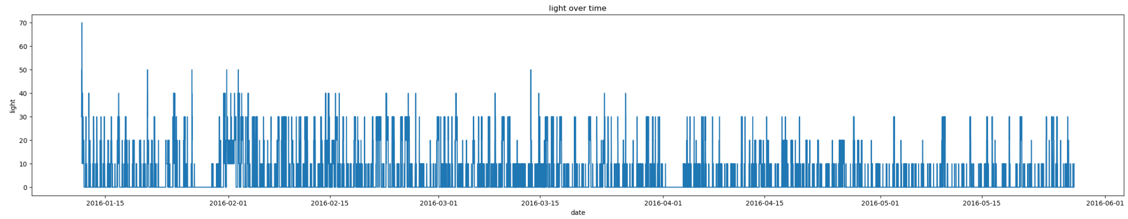

```
[ ]: # too much noise in data appliance, decompose to seperate trend, seasonility,␣
     ↪and noise [4, p. 401-402]
     plt.figure(figsize=(30, 30))
     dcp_appliance = sm.tsa.seasonal_decompose(data['appliance'],␣
     ↪model='multiplicative', period=144)
     dcp_appliance.plot()
     plt.gcf().set_size_inches(30, 30)
     plt.xticks(rotation=90)
     plt.show()
```

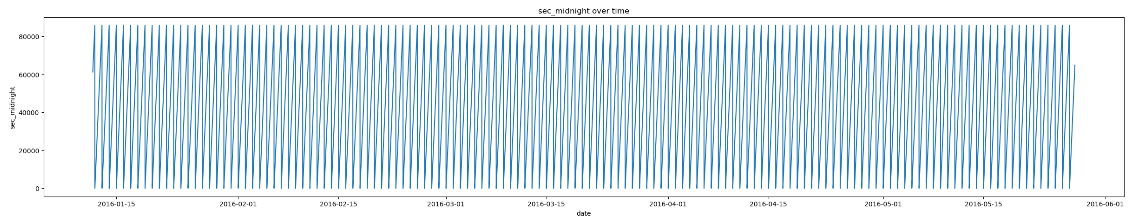
```
<Figure size 3000x3000 with 0 Axes>
```

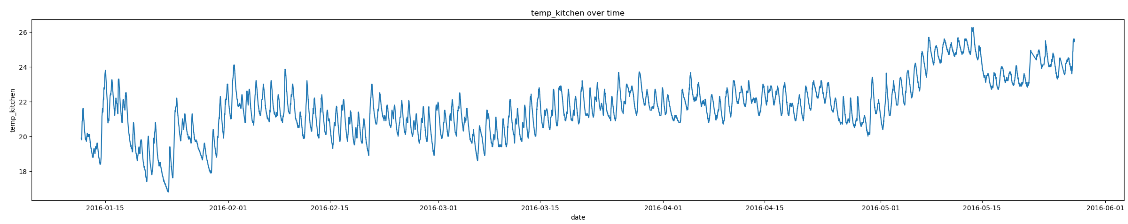


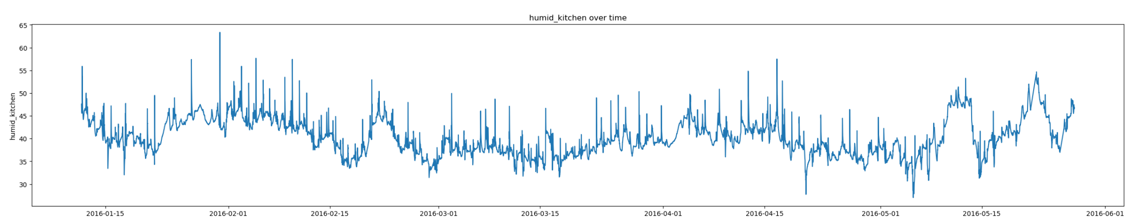
2.2.2 Sensor features visualisation

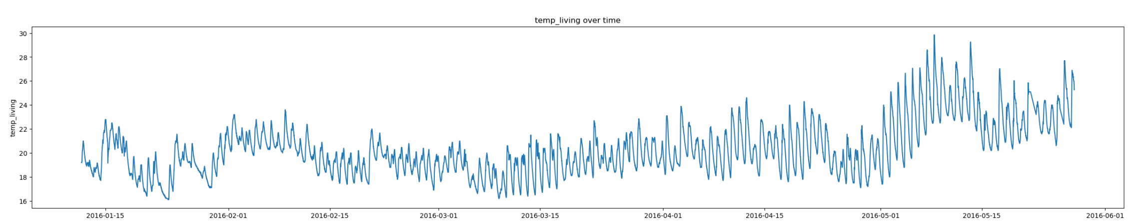
[ ]:
```python
# visualise sensor features
for feature in sensor:
    plt.figure(figsize=(30, 5))
    sns.lineplot(data[feature])
    plt.title(f'{feature} over time')
    plt.xlabel('date')
    plt.ylabel(f'{feature}')
    plt.show()
```

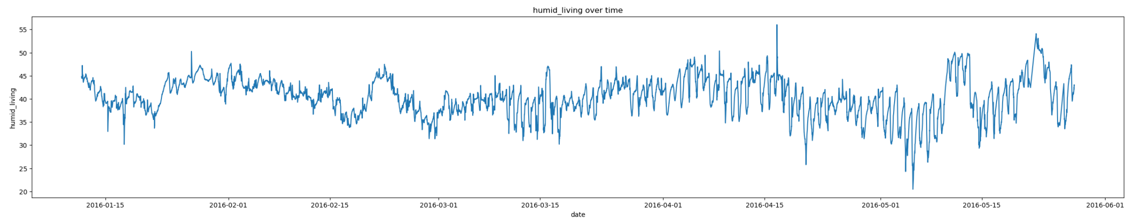

light over time
light
date

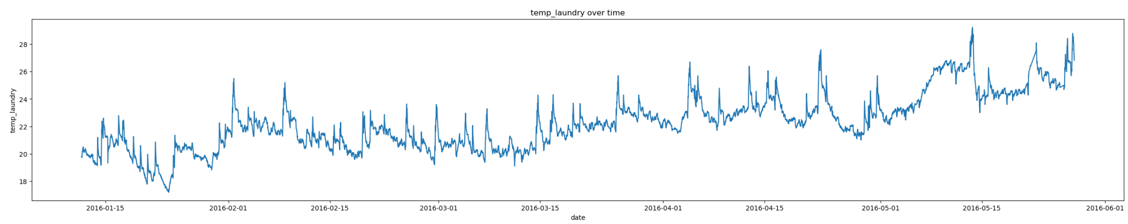

sec_midnight over time
sec_midnight
date

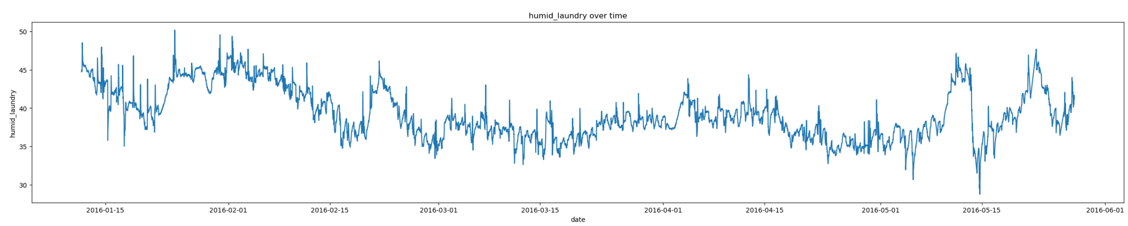

temp_kitchen over time
temp_kitchen
date

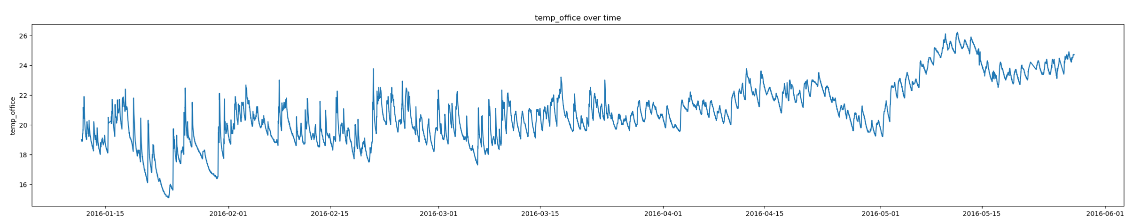

humid_kitchen over time
humid_kitchen
date

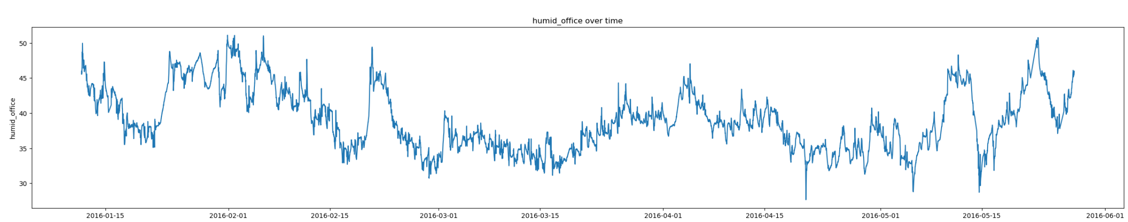

temp_living over time
temp_living
date

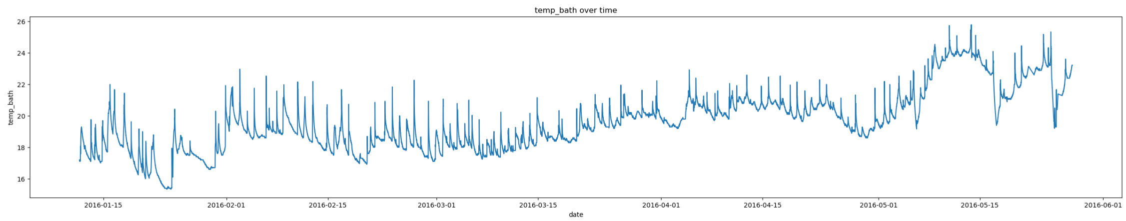

humid_living over time
humid_living
55
50
45
40
35
30
25
20
2016-01-15
2016-02-01
2016-02-15
2016-03-01
2016-03-15
2016-04-01
2016-04-15
2016-05-01
2016-05-15
2016-06-01
date

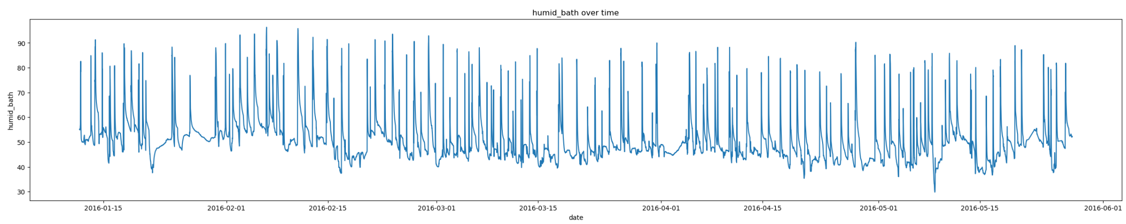

temp_laundry over time
temp_laundry
28
26
24
22
20
18
2016-01-15
2016-02-01
2016-02-15
2016-03-01
2016-03-15
2016-04-01
2016-04-15
2016-05-01
2016-05-15
2016-06-01
date

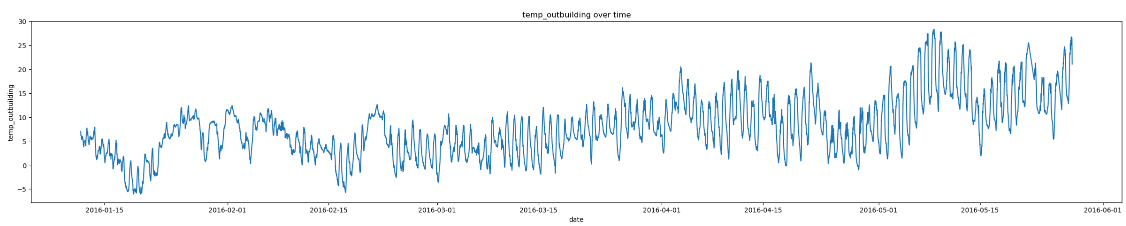

humid_laundry over time
humid_laundry
50
45
40
35
30
2016-01-15
2016-02-01
2016-02-15
2016-03-01
2016-03-15
2016-04-01
2016-04-15
2016-05-01
2016-05-15
2016-06-01
date

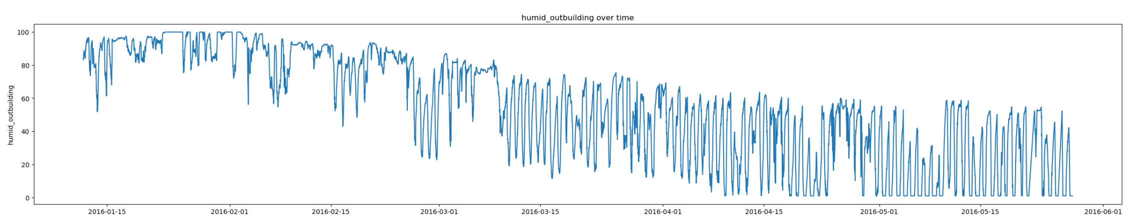

temp_office over time
temp_office
26
24
22
20
18
16
2016-01-15
2016-02-01
2016-02-15
2016-03-01
2016-03-15
2016-04-01
2016-04-15
2016-05-01
2016-05-15
2016-06-01
date

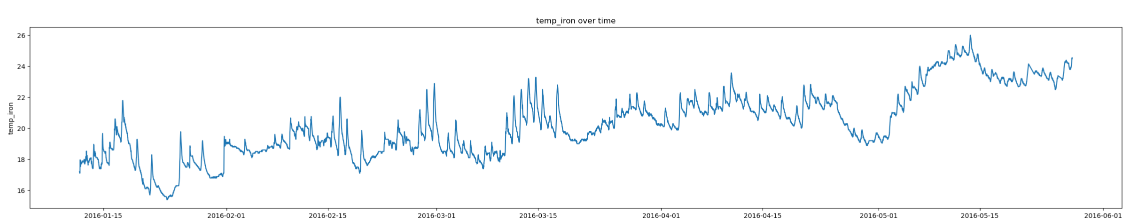

humid_office over time
humid_office
50
45
40
35
30
2016-01-15
2016-02-01
2016-02-15
2016-03-01
2016-03-15
2016-04-01
2016-04-15
2016-05-01
2016-05-15
2016-06-01
date

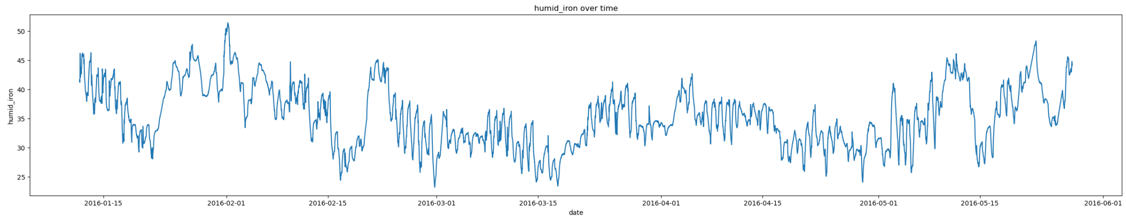

temp_bath over time
temp_bath
date
16
18
20
22
24
26
2016-01-15
2016-02-01
2016-02-15
2016-03-01
2016-03-15
2016-04-01
2016-04-15
2016-05-01
2016-05-15
2016-06-01

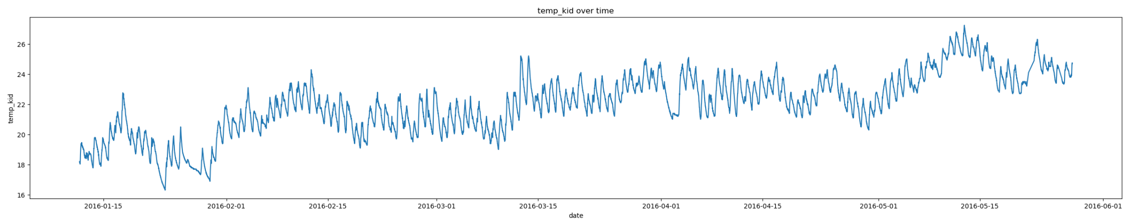

humid_bath over time
humid_bath
date
30
40
50
60
70
80
90
2016-01-15
2016-02-01
2016-02-15
2016-03-01
2016-03-15
2016-04-01
2016-04-15
2016-05-01
2016-05-15
2016-06-01

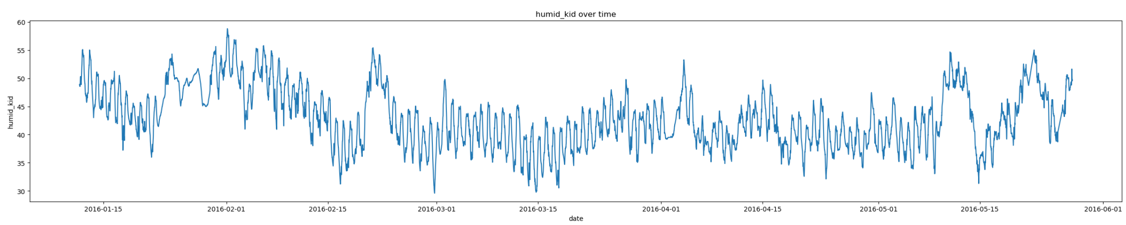

temp_outbuilding over time
temp_outbuilding
date
-5
0
5
10
15
20
25
30
2016-01-15
2016-02-01
2016-02-15
2016-03-01
2016-03-15
2016-04-01
2016-04-15
2016-05-01
2016-05-15
2016-06-01

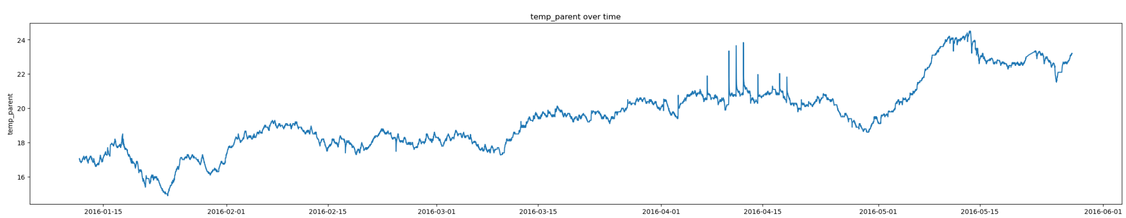

humid_outbuilding over time
humid_outbuilding
date
0
20
40
60
80
100
2016-01-15
2016-02-01
2016-02-15
2016-03-01
2016-03-15
2016-04-01
2016-04-15
2016-05-01
2016-05-15
2016-06-01

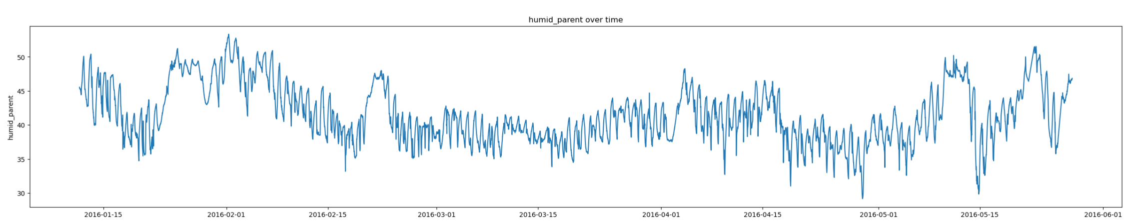

temp_iron over time
temp_iron
date
16
18
20
22
24
26
2016-01-15
2016-02-01
2016-02-15
2016-03-01
2016-03-15
2016-04-01
2016-04-15
2016-05-01
2016-05-15
2016-06-01


humid_iron over time
humid_iron
date
2016-01-15
2016-02-01
2016-02-15
2016-03-01
2016-03-15
2016-04-01
2016-04-15
2016-05-01
2016-05-15
2016-06-01

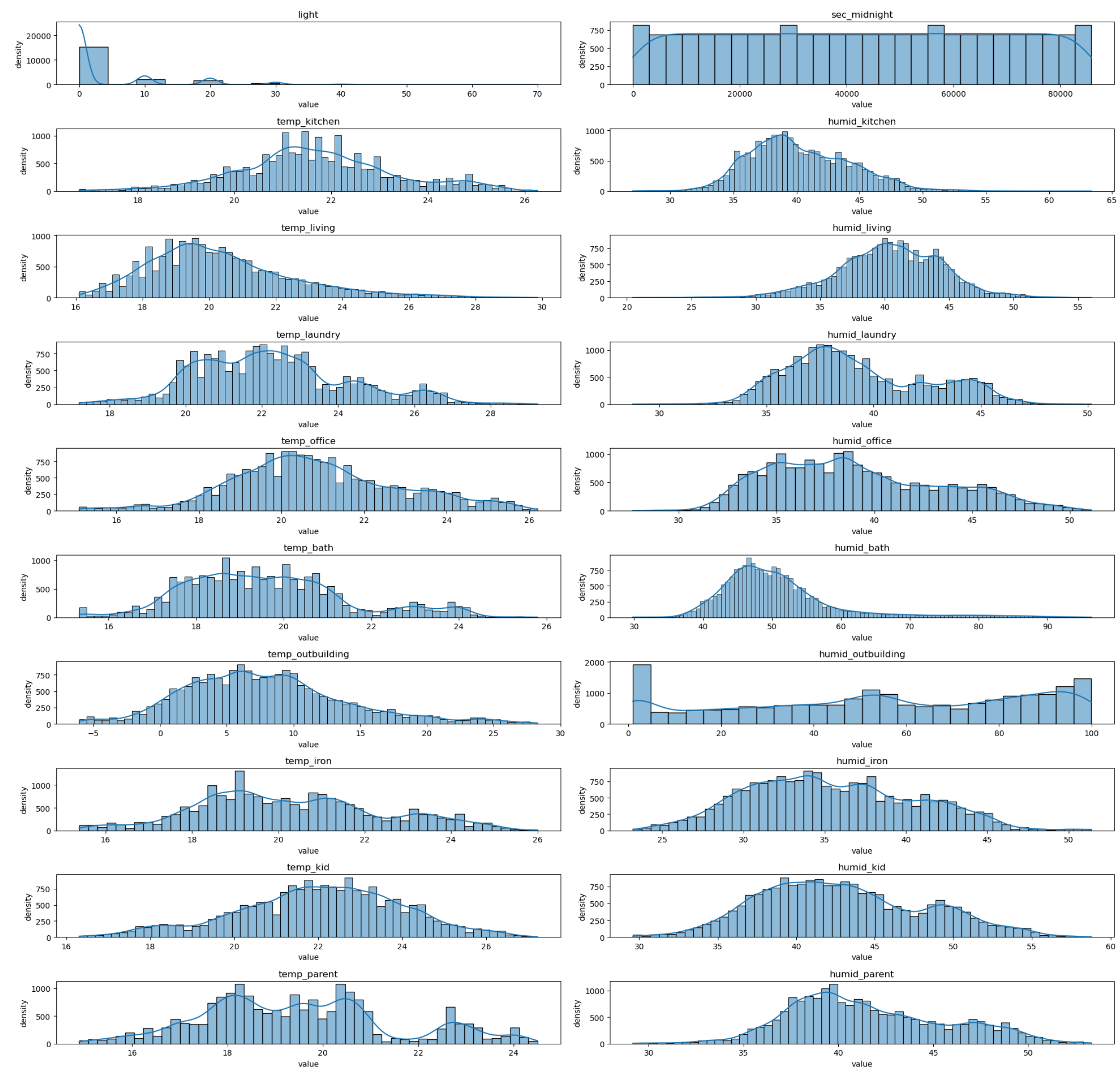

temp_kid over time
temp_kid
date
2016-01-15
2016-02-01
2016-02-15
2016-03-01
2016-03-15
2016-04-01
2016-04-15
2016-05-01
2016-05-15
2016-06-01


humid_kid over time
humid_kid
date
2016-01-15
2016-02-01
2016-02-15
2016-03-01
2016-03-15
2016-04-01
2016-04-15
2016-05-01
2016-05-15
2016-06-01


temp_parent over time
temp_parent
date
2016-01-15
2016-02-01
2016-02-15
2016-03-01
2016-03-15
2016-04-01
2016-04-15
2016-05-01
2016-05-15
2016-06-01


humid_parent over time
humid_parent
date
2016-01-15
2016-02-01
2016-02-15
2016-03-01
2016-03-15
2016-04-01
2016-04-15
2016-05-01
2016-05-15
2016-06-01

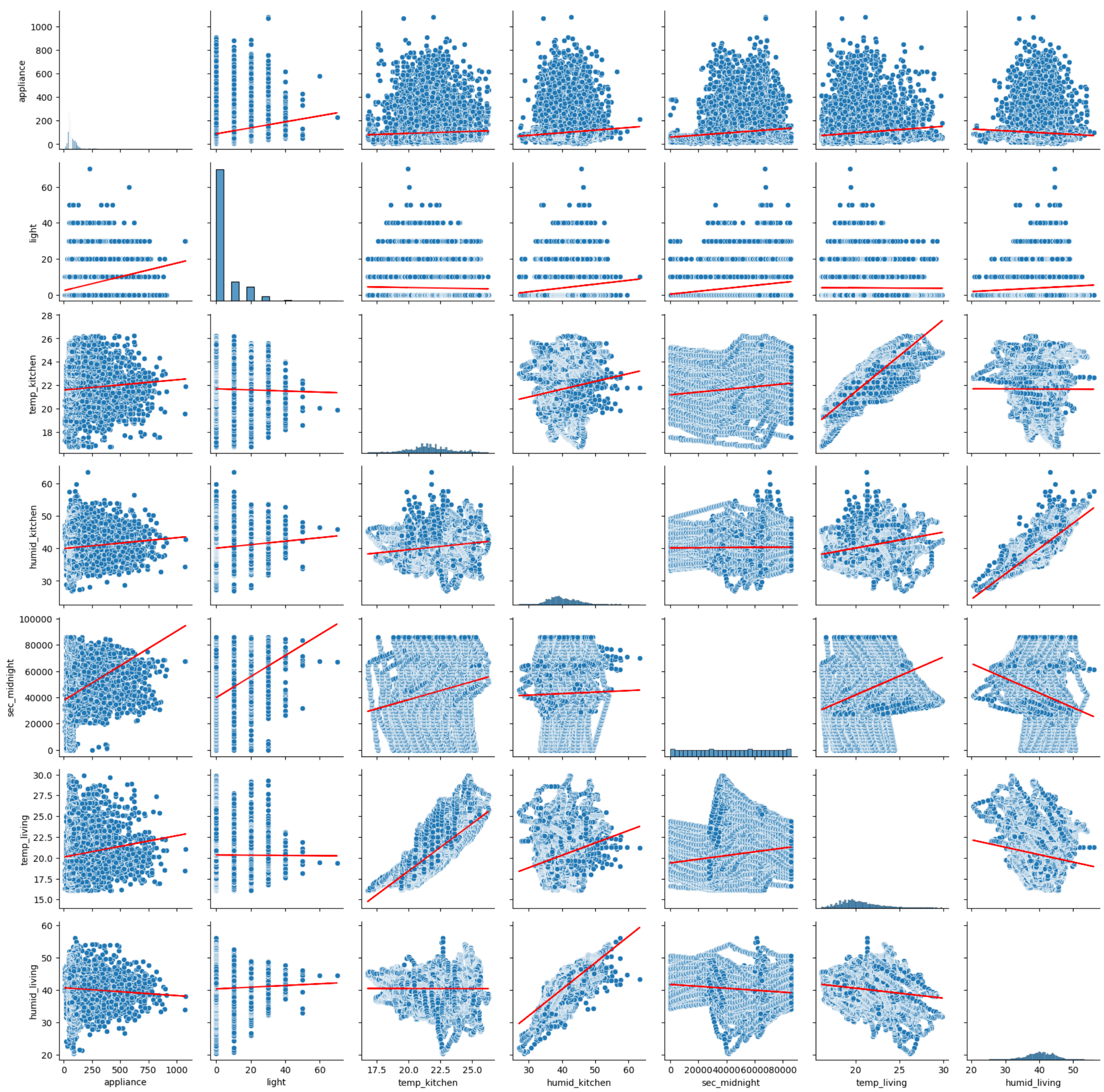
```
[ ]: # distribution of sensor features
fig, axs = plt.subplots(10, 2, figsize=(20,20))
axs = axs.flatten()

for ax, feature in zip(axs, sensor):
    sns.histplot(data[feature], kde=True, ax=ax)
    ax.set_title(feature)
    ax.set_xlabel('value')
    ax.set_ylabel('density')

plt.tight_layout(rect=[0, 0, 1, 0.96])
plt.show()
```



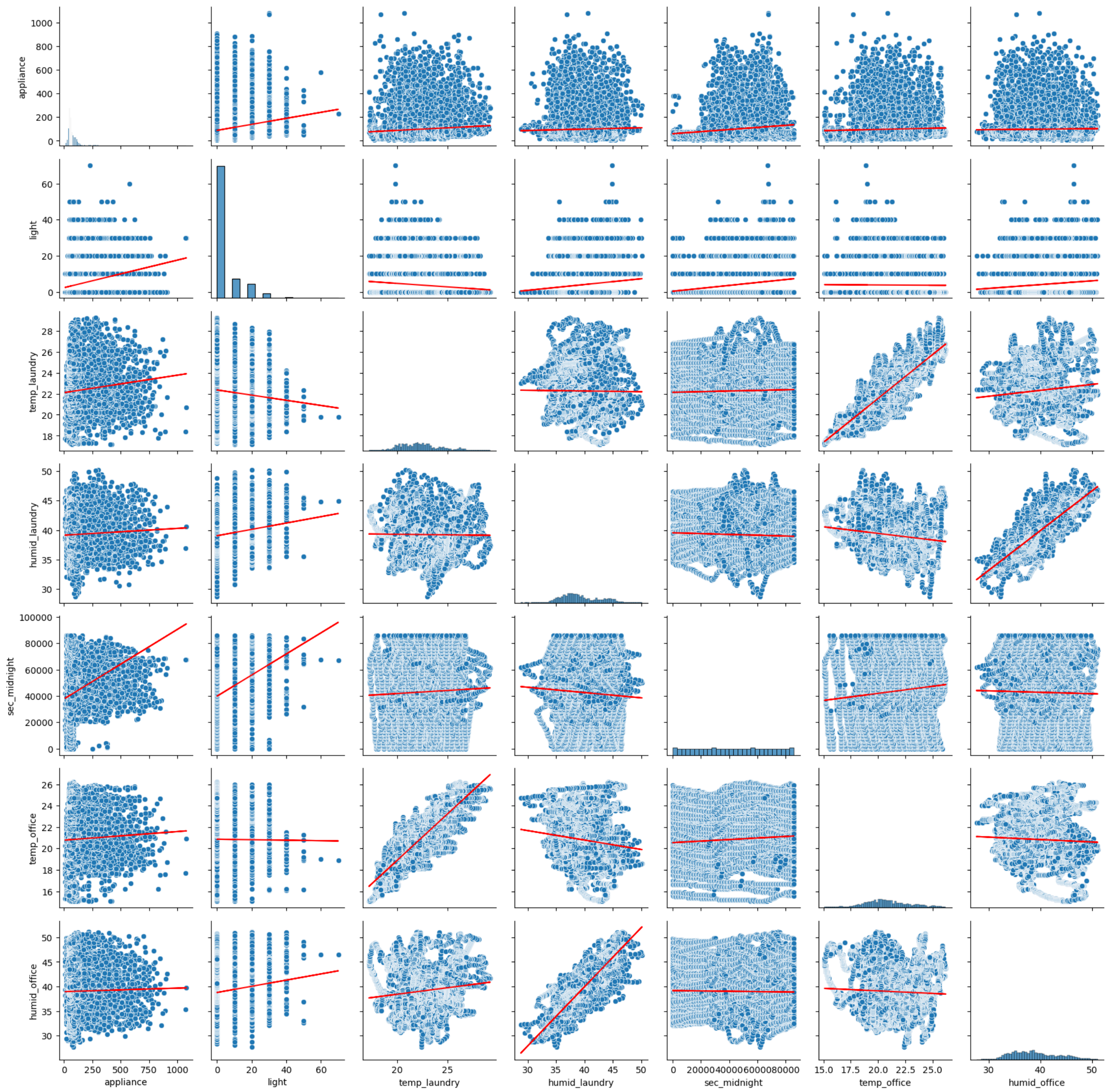
- Check relationship between target and sensor features:

```
[ ]: # define trend line
def plot_trend(x, y, **kwargs):
    coeffs = np.polyfit(x, y, 1)
    plt.plot(x, coeffs[0] * x + coeffs[1], color='red')
```

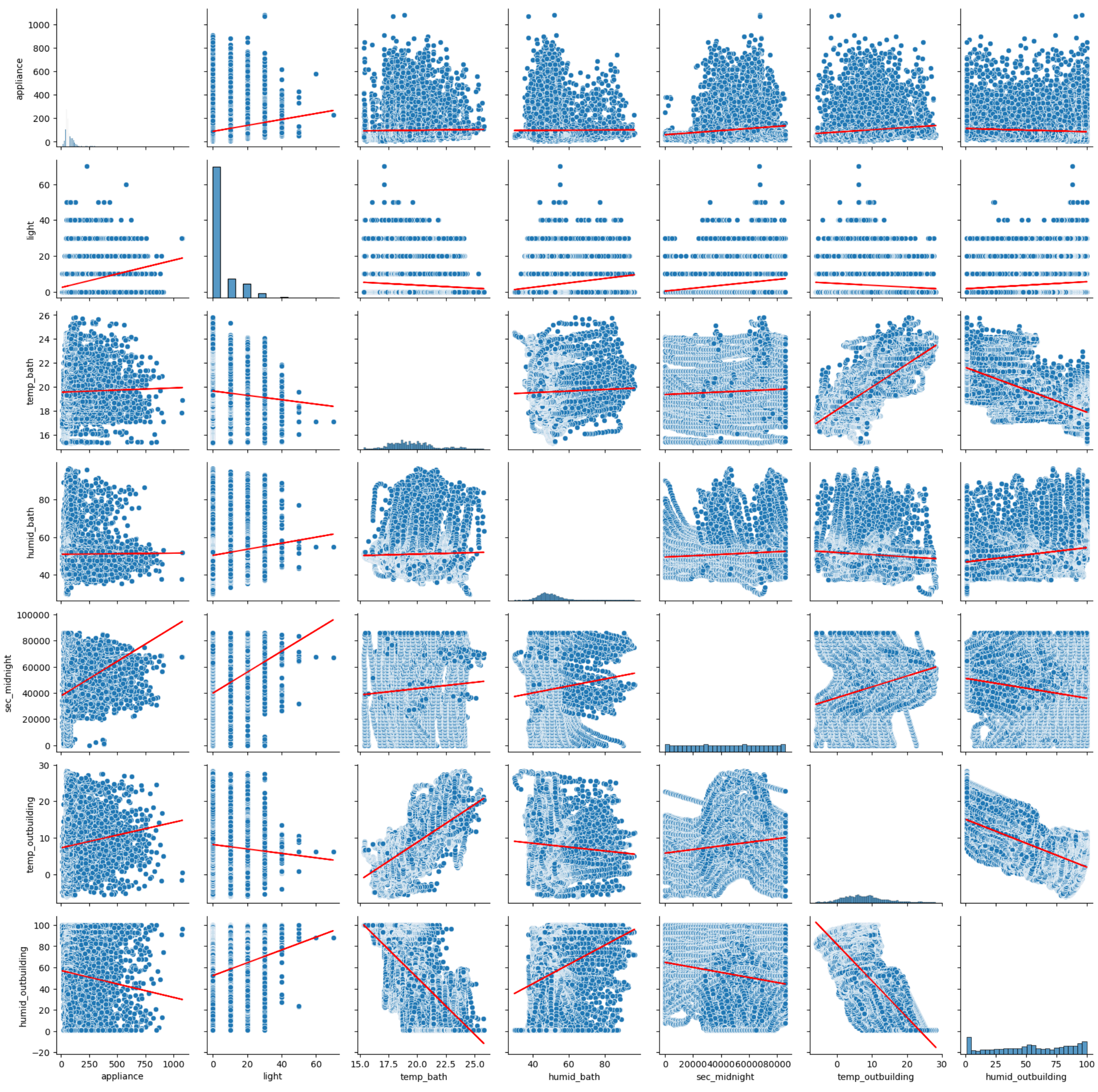
```
[ ]: # sensor features too large, we divided into different plots
sensor_appliance1 = data[['appliance', 'light', 'temp_kitchen',␣
 ↪'humid_kitchen', 'sec_midnight',
                          'temp_living', 'humid_living']].copy()

g = sns.PairGrid(sensor_appliance1)
g.map_offdiag(sns.scatterplot)
g.map_offdiag(plot_trend)
g.map_diag(sns.histplot)
plt.show()
```



[ ]:
```python
# sensor features too large, we divided into different plots
sensor_appliance2 = data[['appliance', 'light', 'temp_laundry', 'humid_laundry',
                         'sec_midnight', 'temp_office', 'humid_office']].copy()

g = sns.PairGrid(sensor_appliance2)
g.map_offdiag(sns.scatterplot)
g.map_offdiag(plot_trend)
g.map_diag(sns.histplot)
plt.show()
```

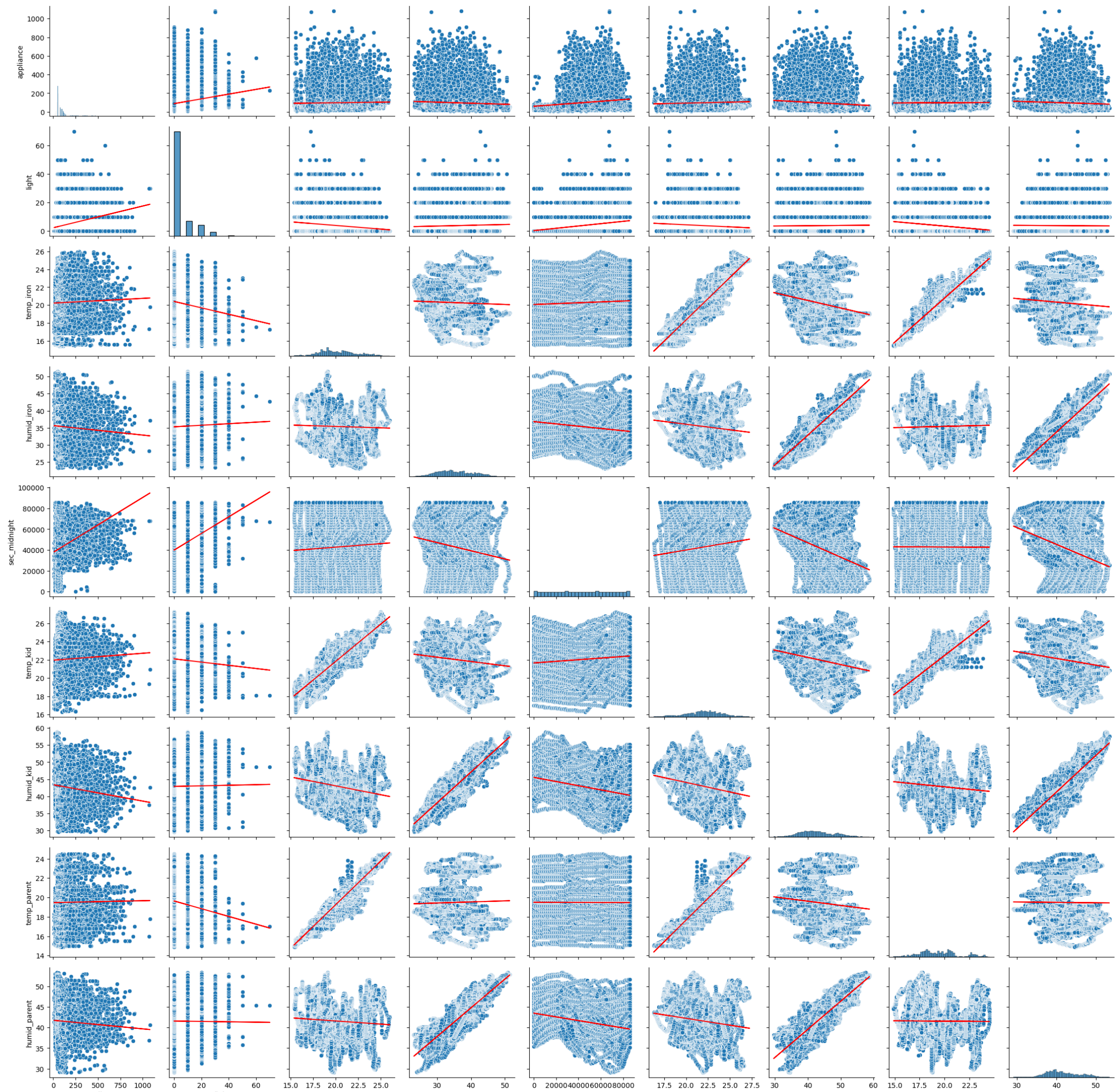


```
[ ]: # sensor features too large, we divided into different plots
sensor_appliance3 = data[['appliance', 'light', 'temp_bath', 'humid_bath',
                          'sec_midnight', 'temp_outbuilding',␣
 ↪'humid_outbuilding']].copy()

g = sns.PairGrid(sensor_appliance3)
g.map_offdiag(sns.scatterplot)
g.map_offdiag(plot_trend)
g.map_diag(sns.histplot)
plt.show()
```



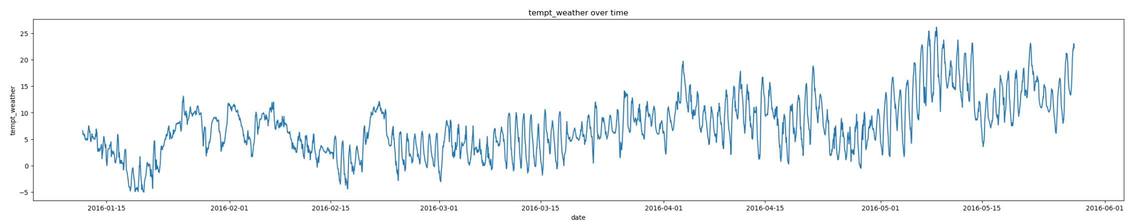

```
[ ]: # sensor features too large, we divided into different plots
```

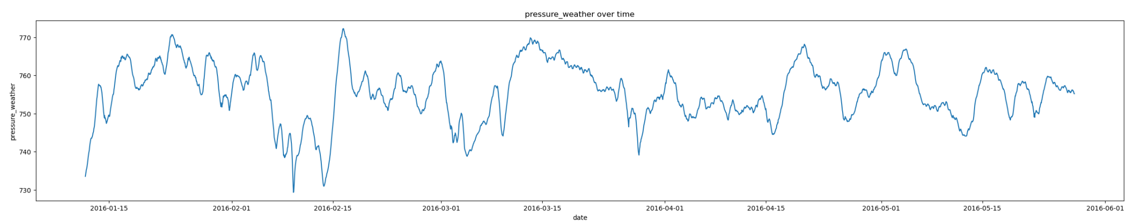
```
sensor_appliance4 = data[['appliance', 'light', 'temp_iron', 'humid_iron',␣
 ↪'sec_midnight',
                              'temp_kid', 'humid_kid', 'temp_parent',␣
 ↪'humid_parent']].copy()

g = sns.PairGrid(sensor_appliance4)
g.map_offdiag(sns.scatterplot)
g.map_offdiag(plot_trend)
g.map_diag(sns.histplot)
plt.show()
```

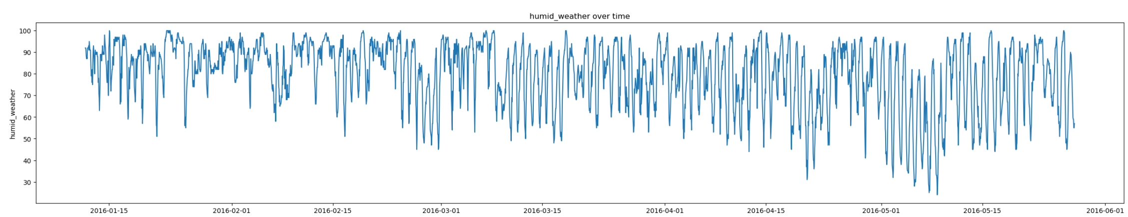


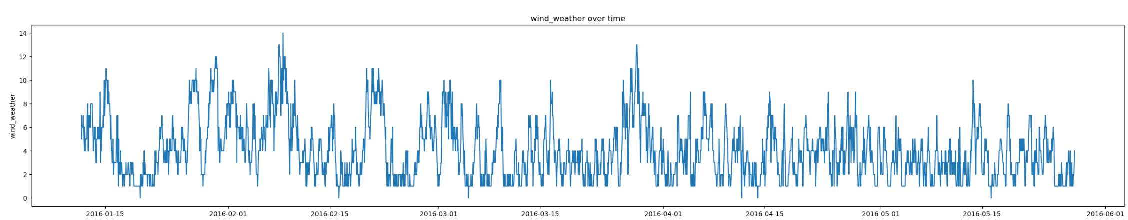
2.2.3 Weather features visualisation

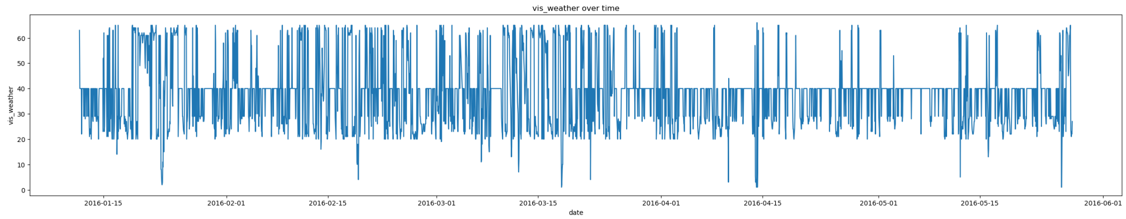
[ ]:
```python
# visualise weather features
for feature in weather:
    plt.figure(figsize=(30, 5))
    sns.lineplot(data[feature])
    plt.title(f'{feature} over time')
    plt.xlabel('date')
    plt.ylabel(f'{feature}')
    plt.show()
```

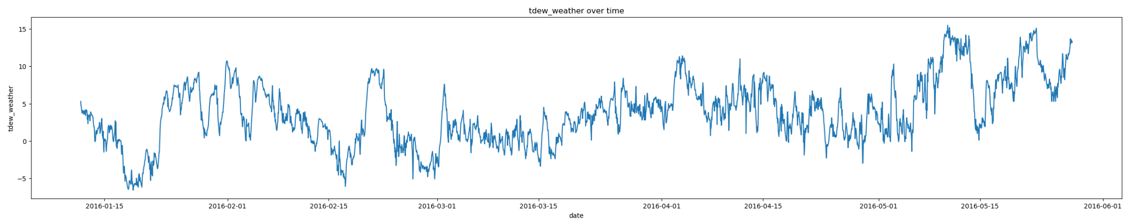






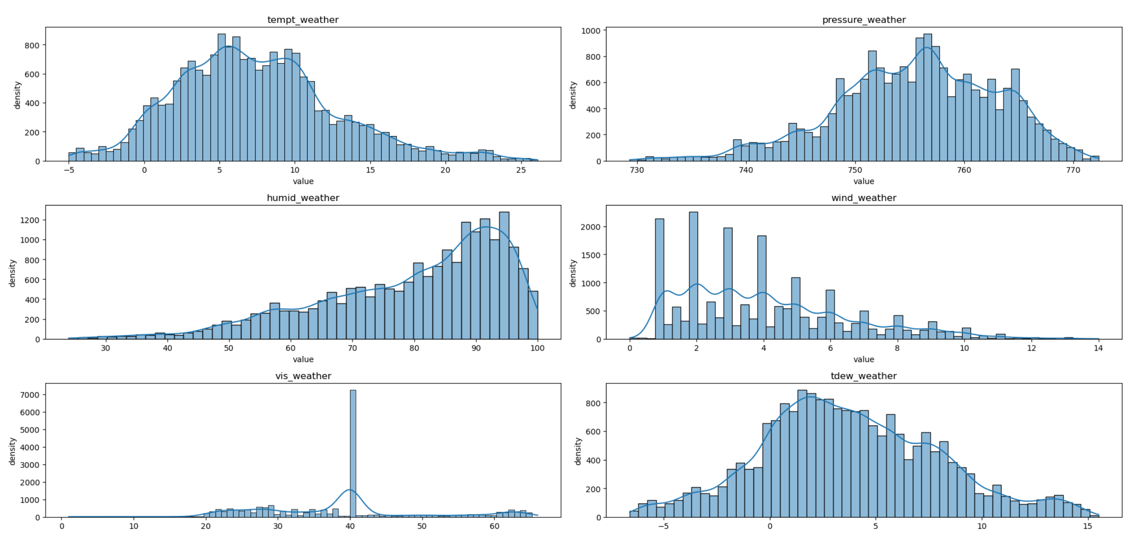






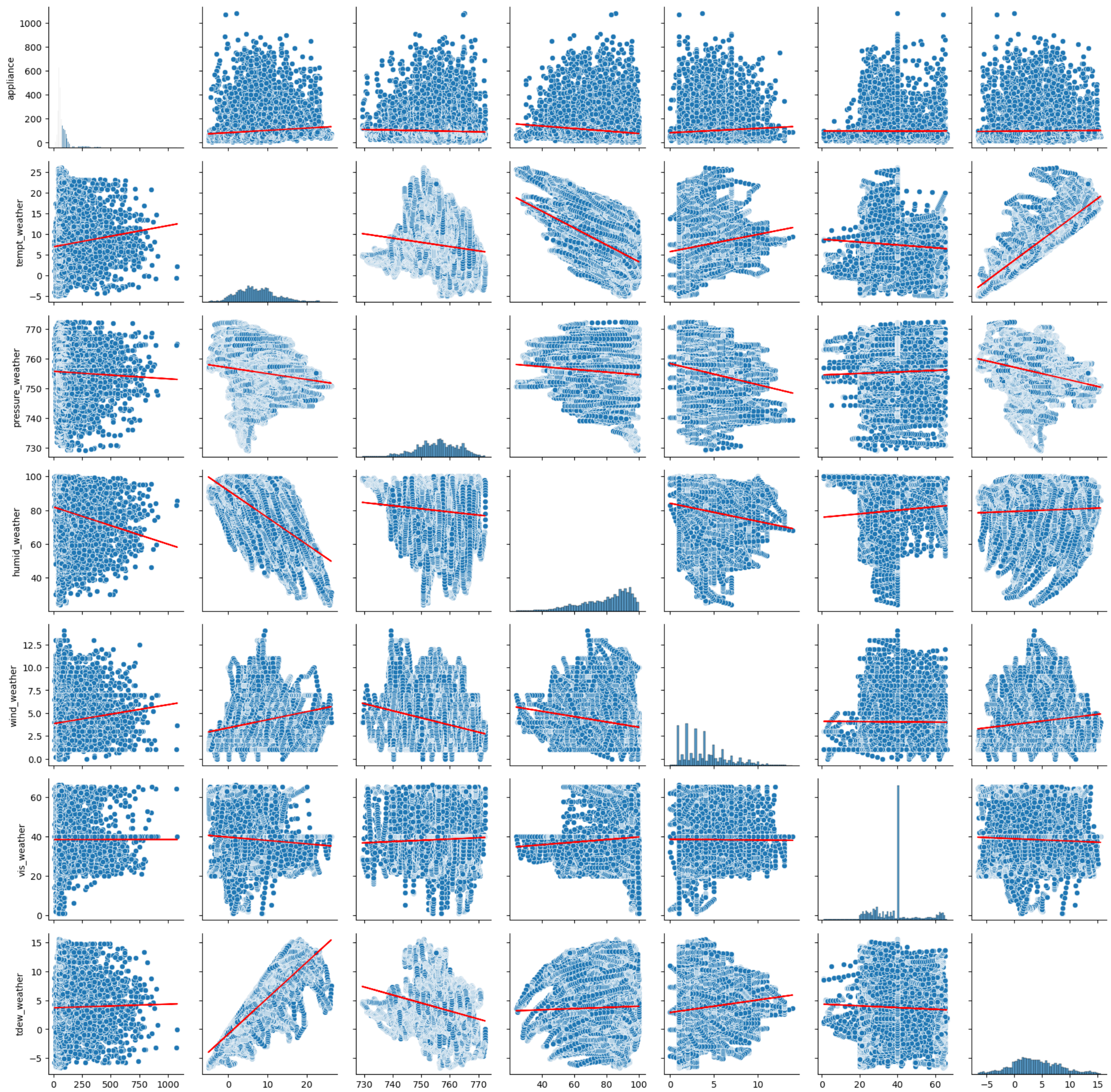
[ ]:

```python
# distribution of weather features
fig, axs = plt.subplots(3, 2, figsize=(20,10))
axs = axs.flatten()

for ax, feature in zip(axs, weather):
    sns.histplot(data[feature], kde=True, ax=ax)
    ax.set_title(feature)
    ax.set_xlabel('value')
    ax.set_ylabel('density')

plt.tight_layout(rect=[0, 0, 1, 0.96])
plt.show()
```



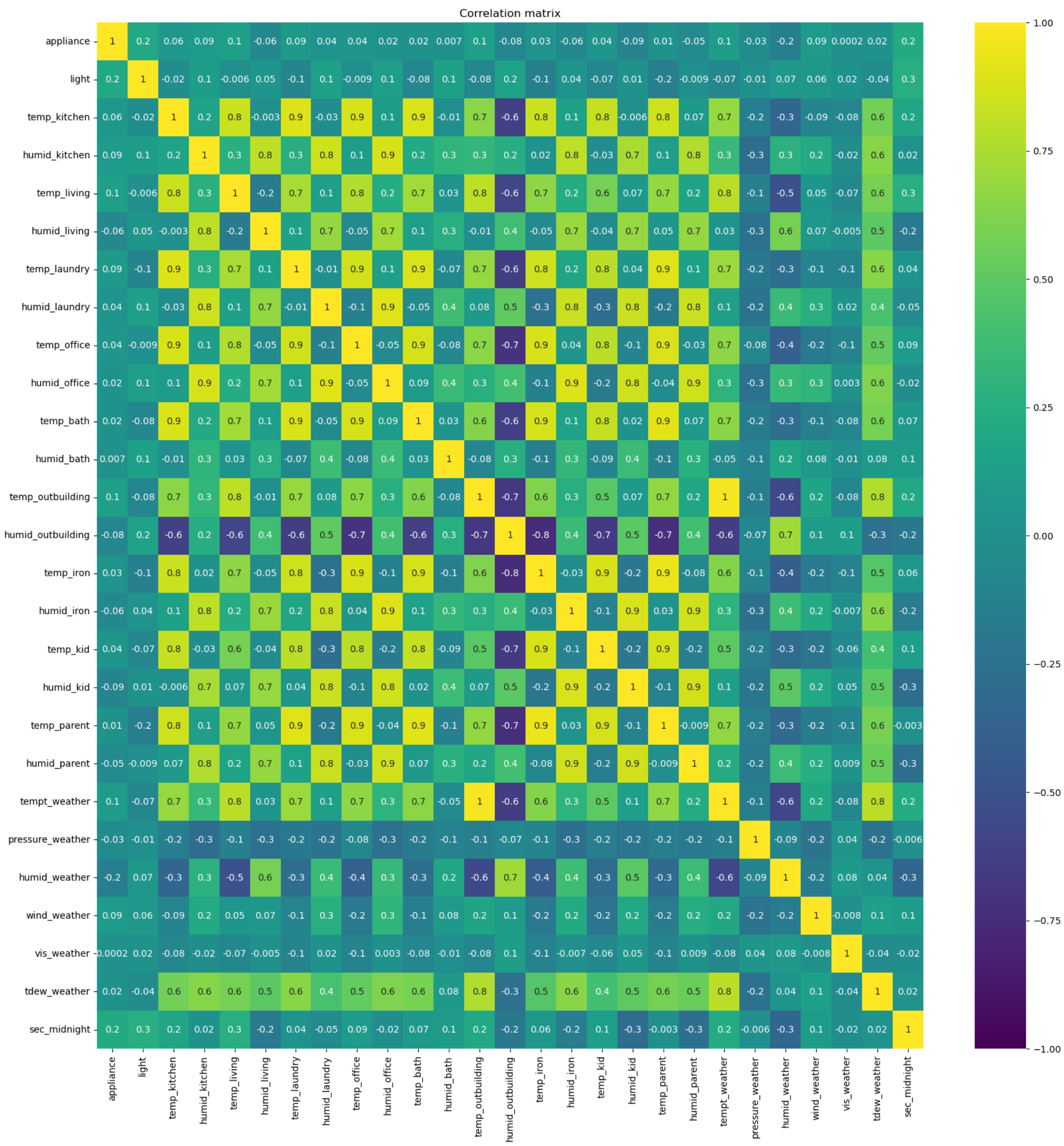
- Check relationship between target and weather features:

```
[ ]: # weather features
weather_appliance = data[['appliance', 'tempt_weather', 'pressure_weather',␣
 ↪'humid_weather',
                          'wind_weather', 'vis_weather', 'tdew_weather']].copy()

g = sns.PairGrid(weather_appliance)
g.map_offdiag(sns.scatterplot)
g.map_offdiag(plot_trend)
g.map_diag(sns.histplot)
plt.show()
```



2.3 Check correlation

```
[ ]: plt.figure(figsize=(20, 20))
     corr = data.corr(numeric_only=True)
     matrix = np.triu(corr)
     sns.heatmap(corr, vmax=1.0, vmin=-1.0, fmt='.1g', annot=True, cmap='viridis')
     plt.title('Correlation matrix')
     plt.show()
```



2.4 Analyse discussion

2.4.1 Relationship between variables From 2.3, there are some observations: - Appliances energy consumption has a high variability. When looking at loser data within 1 month, it seems that it is not seasonal by the day of the week but by hourly and daily. It appears to be affected by the previous day's consumption. When decompositing with multiplicative method, no trend obviously, but have uniform seasonal change. Non-uniform noise that represents outliers and missing values. - Light energy consumption is also quite similar to appliance energy consumption but has less variability. All the sensor features appears to have seasonal data by daily. - All features, including sensor and weather appears non-uniform distribution -> need scaled - It seems like the appliance energy consumption increases if light energy consumption, and temperature in all rooms increase. Energy consumptions increase from midnight the previous day to the next midnight. There is no strong evidence to show any relationship between humidity, weather features and energy consumption.

2.4.2 Model selection We'll use 3 different methods for time series forecasting as [4, p. 4] to compare the results: - Smoothing based method: Seasonal Naive as a baseline - Regression based method: AutoARIMA [5] - Machine learning based method: LSTM [5]

2.4.3 Feature selections and Pre-processing steps With [1, pp. 92-93], we've known that all features have large correlation with each features and helps to reduce RMSE of appliances energy consumption prediction. However, many features have small correlation with appliances energy consumption, we'll use PCA to reduce the dimension for better forecasting models. [7]

0.1.4 3. Implement prediction models

3.1 Pre-processing

[ ]:
```
# create data for modelling
model_data = data.copy()
model_data.head()
```

[ ]:
```
                           appliance  light  temp_kitchen  humid_kitchen  \
date
2016-01-11 17:00:00+00:00         60     30         19.89      47.596667
2016-01-11 17:10:00+00:00         60     30         19.89      46.693333
2016-01-11 17:20:00+00:00         50     30         19.89      46.300000
2016-01-11 17:30:00+00:00         50     40         19.89      46.066667
2016-01-11 17:40:00+00:00         60     40         19.89      46.333333

                           temp_living  humid_living  temp_laundry  \
date
2016-01-11 17:00:00+00:00         19.2     44.790000         19.79
2016-01-11 17:10:00+00:00         19.2     44.722500         19.79
2016-01-11 17:20:00+00:00         19.2     44.626667         19.79
2016-01-11 17:30:00+00:00         19.2     44.590000         19.79
2016-01-11 17:40:00+00:00         19.2     44.530000         19.79

                           humid_laundry  temp_office  humid_office  …  \
date                                                                 …
2016-01-11 17:00:00+00:00      44.730000    19.000000     45.566667  …
```

```
2016-01-11 17:10:00+00:00     44.790000    19.000000     45.992500  …
2016-01-11 17:20:00+00:00     44.933333    18.926667     45.890000  …
2016-01-11 17:30:00+00:00     45.000000    18.890000     45.723333  …
2016-01-11 17:40:00+00:00     45.000000    18.890000     45.530000  …

                           humid_kid  temp_parent  humid_parent  \
date
2016-01-11 17:00:00+00:00  48.900000    17.033333         45.53
2016-01-11 17:10:00+00:00  48.863333    17.066667         45.56
2016-01-11 17:20:00+00:00  48.730000    17.000000         45.50
2016-01-11 17:30:00+00:00  48.590000    17.000000         45.40
2016-01-11 17:40:00+00:00  48.590000    17.000000         45.40

                           tempt_weather  pressure_weather  humid_weather  \
date
2016-01-11 17:00:00+00:00       6.600000             733.5           92.0
2016-01-11 17:10:00+00:00       6.483333             733.6           92.0
2016-01-11 17:20:00+00:00       6.366667             733.7           92.0
2016-01-11 17:30:00+00:00       6.250000             733.8           92.0
2016-01-11 17:40:00+00:00       6.133333             733.9           92.0

                           wind_weather  vis_weather  tdew_weather  \
date
2016-01-11 17:00:00+00:00      7.000000    63.000000           5.3
2016-01-11 17:10:00+00:00      6.666667    59.166667           5.2
2016-01-11 17:20:00+00:00      6.333333    55.333333           5.1
2016-01-11 17:30:00+00:00      6.000000    51.500000           5.0
2016-01-11 17:40:00+00:00      5.666667    47.666667           4.9

                           sec_midnight
date
2016-01-11 17:00:00+00:00         61200
2016-01-11 17:10:00+00:00         61800
2016-01-11 17:20:00+00:00         62400
2016-01-11 17:30:00+00:00         63000
2016-01-11 17:40:00+00:00         63600

[5 rows x 27 columns]
```

[ ]:
```
model_data.columns
```

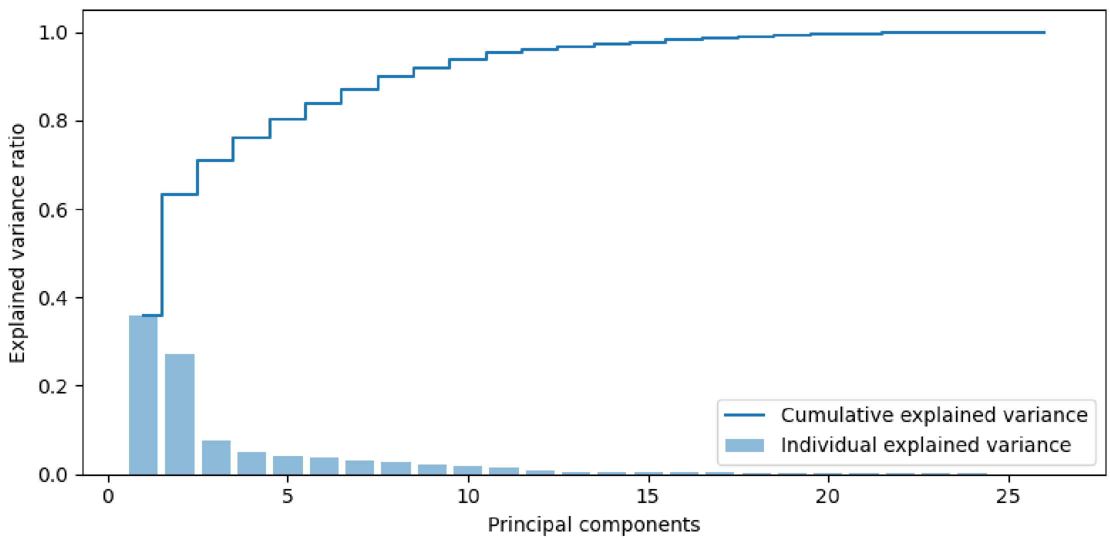
[ ]:
```
Index(['appliance', 'light', 'temp_kitchen', 'humid_kitchen', 'temp_living',
       'humid_living', 'temp_laundry', 'humid_laundry', 'temp_office',
       'humid_office', 'temp_bath', 'humid_bath', 'temp_outbuilding',
       'humid_outbuilding', 'temp_iron', 'humid_iron', 'temp_kid', 'humid_kid',
       'temp_parent', 'humid_parent', 'tempt_weather', 'pressure_weather',
       'humid_weather', 'wind_weather', 'vis_weather', 'tdew_weather',
```

```
       'sec_midnight'],
      dtype='object')
```

[ ]:
```
# scale data for pca
from sklearn.decomposition import PCA
from sklearn.preprocessing import StandardScaler

features = ['light', 'temp_kitchen', 'humid_kitchen', 'temp_living',
       'humid_living', 'temp_laundry', 'humid_laundry', 'temp_office',
       'humid_office', 'temp_bath', 'humid_bath', 'temp_outbuilding',
       'humid_outbuilding', 'temp_iron', 'humid_iron', 'temp_kid', 'humid_kid',
       'temp_parent', 'humid_parent', 'tempt_weather', 'pressure_weather',
       'humid_weather', 'wind_weather', 'vis_weather', 'tdew_weather',
       'sec_midnight']

feature = model_data[features]
target = model_data['appliance']

scaler = StandardScaler()
feature_scaled = scaler.fit_transform(feature)
feature_scaled.shape
```

[ ]: (19735, 26)

[ ]:
```
# check how many components should use for pca
pca = PCA()
feature_pca = pca.fit_transform(feature_scaled)

explained_variance = pca.explained_variance_ratio_

plt.figure(figsize=(8, 4))
plt.bar(range(1, len(explained_variance)+1), explained_variance, alpha=0.5,␣
 ↪align='center',
        label='Individual explained variance')
plt.step(range(1, len(explained_variance)+1), np.cumsum(explained_variance),␣
 ↪where='mid',
         label='Cumulative explained variance')
plt.ylabel('Explained variance ratio')
plt.xlabel('Principal components')
plt.legend(loc='best')
plt.tight_layout()
plt.show()
```



[ ]:
```
# we can see there's none explaination from the components 12, suggest have 11␣
↪components ~ 11 features
pca = PCA(n_components=11)
feature_reduced = pca.fit_transform(feature_scaled)
feature_reduced.shape
```

[ ]: (19735, 11)

[ ]:
```
# merge data together to train model
pca_col = ['PCA1', 'PCA2', 'PCA3', 'PCA4','PCA5', 'PCA6','PCA7', 'PCA8','PCA9',␣
↪'PCA10', 'PCA11']
df_pca = pd.DataFrame(feature_reduced, columns=pca_col, index=model_data.index)

df_pca['appliance'] = target

final_data = df_pca

final_data.describe()
```

[ ]:

	PCA1	PCA2	PCA3	PCA4	PCA5 \
count	19735.000000	1.973500e+04	1.973500e+04	1.973500e+04	1.973500e+04
mean	0.000000	1.152134e-17	2.304268e-17	-2.304268e-17	-1.152134e-17
std	3.056950	2.662081e+00	1.412408e+00	1.163478e+00	1.023178e+00
min	-6.828388	-6.970744e+00	-3.491848e+00	-2.589856e+00	-3.484948e+00
25%	-2.185861	-2.000712e+00	-1.123086e+00	-7.623705e-01	-6.924520e-01
50%	-0.465450	3.869719e-01	1.437731e-01	-2.864891e-01	1.400935e-02
75%	1.785984	1.940998e+00	1.056798e+00	5.427464e-01	6.841799e-01
max	9.048071	7.196335e+00	3.880941e+00	5.785400e+00	3.698356e+00

```
               PCA6          PCA7          PCA8          PCA9         PCA10  \
count  1.973500e+04  1.973500e+04  1.973500e+04  1.973500e+04  1.973500e+04
mean   2.304268e-17 -5.760671e-18 -2.880335e-18  6.336738e-17 -4.824562e-17
std    9.889328e-01  9.178525e-01  8.345308e-01  7.466408e-01  6.997467e-01
min   -3.490086e+00 -4.222105e+00 -2.614079e+00 -2.300641e+00 -2.637617e+00
25%   -6.789331e-01 -4.792773e-01 -5.768780e-01 -5.034695e-01 -4.482365e-01
50%   -1.626084e-02 -9.237270e-02  2.999405e-03  4.391792e-02 -3.392166e-02
75%    6.300275e-01  4.008055e-01  5.656004e-01  5.101629e-01  4.262045e-01
max    3.645304e+00  4.425286e+00  3.714766e+00  2.625079e+00  2.764790e+00

              PCA11     appliance
count  1.973500e+04  19735.000000
mean  -2.304268e-17     97.694958
std    6.105242e-01    102.524891
min   -2.415395e+00     10.000000
25%   -3.999050e-01     50.000000
50%   -9.833825e-03     60.000000
75%    3.890267e-01    100.000000
max    2.598727e+00   1080.000000
```

3.2 Define and train seasonal Naive model

[ ]:
```python
# our data is 10min interval, to predict 1 week data, we split data points of
↪24 x 6 * 7 = 1008 to predict the next week
split_point = 1008
train_snaive = final_data.iloc[:-split_point]
test_snaive = final_data.iloc[-split_point:]

# define seasonal naive model
snaive_forecast = final_data['appliance'].shift(1008).tail(split_point)
snaive_forecast
```

[ ]:
```
date
2016-05-20 18:10:00+00:00    490.0
2016-05-20 18:20:00+00:00    280.0
2016-05-20 18:30:00+00:00    280.0
2016-05-20 18:40:00+00:00    310.0
2016-05-20 18:50:00+00:00    280.0
                             …
2016-05-27 17:20:00+00:00     80.0
2016-05-27 17:30:00+00:00     70.0
2016-05-27 17:40:00+00:00     80.0
2016-05-27 17:50:00+00:00     70.0
2016-05-27 18:00:00+00:00     90.0
Name: appliance, Length: 1008, dtype: float64
```

3.3 Define and train autoARIMA model

[ ]:
```
# split data into train and validation sets
import pmdarima
from pmdarima import auto_arima

train_arima, test_arima = final_data.iloc[:int(0.8 * len(final_data))],␣
↪final_data.iloc[int(0.8 * len(final_data)):]
```

[ ]:
```
#decompose seasonal by using Fourier
_, ff_X = FourierFeaturizer(144, k=6).fit_transform(train_arima['appliance'])

new_feature = ['PCA1', 'PCA2', 'PCA3', 'PCA4', 'PCA5', 'PCA6',
               'PCA7', 'PCA8', 'PCA9', 'PCA10', 'PCA11']

exog = pd.concat([ff_X, train_arima[new_feature].reset_index(drop=True)],␣
↪axis=1)
exog
```

[ ]:
```
       FOURIER_S144-0  FOURIER_C144-0  FOURIER_S144-1  FOURIER_C144-1  \
0            0.043619        0.999048        0.087156        0.996195
1            0.087156        0.996195        0.173648        0.984808
2            0.130526        0.991445        0.258819        0.965926
3            0.173648        0.984808        0.342020        0.939693
4            0.216440        0.976296        0.422618        0.906308
…                 …               …               …               …
15783       -0.642772       -0.766057        0.984801        0.173688
15784       -0.675575       -0.737291        0.996191        0.087196
15785       -0.707093       -0.707121        1.000000        0.000040
15786       -0.737264       -0.675605        0.996198       -0.087116
15787       -0.766032       -0.642803        0.984815       -0.173609

       FOURIER_S144-2  FOURIER_C144-2  FOURIER_S144-3  FOURIER_C144-3  \
0            0.130526        0.991445        0.173648        0.984808
1            0.258819        0.965926        0.342020        0.939693
2            0.382683        0.923880        0.500000        0.866025
3            0.500000        0.866025        0.642788        0.766044
4            0.608761        0.793353        0.766044        0.642788
…                 …               …               …               …
15783       -0.865997        0.500050        0.342095       -0.939665
15784       -0.793318        0.608807        0.173727       -0.984794
15785       -0.707066        0.707147        0.000080       -1.000000
15786       -0.608716        0.793388       -0.173569       -0.984822
15787       -0.499950        0.866054       -0.341945       -0.939720

       FOURIER_S144-4  FOURIER_C144-4  …      PCA2      PCA3      PCA4  \
0            0.216440        0.976296  … -4.584734  2.267430  2.028781
1            0.422618        0.906308  … -4.512067  2.211060  2.060636
2            0.608761        0.793353  … -4.424334  2.164937  2.097534
```

```
3             0.766044        0.642788  … -4.395544  2.333612  2.891894
4             0.887011        0.461749  … -4.373549  2.269404  2.945647
…                …               …   …       …         …         …
15783         0.342037        0.939687  …  0.549532 -1.523905 -0.820407
15784         0.537314        0.843382  …  0.527817 -1.479021 -0.819717
15785         0.707119        0.707094  …  0.495588 -1.400451 -0.832804
15786         0.843401        0.537285  …  0.524051 -1.340333 -0.847591
15787         0.939699        0.342004  …  0.543966 -1.279992 -0.854967

           PCA5      PCA6      PCA7      PCA8      PCA9     PCA10     PCA11
0     -0.495716  2.864711 -1.638600  0.690243 -0.781087 -1.454360  0.610827
1     -0.613119  2.560064 -1.647138  0.690984 -0.887842 -1.450524  0.539807
2     -0.736862  2.257623 -1.675274  0.662663 -0.989287 -1.450704  0.526745
3     -0.721332  1.958864 -2.313756  1.302523 -1.056990 -1.773713  0.565939
4     -0.844331  1.654080 -2.352275  1.255474 -1.144801 -1.774929  0.592575
…           …         …         …         …         …         …
15783  0.510085 -0.076017 -0.546337 -0.400061 -0.432233 -0.494858 -0.794005
15784  0.524414 -0.081250 -0.577666 -0.451219 -0.417823 -0.511003 -0.786366
15785  0.558164 -0.098041 -0.600981 -0.487431 -0.422496 -0.549756 -0.821596
15786  0.580022 -0.102203 -0.631907 -0.507281 -0.457407 -0.542587 -0.824544
15787  0.590126 -0.108208 -0.666996 -0.551745 -0.444510 -0.551457 -0.749895

[15788 rows x 23 columns]
```

[ ]:
```python
arima_model = auto_arima(train_arima['appliance'], exogenous=exog,
                         start_p=1, start_q=1, max_p=3, max_q=3,
                         m=144, start_P=0, seasonal=False, d=1, D=1,
                         trace=True, error_action='ignore',␣
 ↪suppress_warnings=True)

print(arima_model.summary())
```

```
Performing stepwise search to minimize aic
 ARIMA(1,1,1)(0,0,0)[0] intercept   : AIC=178368.848, Time=3.71 sec
 ARIMA(0,1,0)(0,0,0)[0] intercept   : AIC=180426.307, Time=0.22 sec
 ARIMA(1,1,0)(0,0,0)[0] intercept   : AIC=180382.539, Time=0.16 sec
 ARIMA(0,1,1)(0,0,0)[0] intercept   : AIC=180335.432, Time=1.65 sec
 ARIMA(0,1,0)(0,0,0)[0]             : AIC=180424.308, Time=0.13 sec
 ARIMA(2,1,1)(0,0,0)[0] intercept   : AIC=178013.288, Time=3.13 sec
 ARIMA(2,1,0)(0,0,0)[0] intercept   : AIC=179432.157, Time=0.56 sec
 ARIMA(3,1,1)(0,0,0)[0] intercept   : AIC=177975.486, Time=9.34 sec
 ARIMA(3,1,0)(0,0,0)[0] intercept   : AIC=179115.377, Time=0.77 sec
 ARIMA(3,1,2)(0,0,0)[0] intercept   : AIC=177977.362, Time=14.81 sec
 ARIMA(2,1,2)(0,0,0)[0] intercept   : AIC=177977.844, Time=8.00 sec
 ARIMA(3,1,1)(0,0,0)[0]             : AIC=177973.486, Time=1.48 sec
 ARIMA(2,1,1)(0,0,0)[0]             : AIC=178011.289, Time=0.76 sec
 ARIMA(3,1,0)(0,0,0)[0]             : AIC=179113.378, Time=0.32 sec
 ARIMA(3,1,2)(0,0,0)[0]             : AIC=177975.363, Time=2.34 sec
```

```
 ARIMA(2,1,0)(0,0,0)[0]             : AIC=179430.158, Time=0.27 sec
 ARIMA(2,1,2)(0,0,0)[0]             : AIC=177975.844, Time=1.38 sec

Best model:  ARIMA(3,1,1)(0,0,0)[0]
Total fit time: 49.071 seconds
                               SARIMAX Results
==============================================================================
Dep. Variable:                      y   No. Observations:                15788
Model:               SARIMAX(3, 1, 1)   Log Likelihood              -88981.743
Date:                Tue, 07 May 2024   AIC                         177973.486
Time:                        23:03:16   BIC                         178011.820
Sample:                    01-11-2016   HQIC                        177986.173
                         - 04-30-2016
Covariance Type:                  opg
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ar.L1          0.7346      0.005    133.787      0.000       0.724       0.745
ar.L2         -0.1957      0.005    -39.667      0.000      -0.205      -0.186
ar.L3          0.0589      0.005     11.012      0.000       0.048       0.069
ma.L1         -0.9174      0.004   -237.851      0.000      -0.925      -0.910
sigma2      4604.7886     15.914    289.346      0.000    4573.597    4635.980
================================================================================
===
Ljung-Box (L1) (Q):                   0.00   Jarque-Bera (JB):
314697.72
Prob(Q):                              0.99   Prob(JB):
0.00
Heteroskedasticity (H):               0.81   Skew:
2.87
Prob(H) (two-sided):                  0.00   Kurtosis:
24.11
================================================================================
===

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

3.4 Define and train LSTM model Follow code instruction of [6]:

[ ]:
```
# split data into train and validation sets
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import LSTM, Dense, Dropout

train_lstm, test_lstm = final_data.iloc[:int(0.8 * len(final_data))],␣
 ↪final_data.iloc[int(0.8 * len(final_data)):]
```

[ ]:
```
# convert to x_train, y_train
x_train, y_train = [], []
for i in range(144, len(train_lstm)):
    x_train.append(train_lstm.iloc[i-144:i, 0].values)
    y_train.append(train_lstm.iloc[i, 0])

x_train, y_train = np.array(x_train), np.array(y_train)
```

[ ]:
```
# define model
lstm_model = Sequential()
lstm_model.add(LSTM(units=64, return_sequences=True, dropout=0.15,␣
 ↪recurrent_dropout=0.25,
                    input_shape=(x_train.shape[1],1)))
lstm_model.add(LSTM(units=64))
lstm_model.add(Dense(1))
lstm_model.compile(loss='mean_squared_error', optimizer='adam')
lstm_model.summary()
```

Model: "sequential"

Layer (type)	Output Shape	Param #
lstm (LSTM)	(None, 144, 64)	16,896
lstm_1 (LSTM)	(None, 64)	33,024
dense (Dense)	(None, 1)	65

Total params: 49,985 (195.25 KB)

Trainable params: 49,985 (195.25 KB)

Non-trainable params: 0 (0.00 B)

[ ]:
```
# Train data
lstm_model.fit(x_train, y_train, epochs=20, batch_size=32, verbose=2)
```

```
Epoch 1/20

489/489 - 27s - 55ms/step - loss: 0.6691
Epoch 2/20
489/489 - 27s - 56ms/step - loss: 0.6282
Epoch 3/20
489/489 - 28s - 57ms/step - loss: 0.6861
```

```
Epoch 4/20
489/489 - 28s - 57ms/step - loss: 0.6535
Epoch 5/20
489/489 - 29s - 59ms/step - loss: 0.6882
Epoch 6/20
489/489 - 28s - 56ms/step - loss: 0.6542
Epoch 7/20
489/489 - 27s - 54ms/step - loss: 0.6610
Epoch 8/20
489/489 - 28s - 57ms/step - loss: 0.6587
Epoch 9/20
489/489 - 27s - 56ms/step - loss: 0.6899
Epoch 10/20
489/489 - 27s - 55ms/step - loss: 0.6465
Epoch 11/20
489/489 - 27s - 56ms/step - loss: 0.6838
Epoch 12/20
489/489 - 28s - 57ms/step - loss: 0.6578
Epoch 13/20
489/489 - 27s - 56ms/step - loss: 0.6807
Epoch 14/20
489/489 - 27s - 56ms/step - loss: 0.6504
Epoch 15/20
489/489 - 27s - 55ms/step - loss: 0.6762
Epoch 16/20
489/489 - 27s - 56ms/step - loss: 0.6975
Epoch 17/20
489/489 - 27s - 55ms/step - loss: 0.6582
Epoch 18/20
489/489 - 27s - 56ms/step - loss: 0.6828
Epoch 19/20
489/489 - 28s - 56ms/step - loss: 0.6692
Epoch 20/20
489/489 - 28s - 56ms/step - loss: 0.6605
```

[ ]: <keras.src.callbacks.history.History at 0x3570b9f70>

0.1.5 4. Test prediction models

4.1 Test seasonal Naive model

[ ]:
```
test_snaive['snaive_forecast'] = snaive_forecast[:len(test_snaive)]

snaive_mae = mean_absolute_error(test_snaive['appliance'],
 ↪test_snaive['snaive_forecast'])
snaive_rmse = root_mean_squared_error(test_snaive['appliance'],
 ↪test_snaive['snaive_forecast'])

print(f"Mean Absolute Error of Seasonal Naive: {snaive_mae}")
```

```
print(f"Root Mean Squared Error of Season Naive: {snaive_rmse}")
```

```
Mean Absolute Error of Seasonal Naive: 61.68650793650794
Root Mean Squared Error of Season Naive: 124.08554396956248
```

4.2 Test autoARIMA model

[ ]:
```
_, ff_test = FourierFeaturizer(6 * 24, k=6).
 ↪fit_transform(test_arima['appliance'])
ff_test
```

[ ]:
```
      FOURIER_S144-0  FOURIER_C144-0  FOURIER_S144-1  FOURIER_C144-1  \
0           0.043619        0.999048        0.087156        0.996195
1           0.087156        0.996195        0.173648        0.984808
2           0.130526        0.991445        0.258819        0.965926
3           0.173648        0.984808        0.342020        0.939693
4           0.216440        0.976296        0.422618        0.906308
…                …             …              …             …
3942        0.675594       -0.737274       -0.996196        0.087146
3943        0.642791       -0.766041       -0.984809        0.173638
3944        0.608765       -0.793350       -0.965928        0.258809
3945        0.573581       -0.819149       -0.939696        0.342011
3946        0.537304       -0.843389       -0.906312        0.422609

      FOURIER_S144-2  FOURIER_C144-2  FOURIER_S144-3  FOURIER_C144-3  \
0           0.130526        0.991445        0.173648        0.984808
1           0.258819        0.965926        0.342020        0.939693
2           0.382683        0.923880        0.500000        0.866025
3           0.500000        0.866025        0.642788        0.766044
4           0.608761        0.793353        0.766044        0.642788
…                …             …              …             …
3942        0.793362        0.608750       -0.173628       -0.984811
3943        0.866033        0.499988       -0.342001       -0.939699
3944        0.923885        0.382670       -0.499983       -0.866035
3945        0.965930        0.258805       -0.642772       -0.766057
3946        0.991447        0.130512       -0.766032       -0.642803

      FOURIER_S144-4  FOURIER_C144-4  FOURIER_S144-5  FOURIER_C144-5
0           0.216440        0.976296        0.258819        0.965926
1           0.422618        0.906308        0.500000        0.866025
2           0.608761        0.793353        0.707107        0.707107
3           0.766044        0.642788        0.866025        0.500000
4           0.887011        0.461749        0.965926        0.258819
…                …             …              …             …
3942       -0.537296        0.843394        0.965918       -0.258847
3943       -0.342016        0.939694        0.866011       -0.500025
3944       -0.130522        0.991445        0.707086       -0.707127
3945        0.087160        0.996194        0.499975       -0.866040
```

```
3946        0.300710        0.953716        0.258791        -0.965933

[3947 rows x 12 columns]
```

[ ]:
```python
exog_test = pd.concat([ff_test, test_arima[new_feature].
 ↪reset_index(drop=True)], axis=1)
exog_test
```

[ ]:
```
      FOURIER_S144-0  FOURIER_C144-0  FOURIER_S144-1  FOURIER_C144-1  \
0           0.043619        0.999048        0.087156        0.996195
1           0.087156        0.996195        0.173648        0.984808
2           0.130526        0.991445        0.258819        0.965926
3           0.173648        0.984808        0.342020        0.939693
4           0.216440        0.976296        0.422618        0.906308
…                …               …               …               …
3942        0.675594       -0.737274       -0.996196        0.087146
3943        0.642791       -0.766041       -0.984809        0.173638
3944        0.608765       -0.793350       -0.965928        0.258809
3945        0.573581       -0.819149       -0.939696        0.342011
3946        0.537304       -0.843389       -0.906312        0.422609

      FOURIER_S144-2  FOURIER_C144-2  FOURIER_S144-3  FOURIER_C144-3  \
0           0.130526        0.991445        0.173648        0.984808
1           0.258819        0.965926        0.342020        0.939693
2           0.382683        0.923880        0.500000        0.866025
3           0.500000        0.866025        0.642788        0.766044
4           0.608761        0.793353        0.766044        0.642788
…                …               …               …               …
3942        0.793362        0.608750       -0.173628       -0.984811
3943        0.866033        0.499988       -0.342001       -0.939699
3944        0.923885        0.382670       -0.499983       -0.866035
3945        0.965930        0.258805       -0.642772       -0.766057
3946        0.991447        0.130512       -0.766032       -0.642803

      FOURIER_S144-4  FOURIER_C144-4  …      PCA2      PCA3      PCA4  \
0           0.216440        0.976296  …  0.608137 -1.204359 -0.858059
1           0.422618        0.906308  …  0.650529 -1.104861 -0.858436
2           0.608761        0.793353  …  0.689496 -1.001275 -0.871682
3           0.766044        0.642788  …  0.715758 -0.684631 -0.131879
4           0.887011        0.461749  …  0.810913 -0.763136 -0.945739
…                …               …  …       …         …         …
3942       -0.537296        0.843394  … -2.607310  1.098305 -0.542532
3943       -0.342016        0.939694  … -2.585757  1.083144 -0.521041
3944       -0.130522        0.991445  … -2.741860  1.264196  0.276275
3945        0.087160        0.996194  … -2.739476  1.216238  0.312973
3946        0.300710        0.953716  … -2.693941  1.156784  0.354489
```

```
          PCA5      PCA6      PCA7      PCA8      PCA9     PCA10     PCA11
0     0.600859 -0.116013 -0.661672 -0.569872 -0.453323 -0.570276 -0.724249
1     0.622264 -0.135333 -0.622998 -0.575063 -0.463900 -0.611276 -0.701582
2     0.647750 -0.156291 -0.597857 -0.581361 -0.481467 -0.643841 -0.666822
3     0.818357 -0.169749 -1.159206  0.114460 -0.489575 -0.972849 -0.582185
4     0.724204 -0.197998 -0.520005 -0.531384 -0.593469 -0.713800 -0.639889
…          …         …         …         …         …         …         …
3942  0.422911 -1.433150  0.181687 -0.398155 -0.526756 -0.117342  0.004837
3943  0.415284 -1.351469  0.171883 -0.407689 -0.447852 -0.063877  0.023987
3944  0.548698 -1.268516 -0.474391  0.218250 -0.312469 -0.287833  0.169180
3945  0.528738 -1.182534 -0.509758  0.177834 -0.187134 -0.238784  0.198198
3946  0.513887 -1.091140 -0.480793  0.212202 -0.120547 -0.136056  0.152778

[3947 rows x 23 columns]
```

[ ]:
```
# test data
arima_forecast = arima_model.predict(n_periods=test_arima.shape[0],␣
 ↪exogenous=exog_test)
arima_forecast
```

[ ]:
```
2016-04-30 08:20:00+00:00    251.811605
2016-04-30 08:30:00+00:00    172.577446
2016-04-30 08:40:00+00:00    137.342933
2016-04-30 08:50:00+00:00    124.128802
2016-04-30 09:00:00+00:00    116.652338
                                 …
2016-05-27 17:20:00+00:00    104.878877
2016-05-27 17:30:00+00:00    104.878877
2016-05-27 17:40:00+00:00    104.878877
2016-05-27 17:50:00+00:00    104.878877
2016-05-27 18:00:00+00:00    104.878877
Freq: 10T, Length: 3947, dtype: float64
```

[ ]:
```
test_arima['arima_forecast'] = arima_forecast[:len(test_arima)]
test_arima
```

[ ]:
```
                               PCA1      PCA2      PCA3      PCA4      PCA5  \
date
2016-04-30 08:20:00+00:00 -0.963322  0.608137 -1.204359 -0.858059  0.600859
2016-04-30 08:30:00+00:00 -0.898395  0.650529 -1.104861 -0.858436  0.622264
2016-04-30 08:40:00+00:00 -0.834813  0.689496 -1.001275 -0.871682  0.647750
2016-04-30 08:50:00+00:00 -0.729720  0.715758 -0.684631 -0.131879  0.818357
2016-04-30 09:00:00+00:00 -0.589682  0.810913 -0.763136 -0.945739  0.724204
…                                …         …         …         …         …
2016-05-27 17:20:00+00:00  8.015026 -2.607310  1.098305 -0.542532  0.422911
2016-05-27 17:30:00+00:00  7.944387 -2.585757  1.083144 -0.521041  0.415284
2016-05-27 17:40:00+00:00  7.838545 -2.741860  1.264196  0.276275  0.548698
```

```
2016-05-27 17:50:00+00:00  7.712669 -2.739476  1.216238  0.312973  0.528738
2016-05-27 18:00:00+00:00  7.607120 -2.693941  1.156784  0.354489  0.513887

                               PCA6      PCA7      PCA8      PCA9     PCA10  \
date
2016-04-30 08:20:00+00:00 -0.116013 -0.661672 -0.569872 -0.453323 -0.570276
2016-04-30 08:30:00+00:00 -0.135333 -0.622998 -0.575063 -0.463900 -0.611276
2016-04-30 08:40:00+00:00 -0.156291 -0.597857 -0.581361 -0.481467 -0.643841
2016-04-30 08:50:00+00:00 -0.169749 -1.159206  0.114460 -0.489575 -0.972849
2016-04-30 09:00:00+00:00 -0.197998 -0.520005 -0.531384 -0.593469 -0.713800
…                               …         …         …         …         …
2016-05-27 17:20:00+00:00 -1.433150  0.181687 -0.398155 -0.526756 -0.117342
2016-05-27 17:30:00+00:00 -1.351469  0.171883 -0.407689 -0.447852 -0.063877
2016-05-27 17:40:00+00:00 -1.268516 -0.474391  0.218250 -0.312469 -0.287833
2016-05-27 17:50:00+00:00 -1.182534 -0.509758  0.177834 -0.187134 -0.238784
2016-05-27 18:00:00+00:00 -1.091140 -0.480793  0.212202 -0.120547 -0.136056

                              PCA11  appliance  arima_forecast
date
2016-04-30 08:20:00+00:00 -0.724249        370      251.811605
2016-04-30 08:30:00+00:00 -0.701582        590      172.577446
2016-04-30 08:40:00+00:00 -0.666822        320      137.342933
2016-04-30 08:50:00+00:00 -0.582185        310      124.128802
2016-04-30 09:00:00+00:00 -0.639889        260      116.652338
…                               …        …               …
2016-05-27 17:20:00+00:00  0.004837        100      104.878877
2016-05-27 17:30:00+00:00  0.023987         90      104.878877
2016-05-27 17:40:00+00:00  0.169180        270      104.878877
2016-05-27 17:50:00+00:00  0.198198        420      104.878877
2016-05-27 18:00:00+00:00  0.152778        430      104.878877

[3947 rows x 13 columns]
```

[ ]:
```python
arima_mae = mean_absolute_error(test_arima['appliance'],
 ↪test_arima['arima_forecast'])
arima_rmse = root_mean_squared_error(test_arima['appliance'],
 ↪test_arima['arima_forecast'])

print(f"Mean Absolute Error of AutoARIMA: {arima_mae}")
print(f"Root Mean Squared Error of AutoARIMA: {arima_rmse}")
```

```
Mean Absolute Error of AutoARIMA: 56.37533780661013
Root Mean Squared Error of AutoARIMA: 91.23359123841618
```

4.3 Test LSTM model

[ ]:
```python
# predict values using past 144 from the test data
inputs = model_data.iloc[-len(test_lstm) - 144:, 0].values
```

```python
y_pred = []
for i in range(144, inputs.shape[0]):
    X_test = inputs[i-144:i].reshape(1,-1)
    lstm_forecast = lstm_model.predict(X_test)
    y_pred.append(lstm_forecast[0, 0])
```

```
1/1              0s 30ms/step
1/1              0s 18ms/step
1/1              0s 17ms/step
1/1              0s 17ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 14ms/step
1/1              0s 15ms/step
1/1              0s 21ms/step
1/1              0s 23ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
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1/1              0s 16ms/step
1/1              0s 18ms/step
1/1              0s 23ms/step
1/1              0s 24ms/step
1/1              0s 18ms/step
1/1              0s 54ms/step
1/1              0s 18ms/step
1/1              0s 20ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
```

```
1/1               0s 15ms/step
1/1               0s 17ms/step
1/1               0s 16ms/step
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1/1               0s 16ms/step
1/1               0s 16ms/step
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1/1               0s 36ms/step
1/1               0s 22ms/step
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```

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1/1                0s 15ms/step
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1/1                0s 65ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 18ms/step
1/1                0s 19ms/step
1/1                0s 22ms/step
1/1                0s 24ms/step
1/1                0s 16ms/step
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1/1                0s 17ms/step
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1/1                0s 17ms/step
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1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 14ms/step
1/1                0s 16ms/step
1/1                0s 33ms/step
1/1                0s 26ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
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1/1                0s 15ms/step
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1/1                0s 18ms/step
1/1                0s 38ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
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1/1                0s 15ms/step
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1/1                0s 16ms/step
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1/1                0s 15ms/step
1/1                0s 26ms/step
1/1                0s 19ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 57ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
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1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 23ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
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1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
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```

```
1/1              0s 16ms/step
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1/1              0s 31ms/step
1/1              0s 18ms/step
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1/1              0s 16ms/step
1/1              0s 17ms/step
1/1              0s 17ms/step
1/1              0s 37ms/step
1/1              0s 17ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 70ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 17ms/step
1/1              0s 18ms/step
1/1              0s 16ms/step
1/1              0s 17ms/step
1/1              0s 18ms/step
1/1              0s 81ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 22ms/step
1/1              0s 17ms/step
1/1              0s 16ms/step
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1/1              0s 16ms/step
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1/1              0s 16ms/step
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```

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1/1            0s 15ms/step
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1/1            0s 21ms/step
1/1            0s 17ms/step
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1/1            0s 16ms/step
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1/1            0s 15ms/step
1/1            0s 30ms/step
1/1            0s 24ms/step
1/1            0s 18ms/step
1/1            0s 15ms/step
1/1            0s 16ms/step
1/1            0s 17ms/step
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1/1            0s 15ms/step
1/1            0s 15ms/step
1/1            0s 18ms/step
1/1            0s 73ms/step
1/1            0s 16ms/step
1/1            0s 16ms/step
1/1            0s 16ms/step
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1/1            0s 15ms/step
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1/1            0s 15ms/step
1/1            0s 16ms/step
1/1            0s 18ms/step
1/1            0s 25ms/step
1/1            0s 16ms/step
1/1            0s 16ms/step
1/1            0s 15ms/step
1/1            0s 15ms/step
1/1            0s 15ms/step
1/1            0s 16ms/step
1/1            0s 22ms/step
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```

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1/1                0s 15ms/step
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1/1                0s 34ms/step
1/1                0s 47ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
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1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 29ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 18ms/step
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1/1                0s 16ms/step
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1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 20ms/step
1/1                0s 16ms/step
1/1                0s 22ms/step
1/1                0s 20ms/step
1/1                0s 19ms/step
1/1                0s 14ms/step
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1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
```

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1/1               0s 16ms/step
1/1               0s 15ms/step
1/1               0s 17ms/step
1/1               0s 17ms/step
1/1               0s 20ms/step
1/1               0s 17ms/step
1/1               0s 17ms/step
1/1               0s 16ms/step
1/1               0s 15ms/step
1/1               0s 18ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 18ms/step
1/1               0s 15ms/step
1/1               0s 17ms/step
1/1               0s 16ms/step
1/1               0s 19ms/step
1/1               0s 16ms/step
1/1               0s 16ms/step
1/1               0s 18ms/step
1/1               0s 16ms/step
1/1               0s 16ms/step
1/1               0s 18ms/step
1/1               0s 42ms/step
1/1               0s 21ms/step
1/1               0s 17ms/step
1/1               0s 16ms/step
1/1               0s 15ms/step
1/1               0s 16ms/step
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1/1               0s 16ms/step
1/1               0s 16ms/step
1/1               0s 15ms/step
1/1               0s 28ms/step
1/1               0s 16ms/step
1/1               0s 17ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 16ms/step
1/1               0s 17ms/step
1/1               0s 15ms/step
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```

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1/1               0s 15ms/step
1/1               0s 16ms/step
1/1               0s 18ms/step
1/1               0s 15ms/step
1/1               0s 17ms/step
1/1               0s 19ms/step
1/1               0s 19ms/step
1/1               0s 35ms/step
1/1               0s 23ms/step
1/1               0s 16ms/step
1/1               0s 18ms/step
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1/1               0s 17ms/step
1/1               0s 16ms/step
1/1               0s 18ms/step
1/1               0s 69ms/step
1/1               0s 21ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 17ms/step
1/1               0s 16ms/step
1/1               0s 16ms/step
1/1               0s 16ms/step
1/1               0s 15ms/step
```

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1/1          0s 15ms/step
1/1          0s 16ms/step
1/1          0s 18ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 19ms/step
1/1          0s 15ms/step
1/1          0s 16ms/step
1/1          0s 17ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 15ms/step
1/1          0s 18ms/step
1/1          0s 17ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 15ms/step
1/1          0s 28ms/step
1/1          0s 36ms/step
1/1          0s 18ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 17ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
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1/1          0s 16ms/step
1/1          0s 15ms/step
1/1          0s 16ms/step
1/1          0s 21ms/step
1/1          0s 17ms/step
1/1          0s 23ms/step
1/1          0s 18ms/step
1/1          0s 19ms/step
1/1          0s 19ms/step
1/1          0s 16ms/step
1/1          0s 17ms/step
1/1          0s 17ms/step
1/1          0s 17ms/step
1/1          0s 18ms/step
1/1          0s 18ms/step
1/1          0s 17ms/step
```

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1/1                0s 20ms/step
1/1                0s 19ms/step
1/1                0s 29ms/step
1/1                0s 21ms/step
1/1                0s 28ms/step
1/1                0s 18ms/step
1/1                0s 18ms/step
1/1                0s 19ms/step
1/1                0s 18ms/step
1/1                0s 18ms/step
1/1                0s 17ms/step
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1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 47ms/step
1/1                0s 17ms/step
1/1                0s 18ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 19ms/step
1/1                0s 22ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 19ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
```

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1/1                0s 19ms/step
1/1                0s 18ms/step
1/1                0s 18ms/step
1/1                0s 21ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 25ms/step
1/1                0s 52ms/step
1/1                0s 32ms/step
1/1                0s 16ms/step
1/1                0s 19ms/step
1/1                0s 18ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
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1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 18ms/step
1/1                0s 16ms/step
1/1                0s 24ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 18ms/step
1/1                0s 18ms/step
1/1                0s 18ms/step
1/1                0s 18ms/step
1/1                0s 17ms/step
1/1                0s 17ms/step
1/1                0s 39ms/step
1/1                0s 29ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 19ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
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1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 20ms/step
1/1                0s 17ms/step
1/1                0s 18ms/step
1/1                0s 33ms/step
1/1                0s 16ms/step
1/1                0s 18ms/step
```

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1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 18ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 25ms/step
1/1                0s 23ms/step
1/1                0s 20ms/step
1/1                0s 17ms/step
1/1                0s 22ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
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1/1                0s 19ms/step
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1/1                0s 18ms/step
1/1                0s 23ms/step
1/1                0s 18ms/step
1/1                0s 24ms/step
1/1                0s 18ms/step
1/1                0s 25ms/step
1/1                0s 19ms/step
1/1                0s 17ms/step
1/1                0s 21ms/step
1/1                0s 18ms/step
1/1                0s 18ms/step
1/1                0s 28ms/step
1/1                0s 26ms/step
1/1                0s 24ms/step
1/1                0s 16ms/step
1/1                0s 18ms/step
1/1                0s 18ms/step
1/1                0s 18ms/step
1/1                0s 18ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 21ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
```

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1/1              0s 17ms/step
1/1              0s 17ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 17ms/step
1/1              0s 17ms/step
1/1              0s 16ms/step
1/1              0s 17ms/step
1/1              0s 15ms/step
1/1              0s 21ms/step
1/1              0s 17ms/step
1/1              0s 25ms/step
1/1              0s 25ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
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1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 19ms/step
1/1              0s 17ms/step
1/1              0s 16ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 17ms/step
1/1              0s 17ms/step
1/1              0s 16ms/step
1/1              0s 26ms/step
1/1              0s 22ms/step
1/1              0s 20ms/step
1/1              0s 16ms/step
1/1              0s 17ms/step
1/1              0s 17ms/step
1/1              0s 23ms/step
1/1              0s 17ms/step
1/1              0s 17ms/step
1/1              0s 19ms/step
1/1              0s 16ms/step
1/1              0s 16ms/step
```

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1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 19ms/step
1/1                0s 19ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 29ms/step
1/1                0s 18ms/step
1/1                0s 15ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 21ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
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1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 22ms/step
1/1                0s 20ms/step
1/1                0s 43ms/step
1/1                0s 20ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 26ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
```

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1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 18ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 34ms/step
1/1                0s 33ms/step
1/1                0s 18ms/step
1/1                0s 15ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 18ms/step
1/1                0s 16ms/step
1/1                0s 20ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 19ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 22ms/step
1/1                0s 44ms/step
1/1                0s 21ms/step
1/1                0s 18ms/step
1/1                0s 16ms/step
1/1                0s 18ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 18ms/step
1/1                0s 21ms/step
1/1                0s 19ms/step
1/1                0s 18ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 18ms/step
1/1                0s 19ms/step
```

```
1/1               0s 45ms/step
1/1               0s 21ms/step
1/1               0s 17ms/step
1/1               0s 17ms/step
1/1               0s 17ms/step
1/1               0s 16ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 24ms/step
1/1               0s 17ms/step
1/1               0s 16ms/step
1/1               0s 15ms/step
1/1               0s 16ms/step
1/1               0s 15ms/step
1/1               0s 17ms/step
1/1               0s 15ms/step
1/1               0s 16ms/step
1/1               0s 17ms/step
1/1               0s 18ms/step
1/1               0s 16ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 21ms/step
1/1               0s 19ms/step
1/1               0s 19ms/step
1/1               0s 16ms/step
1/1               0s 16ms/step
1/1               0s 19ms/step
1/1               0s 18ms/step
1/1               0s 16ms/step
1/1               0s 16ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
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1/1               0s 16ms/step
1/1               0s 16ms/step
1/1               0s 16ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 16ms/step
1/1               0s 24ms/step
1/1               0s 33ms/step
1/1               0s 32ms/step
```

```
1/1          0s 17ms/step
1/1          0s 19ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 17ms/step
1/1          0s 16ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 20ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 15ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 15ms/step
1/1          0s 16ms/step
1/1          0s 46ms/step
1/1          0s 19ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 16ms/step
1/1          0s 15ms/step
1/1          0s 16ms/step
1/1          0s 17ms/step
1/1          0s 16ms/step
1/1          0s 47ms/step
1/1          0s 19ms/step
1/1          0s 25ms/step
1/1          0s 15ms/step
1/1          0s 16ms/step
1/1          0s 15ms/step
1/1          0s 16ms/step
1/1          0s 15ms/step
1/1          0s 27ms/step
1/1          0s 24ms/step
1/1          0s 18ms/step
1/1          0s 16ms/step
1/1          0s 15ms/step
1/1          0s 16ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 16ms/step
1/1          0s 25ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
```

```
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 46ms/step
1/1                0s 22ms/step
1/1                0s 18ms/step
1/1                0s 16ms/step
1/1                0s 18ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
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1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 19ms/step
1/1                0s 21ms/step
1/1                0s 16ms/step
1/1                0s 23ms/step
1/1                0s 23ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 21ms/step
1/1                0s 20ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 18ms/step
1/1                0s 17ms/step
```

```
1/1             0s 16ms/step
1/1             0s 32ms/step
1/1             0s 20ms/step
1/1             0s 23ms/step
1/1             0s 16ms/step
1/1             0s 16ms/step
1/1             0s 17ms/step
1/1             0s 15ms/step
1/1             0s 16ms/step
1/1             0s 17ms/step
1/1             0s 17ms/step
1/1             0s 17ms/step
1/1             0s 23ms/step
1/1             0s 16ms/step
1/1             0s 16ms/step
1/1             0s 15ms/step
1/1             0s 15ms/step
1/1             0s 15ms/step
1/1             0s 16ms/step
1/1             0s 16ms/step
1/1             0s 16ms/step
1/1             0s 17ms/step
1/1             0s 17ms/step
1/1             0s 22ms/step
1/1             0s 20ms/step
1/1             0s 17ms/step
1/1             0s 16ms/step
1/1             0s 16ms/step
1/1             0s 16ms/step
1/1             0s 18ms/step
1/1             0s 18ms/step
1/1             0s 14ms/step
1/1             0s 16ms/step
1/1             0s 15ms/step
1/1             0s 15ms/step
1/1             0s 15ms/step
1/1             0s 17ms/step
1/1             0s 26ms/step
1/1             0s 20ms/step
1/1             0s 18ms/step
1/1             0s 15ms/step
1/1             0s 15ms/step
1/1             0s 16ms/step
1/1             0s 15ms/step
1/1             0s 18ms/step
1/1             0s 48ms/step
1/1             0s 17ms/step
1/1             0s 26ms/step
```

```
1/1              0s 16ms/step
1/1              0s 18ms/step
1/1              0s 17ms/step
1/1              0s 23ms/step
1/1              0s 16ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 20ms/step
1/1              0s 16ms/step
1/1              0s 14ms/step
1/1              0s 16ms/step
1/1              0s 17ms/step
1/1              0s 14ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 16ms/step
1/1              0s 19ms/step
1/1              0s 16ms/step
1/1              0s 25ms/step
1/1              0s 18ms/step
1/1              0s 15ms/step
1/1              0s 17ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 22ms/step
1/1              0s 18ms/step
1/1              0s 16ms/step
1/1              0s 16ms/step
1/1              0s 14ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 17ms/step
1/1              0s 17ms/step
1/1              0s 18ms/step
1/1              0s 17ms/step
1/1              0s 18ms/step
1/1              0s 21ms/step
1/1              0s 31ms/step
1/1              0s 19ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 17ms/step
1/1              0s 18ms/step
```

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1/1          0s 17ms/step
1/1          0s 19ms/step
1/1          0s 20ms/step
1/1          0s 19ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 17ms/step
1/1          0s 17ms/step
1/1          0s 34ms/step
1/1          0s 19ms/step
1/1          0s 17ms/step
1/1          0s 16ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 21ms/step
1/1          0s 16ms/step
1/1          0s 15ms/step
1/1          0s 16ms/step
1/1          0s 14ms/step
1/1          0s 15ms/step
1/1          0s 16ms/step
1/1          0s 17ms/step
1/1          0s 21ms/step
1/1          0s 17ms/step
1/1          0s 16ms/step
1/1          0s 25ms/step
1/1          0s 19ms/step
1/1          0s 17ms/step
1/1          0s 16ms/step
1/1          0s 17ms/step
1/1          0s 20ms/step
1/1          0s 16ms/step
1/1          0s 17ms/step
1/1          0s 18ms/step
1/1          0s 17ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 46ms/step
1/1          0s 17ms/step
1/1          0s 15ms/step
1/1          0s 40ms/step
1/1          0s 36ms/step
1/1          0s 20ms/step
```

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1/1                0s 18ms/step
1/1                0s 18ms/step
1/1                0s 18ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 18ms/step
1/1                0s 22ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 40ms/step
1/1                0s 29ms/step
1/1                0s 51ms/step
1/1                0s 28ms/step
1/1                0s 37ms/step
1/1                0s 17ms/step
1/1                0s 17ms/step
1/1                0s 21ms/step
1/1                0s 44ms/step
1/1                0s 16ms/step
1/1                0s 18ms/step
1/1                0s 24ms/step
1/1                0s 21ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
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1/1                0s 16ms/step
1/1                0s 32ms/step
1/1                0s 36ms/step
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1/1                0s 22ms/step
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1/1                0s 25ms/step
1/1                0s 22ms/step
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1/1                0s 16ms/step
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1/1                0s 17ms/step
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1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 55ms/step
1/1                0s 20ms/step
1/1                0s 16ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
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1/1                0s 16ms/step
1/1                0s 70ms/step
1/1                0s 19ms/step
1/1                0s 17ms/step
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1/1              0s 19ms/step
1/1              0s 22ms/step
1/1              0s 17ms/step
1/1              0s 15ms/step
1/1              0s 38ms/step
1/1              0s 27ms/step
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1/1                0s 16ms/step
1/1                0s 16ms/step
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1/1                0s 20ms/step
1/1                0s 29ms/step
1/1                0s 21ms/step
1/1                0s 32ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
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1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 101ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 60ms/step
1/1                0s 17ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
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1/1                0s 14ms/step
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1/1                0s 16ms/step
1/1                0s 50ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 14ms/step
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1/1                0s 20ms/step
```

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1/1              0s 19ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
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1/1              0s 27ms/step
1/1              0s 20ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 17ms/step
1/1              0s 16ms/step
1/1              0s 52ms/step
1/1              0s 21ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
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1/1              0s 17ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 19ms/step
1/1              0s 17ms/step
1/1              0s 42ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
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```

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1/1              0s 15ms/step
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1/1              0s 18ms/step
1/1              0s 16ms/step
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1/1              0s 16ms/step
1/1              0s 19ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 21ms/step
1/1              0s 74ms/step
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1/1              0s 15ms/step
1/1              0s 16ms/step
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1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 19ms/step
1/1              0s 30ms/step
1/1              0s 39ms/step
1/1              0s 18ms/step
1/1              0s 16ms/step
1/1              0s 16ms/step
1/1              0s 20ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
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1/1              0s 16ms/step
1/1              0s 22ms/step
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```

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1/1                0s 16ms/step
1/1                0s 22ms/step
1/1                0s 50ms/step
1/1                0s 29ms/step
1/1                0s 17ms/step
1/1                0s 18ms/step
1/1                0s 18ms/step
1/1                0s 17ms/step
1/1                0s 22ms/step
1/1                0s 15ms/step
1/1                0s 137ms/step
1/1                0s 38ms/step
1/1                0s 61ms/step
1/1                0s 23ms/step
1/1                0s 28ms/step
1/1                0s 31ms/step
1/1                0s 72ms/step
1/1                0s 34ms/step
1/1                0s 18ms/step
1/1                0s 18ms/step
1/1                0s 17ms/step
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1/1                0s 15ms/step
1/1                0s 17ms/step
1/1                0s 92ms/step
1/1                0s 17ms/step
1/1                0s 18ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 25ms/step
1/1                0s 27ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 49ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
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1/1              0s 41ms/step
1/1              0s 17ms/step
1/1              0s 15ms/step
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1/1              0s 21ms/step
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1/1              0s 20ms/step
1/1              0s 58ms/step
1/1              0s 31ms/step
1/1              0s 19ms/step
1/1              0s 65ms/step
1/1              0s 18ms/step
1/1              0s 26ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 24ms/step
1/1              0s 18ms/step
1/1              0s 15ms/step
1/1              0s 21ms/step
1/1              0s 44ms/step
1/1              0s 14ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 34ms/step
1/1              0s 16ms/step
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1/1            0s 15ms/step
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1/1            0s 25ms/step
1/1            0s 16ms/step
1/1            0s 22ms/step
1/1            0s 15ms/step
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1/1            0s 14ms/step
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1/1            0s 15ms/step
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1/1            0s 16ms/step
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1/1            0s 17ms/step
1/1            0s 21ms/step
1/1            0s 17ms/step
```

```
1/1                0s 17ms/step
1/1                0s 90ms/step
1/1                0s 25ms/step
1/1                0s 44ms/step
1/1                0s 31ms/step
1/1                0s 20ms/step
1/1                0s 32ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 17ms/step
1/1                0s 18ms/step
1/1                0s 34ms/step
1/1                0s 28ms/step
1/1                0s 19ms/step
1/1                0s 16ms/step
1/1                0s 27ms/step
1/1                0s 76ms/step
1/1                0s 15ms/step
1/1                0s 17ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 17ms/step
1/1                0s 23ms/step
1/1                0s 18ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 21ms/step
1/1                0s 18ms/step
1/1                0s 57ms/step
1/1                0s 36ms/step
1/1                0s 18ms/step
1/1                0s 18ms/step
1/1                0s 16ms/step
1/1                0s 18ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 19ms/step
1/1                0s 16ms/step
1/1                0s 21ms/step
1/1                0s 17ms/step
1/1                0s 18ms/step
1/1                0s 18ms/step
1/1                0s 36ms/step
1/1                0s 55ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
```

```
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 23ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 19ms/step
1/1                0s 45ms/step
1/1                0s 21ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 119ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 19ms/step
1/1                0s 17ms/step
1/1                0s 23ms/step
1/1                0s 34ms/step
1/1                0s 22ms/step
1/1                0s 17ms/step
1/1                0s 18ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 18ms/step
1/1                0s 15ms/step
1/1                0s 21ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 19ms/step
1/1                0s 27ms/step
1/1                0s 17ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 14ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 21ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
```

```
1/1               0s 65ms/step
1/1               0s 18ms/step
1/1               0s 15ms/step
1/1               0s 17ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 29ms/step
1/1               0s 15ms/step
1/1               0s 17ms/step
1/1               0s 16ms/step
1/1               0s 16ms/step
1/1               0s 16ms/step
1/1               0s 20ms/step
1/1               0s 43ms/step
1/1               0s 18ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 18ms/step
1/1               0s 20ms/step
1/1               0s 14ms/step
1/1               0s 14ms/step
1/1               0s 16ms/step
1/1               0s 15ms/step
1/1               0s 17ms/step
1/1               0s 17ms/step
1/1               0s 29ms/step
1/1               0s 27ms/step
1/1               0s 16ms/step
1/1               0s 15ms/step
1/1               0s 28ms/step
1/1               0s 15ms/step
1/1               0s 14ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 25ms/step
1/1               0s 19ms/step
1/1               0s 16ms/step
1/1               0s 17ms/step
1/1               0s 21ms/step
1/1               0s 60ms/step
1/1               0s 21ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 18ms/step
1/1               0s 15ms/step
1/1               0s 19ms/step
1/1               0s 16ms/step
1/1               0s 15ms/step
```

```
1/1               0s 14ms/step
1/1               0s 15ms/step
1/1               0s 14ms/step
1/1               0s 19ms/step
1/1               0s 27ms/step
1/1               0s 16ms/step
1/1               0s 16ms/step
1/1               0s 16ms/step
1/1               0s 15ms/step
1/1               0s 20ms/step
1/1               0s 15ms/step
1/1               0s 16ms/step
1/1               0s 16ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 22ms/step
1/1               0s 16ms/step
1/1               0s 15ms/step
1/1               0s 29ms/step
1/1               0s 17ms/step
1/1               0s 16ms/step
1/1               0s 18ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 16ms/step
1/1               0s 52ms/step
1/1               0s 19ms/step
1/1               0s 17ms/step
1/1               0s 14ms/step
1/1               0s 15ms/step
1/1               0s 14ms/step
1/1               0s 40ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 16ms/step
1/1               0s 16ms/step
1/1               0s 16ms/step
1/1               0s 19ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 17ms/step
1/1               0s 16ms/step
1/1               0s 15ms/step
1/1               0s 14ms/step
1/1               0s 15ms/step
1/1               0s 16ms/step
```

```
1/1              0s 21ms/step
1/1              0s 39ms/step
1/1              0s 23ms/step
1/1              0s 15ms/step
1/1              0s 22ms/step
1/1              0s 14ms/step
1/1              0s 14ms/step
1/1              0s 14ms/step
1/1              0s 15ms/step
1/1              0s 19ms/step
1/1              0s 14ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 14ms/step
1/1              0s 15ms/step
1/1              0s 17ms/step
1/1              0s 14ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 14ms/step
1/1              0s 23ms/step
1/1              0s 39ms/step
1/1              0s 17ms/step
1/1              0s 14ms/step
1/1              0s 14ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 18ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 14ms/step
1/1              0s 16ms/step
1/1              0s 20ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 19ms/step
1/1              0s 44ms/step
1/1              0s 17ms/step
1/1              0s 19ms/step
1/1              0s 15ms/step
1/1              0s 18ms/step
1/1              0s 14ms/step
1/1              0s 14ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 22ms/step
```

```
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 34ms/step
1/1                0s 26ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 14ms/step
1/1                0s 20ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 18ms/step
1/1                0s 20ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 19ms/step
1/1                0s 32ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 29ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 22ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 22ms/step
1/1                0s 14ms/step
1/1                0s 36ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 19ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 54ms/step
1/1                0s 15ms/step
```

```
1/1              0s 22ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 26ms/step
1/1              0s 17ms/step
1/1              0s 23ms/step
1/1              0s 14ms/step
1/1              0s 14ms/step
1/1              0s 15ms/step
1/1              0s 14ms/step
1/1              0s 17ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 29ms/step
1/1              0s 18ms/step
1/1              0s 16ms/step
1/1              0s 14ms/step
1/1              0s 15ms/step
1/1              0s 19ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 22ms/step
1/1              0s 15ms/step
1/1              0s 32ms/step
1/1              0s 19ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 14ms/step
1/1              0s 15ms/step
1/1              0s 22ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 18ms/step
1/1              0s 23ms/step
1/1              0s 27ms/step
1/1              0s 18ms/step
1/1              0s 19ms/step
1/1              0s 15ms/step
1/1              0s 14ms/step
1/1              0s 14ms/step
1/1              0s 15ms/step
1/1              0s 17ms/step
1/1              0s 16ms/step
```

```
1/1            0s 17ms/step
1/1            0s 15ms/step
1/1            0s 55ms/step
1/1            0s 16ms/step
1/1            0s 14ms/step
1/1            0s 15ms/step
1/1            0s 15ms/step
1/1            0s 15ms/step
1/1            0s 18ms/step
1/1            0s 16ms/step
1/1            0s 15ms/step
1/1            0s 16ms/step
1/1            0s 15ms/step
1/1            0s 17ms/step
1/1            0s 15ms/step
1/1            0s 24ms/step
1/1            0s 15ms/step
1/1            0s 16ms/step
1/1            0s 15ms/step
1/1            0s 15ms/step
1/1            0s 14ms/step
1/1            0s 17ms/step
1/1            0s 16ms/step
1/1            0s 16ms/step
1/1            0s 15ms/step
1/1            0s 16ms/step
1/1            0s 19ms/step
1/1            0s 18ms/step
1/1            0s 19ms/step
1/1            0s 16ms/step
1/1            0s 18ms/step
1/1            0s 22ms/step
1/1            0s 14ms/step
1/1            0s 14ms/step
1/1            0s 16ms/step
1/1            0s 22ms/step
1/1            0s 14ms/step
1/1            0s 15ms/step
1/1            0s 15ms/step
1/1            0s 14ms/step
1/1            0s 45ms/step
1/1            0s 21ms/step
1/1            0s 15ms/step
1/1            0s 15ms/step
1/1            0s 15ms/step
1/1            0s 21ms/step
1/1            0s 16ms/step
1/1            0s 14ms/step
```

```
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 14ms/step
1/1              0s 22ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 26ms/step
1/1              0s 15ms/step
1/1              0s 36ms/step
1/1              0s 17ms/step
1/1              0s 15ms/step
1/1              0s 22ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 18ms/step
1/1              0s 15ms/step
1/1              0s 14ms/step
1/1              0s 14ms/step
1/1              0s 16ms/step
1/1              0s 24ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 18ms/step
1/1              0s 20ms/step
1/1              0s 28ms/step
1/1              0s 15ms/step
1/1              0s 14ms/step
1/1              0s 14ms/step
1/1              0s 14ms/step
1/1              0s 23ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 17ms/step
1/1              0s 15ms/step
1/1              0s 22ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 21ms/step
1/1              0s 20ms/step
1/1              0s 26ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 18ms/step
```

```
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 17ms/step
1/1              0s 29ms/step
1/1              0s 23ms/step
1/1              0s 18ms/step
1/1              0s 15ms/step
1/1              0s 20ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 20ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 40ms/step
1/1              0s 17ms/step
1/1              0s 28ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 14ms/step
1/1              0s 17ms/step
1/1              0s 16ms/step
1/1              0s 14ms/step
1/1              0s 15ms/step
1/1              0s 17ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 22ms/step
1/1              0s 20ms/step
1/1              0s 23ms/step
1/1              0s 16ms/step
1/1              0s 18ms/step
1/1              0s 22ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 20ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 21ms/step
```

```
1/1                0s 16ms/step
1/1                0s 24ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 24ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 16ms/step
1/1                0s 22ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 34ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 27ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
1/1                0s 16ms/step
1/1                0s 20ms/step
1/1                0s 15ms/step
1/1                0s 29ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 19ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 24ms/step
1/1                0s 32ms/step
1/1                0s 21ms/step
```

```
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 66ms/step
1/1                0s 24ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 31ms/step
1/1                0s 16ms/step
1/1                0s 20ms/step
1/1                0s 19ms/step
1/1                0s 16ms/step
1/1                0s 18ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 19ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 21ms/step
1/1                0s 24ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
1/1                0s 15ms/step
1/1                0s 18ms/step
1/1                0s 15ms/step
1/1                0s 30ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 18ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
```

```
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 24ms/step
1/1          0s 25ms/step
1/1          0s 20ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 16ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 14ms/step
1/1          0s 19ms/step
1/1          0s 15ms/step
1/1          0s 14ms/step
1/1          0s 15ms/step
1/1          0s 25ms/step
1/1          0s 21ms/step
1/1          0s 15ms/step
1/1          0s 16ms/step
1/1          0s 15ms/step
1/1          0s 20ms/step
1/1          0s 14ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 20ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 16ms/step
1/1          0s 15ms/step
1/1          0s 17ms/step
1/1          0s 15ms/step
1/1          0s 31ms/step
1/1          0s 19ms/step
1/1          0s 16ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 19ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 20ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 14ms/step
```

```
1/1              0s 71ms/step
1/1              0s 19ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 18ms/step
1/1              0s 15ms/step
1/1              0s 14ms/step
1/1              0s 14ms/step
1/1              0s 19ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 18ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 23ms/step
1/1              0s 20ms/step
1/1              0s 17ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 23ms/step
1/1              0s 15ms/step
1/1              0s 14ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 19ms/step
1/1              0s 15ms/step
1/1              0s 24ms/step
1/1              0s 19ms/step
1/1              0s 17ms/step
1/1              0s 23ms/step
1/1              0s 14ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 23ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 18ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 14ms/step
1/1              0s 18ms/step
```

```
1/1                0s 15ms/step
1/1                0s 27ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 19ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 19ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 22ms/step
1/1                0s 19ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 24ms/step
1/1                0s 14ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 21ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 13ms/step
1/1                0s 15ms/step
1/1                0s 17ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 27ms/step
1/1                0s 15ms/step
1/1                0s 31ms/step
1/1                0s 18ms/step
1/1                0s 16ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 14ms/step
1/1                0s 18ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 25ms/step
```

```
1/1                0s 21ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 20ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 19ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 18ms/step
1/1                0s 14ms/step
1/1                0s 14ms/step
1/1                0s 25ms/step
1/1                0s 23ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 14ms/step
1/1                0s 20ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 18ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 18ms/step
1/1                0s 18ms/step
1/1                0s 21ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 21ms/step
1/1                0s 17ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
```

```
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 19ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 75ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 28ms/step
1/1                0s 21ms/step
1/1                0s 17ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 29ms/step
1/1                0s 16ms/step
1/1                0s 103ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 14ms/step
1/1                0s 23ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 18ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 32ms/step
1/1                0s 17ms/step
```

```
1/1             0s 15ms/step
1/1             0s 15ms/step
1/1             0s 14ms/step
1/1             0s 21ms/step
1/1             0s 15ms/step
1/1             0s 14ms/step
1/1             0s 14ms/step
1/1             0s 26ms/step
1/1             0s 15ms/step
1/1             0s 15ms/step
1/1             0s 15ms/step
1/1             0s 14ms/step
1/1             0s 17ms/step
1/1             0s 33ms/step
1/1             0s 16ms/step
1/1             0s 15ms/step
1/1             0s 15ms/step
1/1             0s 18ms/step
1/1             0s 16ms/step
1/1             0s 15ms/step
1/1             0s 15ms/step
1/1             0s 18ms/step
1/1             0s 14ms/step
1/1             0s 16ms/step
1/1             0s 15ms/step
1/1             0s 16ms/step
1/1             0s 28ms/step
1/1             0s 19ms/step
1/1             0s 18ms/step
1/1             0s 23ms/step
1/1             0s 18ms/step
1/1             0s 15ms/step
1/1             0s 15ms/step
1/1             0s 14ms/step
1/1             0s 15ms/step
1/1             0s 16ms/step
1/1             0s 15ms/step
1/1             0s 15ms/step
1/1             0s 15ms/step
1/1             0s 40ms/step
1/1             0s 21ms/step
1/1             0s 19ms/step
1/1             0s 16ms/step
1/1             0s 17ms/step
1/1             0s 15ms/step
1/1             0s 14ms/step
1/1             0s 15ms/step
1/1             0s 16ms/step
```

```
1/1                0s 19ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 18ms/step
1/1                0s 14ms/step
1/1                0s 20ms/step
1/1                0s 21ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 27ms/step
1/1                0s 15ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 25ms/step
1/1                0s 15ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 51ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 25ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
1/1                0s 23ms/step
1/1                0s 18ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 19ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 19ms/step
```

```
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 46ms/step
1/1               0s 18ms/step
1/1               0s 19ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 20ms/step
1/1               0s 14ms/step
1/1               0s 14ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 21ms/step
1/1               0s 15ms/step
1/1               0s 14ms/step
1/1               0s 15ms/step
1/1               0s 26ms/step
1/1               0s 24ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 18ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 21ms/step
1/1               0s 14ms/step
1/1               0s 15ms/step
1/1               0s 23ms/step
1/1               0s 19ms/step
1/1               0s 21ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 18ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 20ms/step
1/1               0s 16ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 31ms/step
1/1               0s 15ms/step
1/1               0s 30ms/step
1/1               0s 16ms/step
1/1               0s 16ms/step
```

```
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 18ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 19ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 14ms/step
1/1                0s 19ms/step
1/1                0s 16ms/step
1/1                0s 20ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 19ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 19ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 19ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 23ms/step
1/1                0s 24ms/step
1/1                0s 30ms/step
1/1                0s 16ms/step
1/1                0s 28ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 24ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 21ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 45ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
```

```
1/1                0s 16ms/step
1/1                0s 20ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 65ms/step
1/1                0s 24ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 19ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 25ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 22ms/step
1/1                0s 22ms/step
1/1                0s 74ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 18ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 21ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 27ms/step
1/1                0s 15ms/step
1/1                0s 32ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 19ms/step
1/1                0s 14ms/step
1/1                0s 16ms/step
1/1                0s 14ms/step
1/1                0s 27ms/step
```

```
1/1            0s 15ms/step
1/1            0s 15ms/step
1/1            0s 16ms/step
1/1            0s 18ms/step
1/1            0s 27ms/step
1/1            0s 22ms/step
1/1            0s 23ms/step
1/1            0s 16ms/step
1/1            0s 20ms/step
1/1            0s 15ms/step
1/1            0s 19ms/step
1/1            0s 16ms/step
1/1            0s 15ms/step
1/1            0s 15ms/step
1/1            0s 17ms/step
1/1            0s 20ms/step
1/1            0s 15ms/step
1/1            0s 15ms/step
1/1            0s 24ms/step
1/1            0s 14ms/step
1/1            0s 25ms/step
1/1            0s 24ms/step
1/1            0s 15ms/step
1/1            0s 15ms/step
1/1            0s 15ms/step
1/1            0s 19ms/step
1/1            0s 15ms/step
1/1            0s 14ms/step
1/1            0s 15ms/step
1/1            0s 19ms/step
1/1            0s 15ms/step
1/1            0s 14ms/step
1/1            0s 15ms/step
1/1            0s 15ms/step
1/1            0s 34ms/step
1/1            0s 20ms/step
1/1            0s 15ms/step
1/1            0s 191ms/step
1/1            0s 15ms/step
1/1            0s 37ms/step
1/1            0s 39ms/step
1/1            0s 16ms/step
1/1            0s 17ms/step
1/1            0s 18ms/step
1/1            0s 22ms/step
1/1            0s 15ms/step
1/1            0s 17ms/step
1/1            0s 19ms/step
```

```
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 23ms/step
1/1              0s 14ms/step
1/1              0s 14ms/step
1/1              0s 17ms/step
1/1              0s 20ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 36ms/step
1/1              0s 23ms/step
1/1              0s 17ms/step
1/1              0s 15ms/step
1/1              0s 24ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 16ms/step
1/1              0s 19ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 26ms/step
1/1              0s 41ms/step
1/1              0s 17ms/step
1/1              0s 14ms/step
1/1              0s 14ms/step
1/1              0s 29ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 18ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 75ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 17ms/step
1/1              0s 17ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 19ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
```

```
1/1                0s 15ms/step
1/1                0s 21ms/step
1/1                0s 19ms/step
1/1                0s 14ms/step
1/1                0s 23ms/step
1/1                0s 20ms/step
1/1                0s 16ms/step
1/1                0s 24ms/step
1/1                0s 23ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 21ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 43ms/step
1/1                0s 21ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 18ms/step
1/1                0s 14ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 29ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 23ms/step
1/1                0s 16ms/step
1/1                0s 24ms/step
1/1                0s 16ms/step
1/1                0s 27ms/step
1/1                0s 20ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 19ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 21ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 23ms/step
1/1                0s 21ms/step
1/1                0s 17ms/step
```

```
1/1              0s 16ms/step
1/1              0s 19ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 19ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 21ms/step
1/1              0s 16ms/step
1/1              0s 14ms/step
1/1              0s 15ms/step
1/1              0s 20ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 38ms/step
1/1              0s 24ms/step
1/1              0s 18ms/step
1/1              0s 16ms/step
1/1              0s 22ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 19ms/step
1/1              0s 19ms/step
1/1              0s 17ms/step
1/1              0s 16ms/step
1/1              0s 19ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 21ms/step
1/1              0s 22ms/step
1/1              0s 19ms/step
1/1              0s 19ms/step
1/1              0s 24ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 20ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 21ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 27ms/step
1/1              0s 24ms/step
```

```
1/1          0s 17ms/step
1/1          0s 15ms/step
1/1          0s 18ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 22ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 24ms/step
1/1          0s 16ms/step
1/1          0s 23ms/step
1/1          0s 15ms/step
1/1          0s 36ms/step
1/1          0s 16ms/step
1/1          0s 15ms/step
1/1          0s 17ms/step
1/1          0s 15ms/step
1/1          0s 16ms/step
1/1          0s 15ms/step
1/1          0s 23ms/step
1/1          0s 15ms/step
1/1          0s 14ms/step
1/1          0s 15ms/step
1/1          0s 25ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 15ms/step
1/1          0s 43ms/step
1/1          0s 25ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 22ms/step
1/1          0s 17ms/step
1/1          0s 15ms/step
1/1          0s 17ms/step
1/1          0s 21ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 18ms/step
1/1          0s 16ms/step
1/1          0s 24ms/step
1/1          0s 40ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
```

```
1/1                0s 16ms/step
1/1                0s 24ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 19ms/step
1/1                0s 44ms/step
1/1                0s 22ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 18ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 25ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 23ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 19ms/step
1/1                0s 22ms/step
1/1                0s 15ms/step
1/1                0s 22ms/step
1/1                0s 21ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 25ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 22ms/step
1/1                0s 18ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 18ms/step
1/1                0s 37ms/step
1/1                0s 21ms/step
```

```
1/1              0s 14ms/step
1/1              0s 18ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 22ms/step
1/1              0s 14ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 20ms/step
1/1              0s 18ms/step
1/1              0s 15ms/step
1/1              0s 19ms/step
1/1              0s 20ms/step
1/1              0s 18ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 18ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 19ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 17ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 23ms/step
1/1              0s 18ms/step
1/1              0s 25ms/step
1/1              0s 17ms/step
1/1              0s 20ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 20ms/step
1/1              0s 16ms/step
1/1              0s 16ms/step
1/1              0s 21ms/step
1/1              0s 17ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 18ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
```

```
1/1               0s 22ms/step
1/1               0s 23ms/step
1/1               0s 22ms/step
1/1               0s 17ms/step
1/1               0s 25ms/step
1/1               0s 16ms/step
1/1               0s 18ms/step
1/1               0s 27ms/step
1/1               0s 15ms/step
1/1               0s 14ms/step
1/1               0s 17ms/step
1/1               0s 22ms/step
1/1               0s 17ms/step
1/1               0s 14ms/step
1/1               0s 15ms/step
1/1               0s 21ms/step
1/1               0s 14ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 21ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 24ms/step
1/1               0s 41ms/step
1/1               0s 17ms/step
1/1               0s 14ms/step
1/1               0s 15ms/step
1/1               0s 24ms/step
1/1               0s 17ms/step
1/1               0s 16ms/step
1/1               0s 16ms/step
1/1               0s 20ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 15ms/step
1/1               0s 46ms/step
1/1               0s 16ms/step
1/1               0s 16ms/step
1/1               0s 21ms/step
1/1               0s 16ms/step
1/1               0s 16ms/step
1/1               0s 15ms/step
1/1               0s 44ms/step
1/1               0s 16ms/step
1/1               0s 17ms/step
1/1               0s 15ms/step
1/1               0s 20ms/step
1/1               0s 18ms/step
```

```
1/1            0s 15ms/step
1/1            0s 16ms/step
1/1            0s 22ms/step
1/1            0s 15ms/step
1/1            0s 16ms/step
1/1            0s 32ms/step
1/1            0s 15ms/step
1/1            0s 20ms/step
1/1            0s 15ms/step
1/1            0s 30ms/step
1/1            0s 16ms/step
1/1            0s 14ms/step
1/1            0s 20ms/step
1/1            0s 16ms/step
1/1            0s 15ms/step
1/1            0s 22ms/step
1/1            0s 15ms/step
1/1            0s 15ms/step
1/1            0s 16ms/step
1/1            0s 18ms/step
1/1            0s 21ms/step
1/1            0s 15ms/step
1/1            0s 29ms/step
1/1            0s 26ms/step
1/1            0s 18ms/step
1/1            0s 61ms/step
1/1            0s 22ms/step
1/1            0s 15ms/step
1/1            0s 14ms/step
1/1            0s 15ms/step
1/1            0s 19ms/step
1/1            0s 19ms/step
1/1            0s 15ms/step
1/1            0s 15ms/step
1/1            0s 20ms/step
1/1            0s 18ms/step
1/1            0s 17ms/step
1/1            0s 27ms/step
1/1            0s 39ms/step
1/1            0s 16ms/step
1/1            0s 32ms/step
1/1            0s 15ms/step
1/1            0s 15ms/step
1/1            0s 16ms/step
1/1            0s 19ms/step
1/1            0s 17ms/step
1/1            0s 18ms/step
1/1            0s 16ms/step
```

```
1/1              0s 22ms/step
1/1              0s 17ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 21ms/step
1/1              0s 27ms/step
1/1              0s 29ms/step
1/1              0s 17ms/step
1/1              0s 15ms/step
1/1              0s 26ms/step
1/1              0s 17ms/step
1/1              0s 15ms/step
1/1              0s 22ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 20ms/step
1/1              0s 19ms/step
1/1              0s 15ms/step
1/1              0s 14ms/step
1/1              0s 19ms/step
1/1              0s 16ms/step
1/1              0s 68ms/step
1/1              0s 15ms/step
1/1              0s 19ms/step
1/1              0s 16ms/step
1/1              0s 19ms/step
1/1              0s 17ms/step
1/1              0s 29ms/step
1/1              0s 20ms/step
1/1              0s 16ms/step
1/1              0s 22ms/step
1/1              0s 17ms/step
1/1              0s 16ms/step
1/1              0s 14ms/step
1/1              0s 22ms/step
1/1              0s 19ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 19ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 16ms/step
1/1              0s 19ms/step
1/1              0s 17ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 45ms/step
1/1              0s 20ms/step
```

```
1/1                0s 19ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
1/1                0s 17ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 21ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 23ms/step
1/1                0s 28ms/step
1/1                0s 15ms/step
1/1                0s 21ms/step
1/1                0s 16ms/step
1/1                0s 32ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 21ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 54ms/step
1/1                0s 23ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
1/1                0s 18ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 23ms/step
1/1                0s 15ms/step
1/1                0s 19ms/step
1/1                0s 21ms/step
1/1                0s 16ms/step
1/1                0s 14ms/step
1/1                0s 19ms/step
1/1                0s 43ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
```

```
1/1                0s 19ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 19ms/step
1/1                0s 18ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 18ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 21ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 40ms/step
1/1                0s 18ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 35ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 23ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
1/1                0s 29ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 22ms/step
1/1                0s 16ms/step
1/1                0s 20ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 20ms/step
1/1                0s 16ms/step
1/1                0s 14ms/step
1/1                0s 29ms/step
1/1                0s 27ms/step
1/1                0s 16ms/step
1/1                0s 19ms/step
1/1                0s 16ms/step
1/1                0s 21ms/step
1/1                0s 15ms/step
```

```
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 19ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 23ms/step
1/1                0s 24ms/step
1/1                0s 19ms/step
1/1                0s 16ms/step
1/1                0s 52ms/step
1/1                0s 25ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 20ms/step
1/1                0s 19ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 24ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 18ms/step
1/1                0s 18ms/step
1/1                0s 29ms/step
1/1                0s 14ms/step
1/1                0s 42ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 18ms/step
1/1                0s 20ms/step
1/1                0s 14ms/step
1/1                0s 16ms/step
1/1                0s 20ms/step
1/1                0s 19ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 25ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 16ms/step
1/1                0s 22ms/step
1/1                0s 22ms/step
1/1                0s 21ms/step
1/1                0s 37ms/step
1/1                0s 18ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
```

```
1/1              0s 30ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 21ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 25ms/step
1/1              0s 14ms/step
1/1              0s 14ms/step
1/1              0s 15ms/step
1/1              0s 20ms/step
1/1              0s 17ms/step
1/1              0s 29ms/step
1/1              0s 16ms/step
1/1              0s 34ms/step
1/1              0s 15ms/step
1/1              0s 18ms/step
1/1              0s 19ms/step
1/1              0s 18ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 31ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 20ms/step
1/1              0s 19ms/step
1/1              0s 20ms/step
1/1              0s 15ms/step
1/1              0s 25ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 20ms/step
1/1              0s 15ms/step
1/1              0s 16ms/step
1/1              0s 15ms/step
1/1              0s 20ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 15ms/step
1/1              0s 65ms/step
1/1              0s 17ms/step
1/1              0s 15ms/step
1/1              0s 14ms/step
1/1              0s 18ms/step
1/1              0s 17ms/step
1/1              0s 15ms/step
```

```
1/1                0s 16ms/step
1/1                0s 18ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 47ms/step
1/1                0s 15ms/step
1/1                0s 21ms/step
1/1                0s 17ms/step
1/1                0s 21ms/step
1/1                0s 21ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
1/1                0s 19ms/step
1/1                0s 14ms/step
1/1                0s 16ms/step
1/1                0s 52ms/step
1/1                0s 22ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 18ms/step
1/1                0s 18ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 19ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 18ms/step
1/1                0s 20ms/step
1/1                0s 15ms/step
1/1                0s 24ms/step
1/1                0s 19ms/step
1/1                0s 20ms/step
1/1                0s 16ms/step
1/1                0s 22ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 14ms/step
1/1                0s 20ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 17ms/step
1/1                0s 20ms/step
1/1                0s 16ms/step
```

```
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 20ms/step
1/1          0s 19ms/step
1/1          0s 25ms/step
1/1          0s 19ms/step
1/1          0s 22ms/step
1/1          0s 21ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 22ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 26ms/step
1/1          0s 23ms/step
1/1          0s 17ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 21ms/step
1/1          0s 14ms/step
1/1          0s 19ms/step
1/1          0s 15ms/step
1/1          0s 21ms/step
1/1          0s 16ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 23ms/step
1/1          0s 28ms/step
1/1          0s 16ms/step
1/1          0s 18ms/step
1/1          0s 22ms/step
1/1          0s 18ms/step
1/1          0s 15ms/step
1/1          0s 31ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 21ms/step
1/1          0s 17ms/step
1/1          0s 15ms/step
1/1          0s 16ms/step
1/1          0s 45ms/step
1/1          0s 17ms/step
1/1          0s 16ms/step
1/1          0s 17ms/step
1/1          0s 20ms/step
1/1          0s 15ms/step
```

```
1/1          0s 19ms/step
1/1          0s 18ms/step
1/1          0s 21ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 22ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 42ms/step
1/1          0s 16ms/step
1/1          0s 14ms/step
1/1          0s 14ms/step
1/1          0s 32ms/step
1/1          0s 19ms/step
1/1          0s 28ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 19ms/step
1/1          0s 16ms/step
1/1          0s 20ms/step
1/1          0s 16ms/step
1/1          0s 15ms/step
1/1          0s 28ms/step
1/1          0s 30ms/step
1/1          0s 19ms/step
1/1          0s 17ms/step
1/1          0s 15ms/step
1/1          0s 22ms/step
1/1          0s 17ms/step
1/1          0s 15ms/step
1/1          0s 18ms/step
1/1          0s 18ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
1/1          0s 24ms/step
1/1          0s 30ms/step
1/1          0s 15ms/step
1/1          0s 19ms/step
1/1          0s 15ms/step
1/1          0s 21ms/step
1/1          0s 16ms/step
1/1          0s 16ms/step
1/1          0s 17ms/step
1/1          0s 15ms/step
1/1          0s 15ms/step
```

```
1/1                0s 25ms/step
1/1                0s 26ms/step
1/1                0s 24ms/step
1/1                0s 16ms/step
1/1                0s 21ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 24ms/step
1/1                0s 22ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 20ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 18ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 23ms/step
1/1                0s 24ms/step
1/1                0s 17ms/step
1/1                0s 21ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 21ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 21ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 19ms/step
1/1                0s 18ms/step
1/1                0s 20ms/step
1/1                0s 22ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 21ms/step
1/1                0s 17ms/step
1/1                0s 15ms/step
```

```
1/1                0s 14ms/step
1/1                0s 25ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 20ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 30ms/step
1/1                0s 27ms/step
1/1                0s 20ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 21ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 18ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 17ms/step
1/1                0s 20ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 15ms/step
1/1                0s 24ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 46ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 23ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 36ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
```

```
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 26ms/step
1/1                0s 15ms/step
1/1                0s 14ms/step
1/1                0s 20ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 33ms/step
1/1                0s 15ms/step
1/1                0s 33ms/step
1/1                0s 19ms/step
1/1                0s 15ms/step
1/1                0s 17ms/step
1/1                0s 18ms/step
1/1                0s 16ms/step
1/1                0s 21ms/step
1/1                0s 19ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 17ms/step
1/1                0s 20ms/step
1/1                0s 24ms/step
1/1                0s 41ms/step
1/1                0s 17ms/step
1/1                0s 16ms/step
1/1                0s 20ms/step
1/1                0s 20ms/step
1/1                0s 16ms/step
1/1                0s 16ms/step
1/1                0s 20ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 19ms/step
1/1                0s 15ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
1/1                0s 15ms/step
1/1                0s 15ms/step
1/1                0s 20ms/step
1/1                0s 22ms/step
1/1                0s 19ms/step
1/1                0s 15ms/step
1/1                0s 21ms/step
1/1                0s 17ms/step
1/1                0s 14ms/step
```

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1/1                0s 14ms/step
1/1                0s 20ms/step
1/1                0s 16ms/step
1/1                0s 15ms/step
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4.0836453,
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2.351992,

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2.7815967,
3.0048785,
4.258033,
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3.808988,
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4.1426845,
3.9999719,
4.10507,
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4.085566,
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4.1910324,
4.066381,
3.9568481,
3.8637207,
3.892078,
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3.7857778,
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4.0805197,
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3.4623773,
3.7256975,
3.9307747,
4.0952506,
3.9259596,
4.023635,
4.009386,
3.9987235,
4.3520727,
4.3354554,
4.166156,
4.302797,
4.304201,
4.298072,
4.295148,
4.1516576,
4.156488,
4.164609,
4.167814,
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4.1642127,
4.3006096,
4.3015223,
4.2934284,
4.290777,
4.148392,
4.2944307,
4.157076,
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 4.1575136,
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 4.1671977,
 4.506499,
 4.1709647,
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 4.164307,
 4.4914074,
 4.1663833,
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 4.4987273,
 4.170569,
 4.15701,
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 4.172753,
 4.313122,
 4.308875,
 4.2999563,
 4.2960525,
 4.2948575,
 4.493994,
 4.3025103,
 4.2893457,
 4.1541066,
 4.1627293,
 …]
```

[ ]:
```
# calculate MAE and RSME
lstm_mae = mean_absolute_error(test_lstm['appliance'], y_pred)
lstm_rmse = root_mean_squared_error(test_lstm['appliance'], y_pred)

print(f"Mean Absolute Error of LSTM: {lstm_mae}")
print(f"Root Mean Squared Error of LSTM: {lstm_rmse}")
```

```
Mean Absolute Error of LSTM: 92.37607531092092
Root Mean Squared Error of LSTM: 129.91874565550856
```

0.1.6 5. Forecasting results

5.1 Forecasting from seasonal Naive model

```
[ ]: import plotly.graph_objects as go
     from plotly.subplots import make_subplots

     fig = make_subplots(rows=1, cols=1, shared_xaxes=True, vertical_spacing=0.03)

     fig.add_trace(go.Scatter(x=train_snaive.index, y=train_snaive['appliance'], name='training data'), row=1, col=1)
     fig.add_trace(go.Scatter(x=test_snaive.index, y=test_snaive['appliance'], name='validation data'), row=1, col=1)
     fig.add_trace(go.Scatter(x=test_snaive.index, y=test_snaive['snaive_forecast'], name='forecasting'), row=1, col=1)

     fig.update_layout(title='Seasonal Naive Forecasting of Appliances Energy Consumption')
     fig.show()
```

5.2 Forecasting from AutoARIMA

```
[ ]: fig = make_subplots(rows=1, cols=1, shared_xaxes=True, vertical_spacing=0.03)

     fig.add_trace(go.Scatter(x=train_arima.index, y=train_arima['appliance'], name='training data'), row=1, col=1)
     fig.add_trace(go.Scatter(x=test_arima.index, y=test_arima['appliance'], name='validation data'), row=1, col=1)
     fig.add_trace(go.Scatter(x=test_arima.index, y=test_arima['arima_forecast'], name='forecasting'), row=1, col=1)

     fig.update_layout(title='AutoARIMA Forecasting of Appliances Energy Consumption')
     fig.show()
```

5.3 Forecasting from LSTM

```
[ ]: lstm_forecast = lstm_forecast.flatten()

     lstm_forecast = lstm_forecast[:len(test_lstm['appliance'])]

     fig = make_subplots(rows=1, cols=1, shared_xaxes=True, vertical_spacing=0.03)

     fig.add_trace(go.Scatter(x=train_lstm.index, y=train_lstm['appliance'], name='Training Data'), row=1, col=1)
     fig.add_trace(go.Scatter(x=test_lstm.index, y=test_lstm['appliance'], name='Validation Data'), row=1, col=1)
     fig.add_trace(go.Scatter(x=test_lstm.index, y=lstm_forecast, name='Forecasting'), row=1, col=1)
```

```
fig.update_layout(title='LSTM Forecasting of Appliances Energy Consumption')
fig.show()
```

0.1.7 6. Compare the results from all candidate models, choose the best model, justify your choice and discuss the results

Compare the results from all candidate models, the best model in this is AutoARIMA with lowest MAE 56.375 and RSME 91.234. However, the RSME and MAE still high, it should be further investigate. Some reasons could be affect the results are: * Appliance energy consumption has both seasonality in hourly and daily with wide variance. * Many features to fit to the models and they also have wide variance and seasonality as well.

```
[ ]: test_result = {'MAE': [snaive_mae, arima_mae, lstm_mae],
                    'RSME': [snaive_rmse, arima_rmse, lstm_rmse]}

     test_result = pd.DataFrame(test_result, index=['Seasonal Naive', 'AutoARIMA',␣
      ↪'LSTM'])

     print('The test result of all models\n', test_result)
```

```
The test result of all models
                       MAE        RSME
Seasonal Naive  61.686508  124.085544
AutoARIMA       56.375338   91.233591
LSTM            92.376075  129.918746
```

0.1.8 7. Reflection

After this analysis, I have learned that: * Time series with seasonality are quite hard to process and predict model because many influences and need further way to process the data before fitting to the model. * Deep learning methods do not always give the optimised results and take a lot of time to run and procceed. * With many features, we should use PCA to reduce the dimensions.

0.1.9 8. References

[1] Candanedo, LM, Feldheim, V & Deramaix, D 2917, ‘Data driven prediction models of energy use of appliances in a low-energy house’, *ELSEVIER Energy and Buildings*, vol. 140, pp. 81-97.

[2] University of Adelaide 2024-1, COMP_SCI_7306 Mining Big Data - Module 6 Lecture: Time Series, pdf, The University of Adelaide, viewed 5 May 2024, https://myuni.adelaide.edu.au/courses/91968/files/14968123?module_item_id=3274629.

[3] Chandra, MG 2022, ‘Appliances Energy - Time Series Analysis’, Kaggle, Python notebook, viewed 5 May 2024, https://www.kaggle.com/code/gaganmaahi224/appliances-energy-time-series-analysis#notebook-container.

[4] Kotu, V 2019, *Data science : concepts and practice*, B Deshpande (ed.), Second edition., Morgan Kaufmann Publishers an imprint of Elsevier, Cambridge, pp. 1-570.

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[6] https://github.com/ranasingh-gkp/Time_series_forcasting/blob/main/Time_series_forcasting.ipynb

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