Windfinder

A basic machine learning approch on predicting the pageviews for the windfinder website when provided with weatherdata.

Participants:

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Course and Semester

Deep Learning from Scratch, SoSe2021

License

Introduction

The website https://www.windfinder.com provides weather data which can be used for different hobbies like kiting or surfing to check if the conditions are right. The page views of the website is fluctuating. It seems that, when the conditions are good for surfing or kiting, the page views tend to be higher. Thus, the page views could be interpreted as a proxy for how good a certain weather condition is for those activities.

With this work, an attempt is made to predict the page views from the weather data. Past page views and weather data is used to train a model, which then could be used to predict new page views from given weather data.

Data and Methods

Hourly weatherdata from windfinder from 2014 to 2019 is used and group to daily averages. This data is then matched with daily pageviews which for the windfinder website. From the weatherdata temperature, page views, air temperature and location are feed into the model to predict the pagviews.

Results

The mode predicts the page views with an accuracy of around 80 %.

Baseline

A basic linear regression achieves an accuracy of 68 %, therefore the neural network model is clearly better.

In [6]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import glob
import tensorflow as tf
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn import linear_model
from sklearn.metrics import mean_absolute_error


import keras
from keras.models import Sequential
from keras.layers import Dense


%matplotlib inline
print(tf.version)
```

```
<module 'tensorflow._api.v2.version' from '/home/kilian/.local/lib/python3.
8/site-packages/tensorflow/_api/v2/version/__init__.py'>
```

Loading the data

To begin with, the data is loaded from the files and put into pandas data frames. In this case only the data for Kiel, St. Peter-Ording and Warnemünde is considered. The code below will only work if the data itself is provided in the folders, which it is not for copyright considerations of the data from wind finder.

The data itself is cannot be provided alongside with this notebook, because of copyright considerations of wind finder. For this notebook to work, the corresponding data needs to be put in the folder structure.

In [5]:
```
pageviews_kiel = pd.concat([pd.read_csv(f, sep = ';',names = ["date", "page
                            for f in glob.glob('data_windfinder/SelectedLo

pageviews_sktPeterOrding = pd.concat([pd.read_csv(f, sep = ';',names = ["da
                            for f in glob.glob('data_windfinder/SelectedLo


pageviews_warnemuende = pd.concat([pd.read_csv(f, sep = ';',names = ["date
                            for f in glob.glob('data_windfinder/SelectedLo

weatherdata_kiel = pd.concat([pd.read_csv(f, sep = ';')
                            for f in glob.glob('data_windfinder/SelectedLo
weatherdata_kiel.columns=["date", "wind", "wind direction", "wind gust", "a
weatherdata_kiel = weatherdata_kiel.assign(location = 1)

weatherdata_sktPeterOrding = pd.concat([pd.read_csv(f, sep = ';')
                            for f in glob.glob('data_windfinder/SelectedLo
weatherdata_sktPeterOrding.columns=["date", "wind", "wind direction", "wind
weatherdata_sktPeterOrding = weatherdata_sktPeterOrding.assign(location = 2


weatherdata_warnemuende = pd.concat([pd.read_csv(f, sep = ';')
                            for f in glob.glob('data_windfinder/SelectedLo
weatherdata_warnemuende.columns=["date", "wind", "wind direction", "wind gu
weatherdata_warnemuende = weatherdata_warnemuende.assign(location = 3)
```

In [220…
```
print(pageviews_kiel.head(5))
print(weatherdata_kiel.head(5))
```

```
       date  pageviews
0  20190101       2954
1  20190102       2304
2  20190103       1225
3  20190104       1288
4  20190105        840
                  date  wind  wind direction  wind gust  air temp  location
0  2016-01-01 00:08:00  16.0             208       17.0       6.0         1
1  2016-01-01 01:36:00  12.0             194       14.0       6.0         1
2  2016-01-01 01:52:00  14.0             193       14.0       6.0         1
3  2016-01-01 02:08:00  12.0             192       14.0       6.0         1
4  2016-01-01 02:16:00  12.0             185       16.0       6.0         1
```

Helper functions for data preparation

group_hourly_weatherdata_to_daily() is used to create daily weather data from the provided hourly weather data. The reasons for this, is that the pageviews are also provided daily and they need to be matched.

prepare_pageviews() is used to convert the integer number which is used as a date in the default date format as used in pandas.

In [24]:
```
def group_hourly_weatherdata_to_daily(weatherdata):
    weatherdata["date"] = pd.to_datetime(weatherdata["date"])
    weatherdata = weatherdata.resample('D', on="date").mean()
    weatherdata = weatherdata.reset_index()
    return weatherdata
```

In [25]:
```
def prepare_pageviews(pageviews):
        new_pageviews = pageviews
        new_pageviews['date'] = pd.to_datetime(pageviews['date'], format='
        return new_pageviews
```

Preparing the data

The data is combined and rows with missing entries are deleted.

In [27]:
```
#preparing data

pageviews_kiel = prepare_pageviews(pageviews_kiel)
pageviews_sktPeterOrding = prepare_pageviews(pageviews_sktPeterOrding)
pageviews_warnemuende = prepare_pageviews(pageviews_warnemuende)

#group hourly data to daily data

daily_weather_kiel = group_hourly_weatherdata_to_daily(weatherdata_kiel)
daily_weather_sktPeterOrding = group_hourly_weatherdata_to_daily(weatherda
daily_weather_warnemuende = group_hourly_weatherdata_to_daily(weatherdata_

#combine pageviews and weatherdata into one data frame

kiel_combined = pd.merge(daily_weather_kiel,pageviews_kiel, on = 'date')
sktPeterOrding_combined = pd.merge(daily_weather_sktPeterOrding,pageviews_
warnemuende_combined = pd.merge(daily_weather_warnemuende,pageviews_warnem

combined_data = pd.concat([kiel_combined, sktPeterOrding_combined,warnemue
combined_data = combined_data.reset_index(drop="True")

print(combined_data)
```

In [30]:
```
# check for missing values

print("missing values in data: ", combined_data.isnull().sum())
```

```
missing values in data:  date              0
wind              52
wind direction    52
wind gust         83
air temp          51
location          51
pageviews          0
dtype: int64
```

In [212...
```
#seperate rows with missing data from dataset

incomplete_rows = combined_data[combined_data.isna().any(axis=1)]
combined_data = combined_data.dropna()

print("missing values in data: ", combined_data.isnull().sum())
```

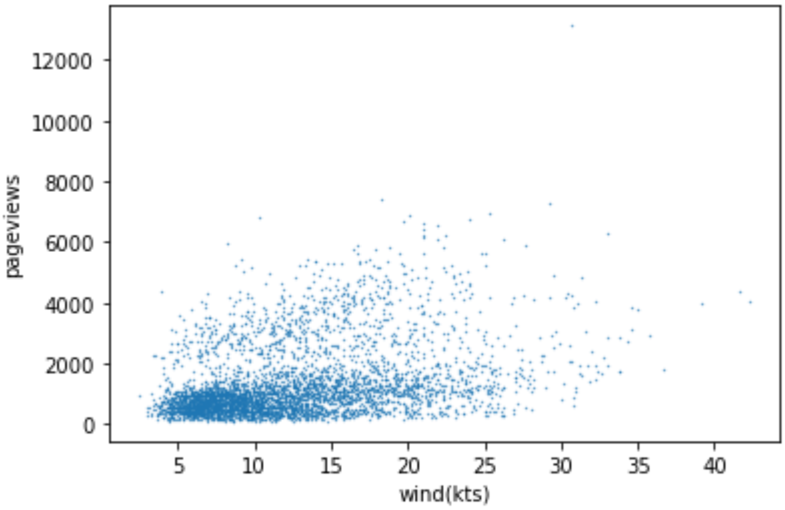
```
missing values in data:  date             0
wind              0
wind direction    0
wind gust         0
air temp          0
location          0
pageviews         0
```

```
dtype: int64
```

Data exploration

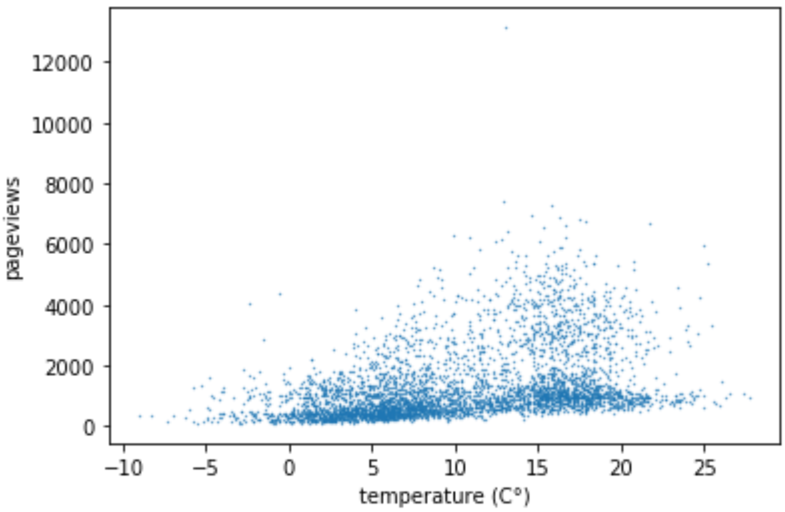
In [51]:

```
wind = combined_data.loc[:,'wind']
views = combined_data.loc[:,'pageviews']
plt.scatter(wind, views, s=0.1)
plt.xlabel("wind(kts)")
plt.ylabel("pageviews")
plt.show()
```



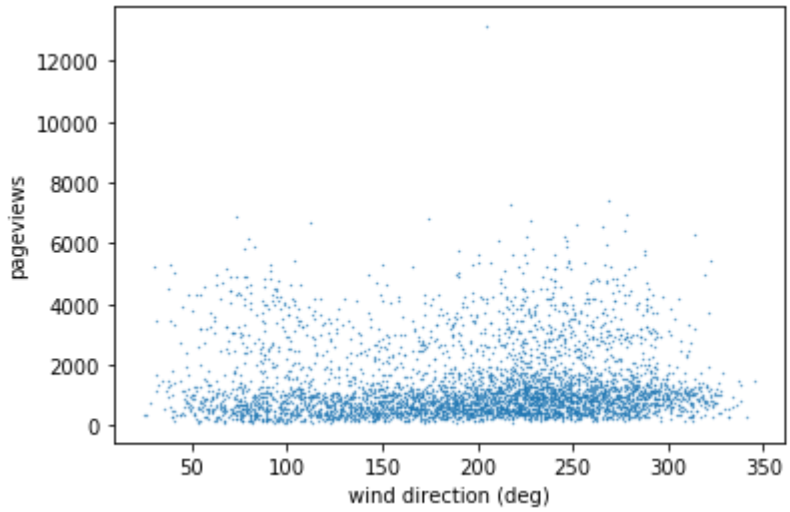
In [56]:

```
temp = combined_data.loc[:,'air temp']
plt.scatter(temp, views, s=0.1)
plt.xlabel("temperature (C°)")
plt.ylabel("pageviews")
plt.show()
```



In [58]:

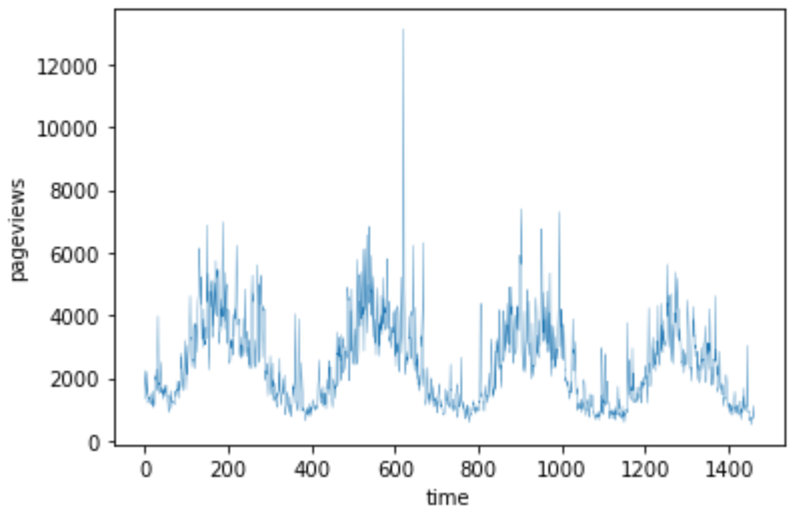
```
wind_direction = combined_data.loc[:,'wind direction']
plt.scatter(wind_direction, views, s=0.1)
plt.xlabel("wind direction (deg)")
plt.ylabel("pageviews")
plt.show()
```



In [216...

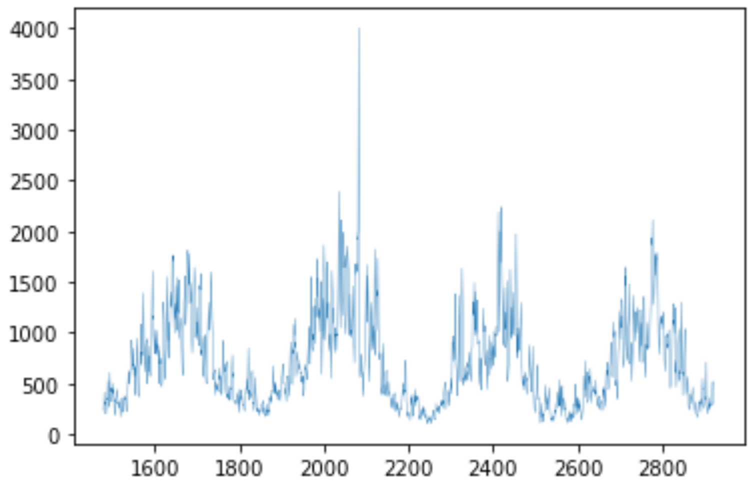
```
data_kiel = combined_data[combined_data['location'] == 1]
data_sktPeterOrding = combined_data[combined_data['location'] == 2]
data_warnemuende = combined_data[combined_data['location'] == 3]

data_kiel['pageviews'].plot(linewidth=0.3, xlabel = "time", ylabel = "page
```



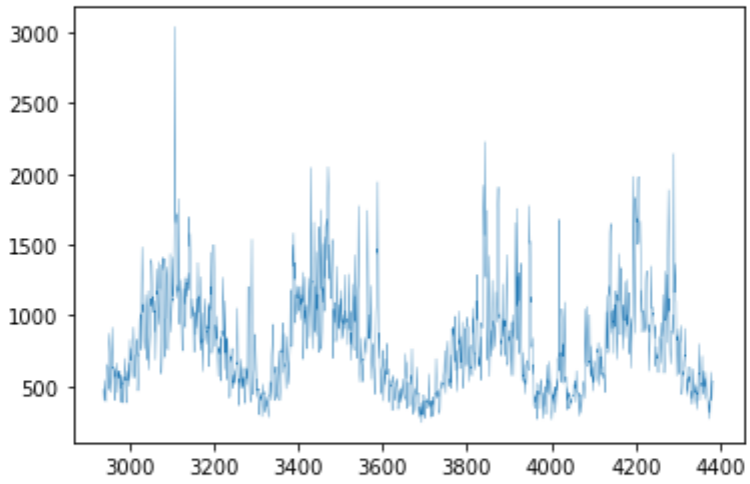
In [67]:

```
data_sktPeterOrding['pageviews'].plot(linewidth=0.3, xlabel = "time", ylab
```



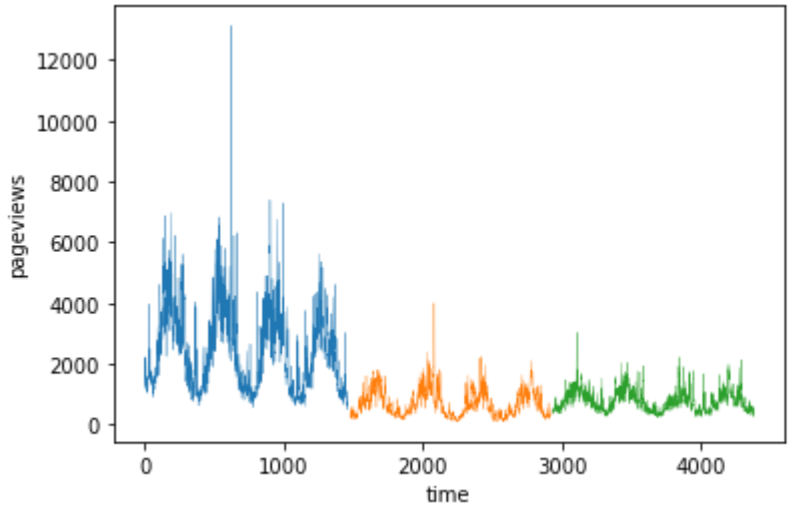
In [68]:

```
data_warnemuende['pageviews'].plot(linewidth=0.3, xlabel = "time", ylabel =
```



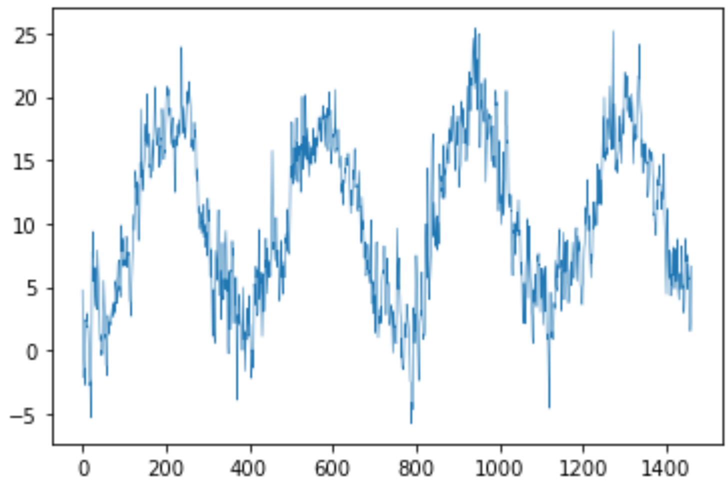
In [218…

```
data_kiel['pageviews'].plot(linewidth=0.3, xlabel = "time", ylabel = "pagev
data_sktPeterOrding['pageviews'].plot(linewidth=0.3, xlabel = "time", ylabe
data_warnemuende['pageviews'].plot(linewidth=0.3, xlabel = "time", ylabel =
```



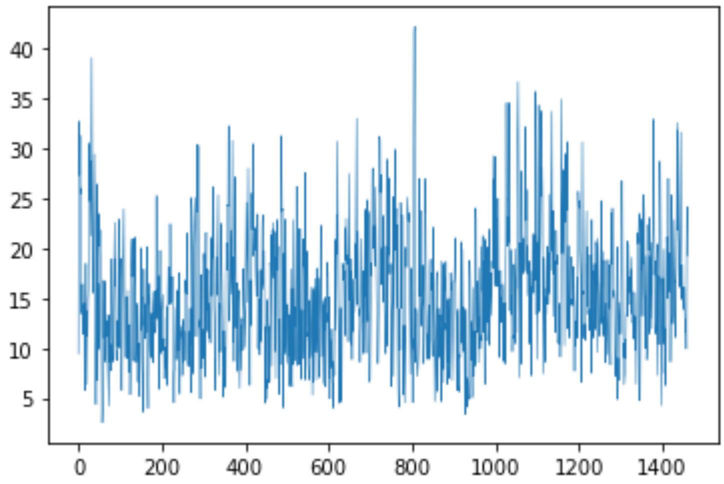
In [71]:

```
data_kiel['air temp'].plot(linewidth=0.5);
```



In [72]:

```
data_kiel['wind'].plot(linewidth=0.5);
```



- contradicting my expectations, the popularity of the wind finder website seems to be stable over the 4 years for which I have data.
- as expected, both the wind speed and the temperature are positively correlated with the number of page views
- the repeating sin-like patter of the page views seems to match the repeating pattern of the air temperature. I would assume that the most important factor for the page views is the air temperature.
- the wind direction seems not to be very important for the prediction of page views

Splitting the Data and building the model

In [192…

```
X = combined_data.drop(columns=['pageviews','date', 'wind direction','wind
y = combined_data.drop(columns=['date', 'wind', 'wind direction', 'wind gus
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33,
```

In [193…

```
print(X_train.describe())
```

```
              wind     air temp     location
count  2881.000000  2881.000000  2881.000000
mean     12.240006    10.527809     2.012149
std       5.846952     6.456361     0.814916
min       2.956522    -9.000000     1.000000
25%       7.583333     5.384615     1.000000
50%      11.041667    10.208333     2.000000
75%      15.833333    16.152778     3.000000
max      41.671329    27.708333     3.000000
```

In [194…

```
print(X_test.describe())
```

```
              wind     air temp     location
count  1419.000000  1419.000000  1419.000000
mean     12.665607    10.104142     1.970402
std       5.996547     6.329566     0.819696
min       2.513274    -8.291667     1.000000
25%       8.031944     5.272727     1.000000
50%      11.416667     9.541667     2.000000
75%      16.104286    15.750000     3.000000
max      42.244755    26.333333     3.000000
```

In [195…

```
# scaling the data

sc = StandardScaler()

X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)
```

In [209…

```
# building the model

model = Sequential()
d_rate = 0.8
reg = 0
model.add(Dense(256, activation='relu',kernel_regularizer=regularizers.l2(
Dropout(d_rate)
model.add(Dense(128,activation='relu',kernel_regularizer=regularizers.l2(r
Dropout(d_rate)
model.add(Dense(128,activation='relu',kernel_regularizer=regularizers.l2(r
Dropout(d_rate)
model.add(Dense(16,activation='relu',kernel_regularizer=regularizers.l2(reg
model.add(Dense(1, activation='relu'))


# Compile model
model.compile(loss='mae', optimizer='adam', metrics=['mae'])
# Fit the model
history = model.fit(X_train, y_train, epochs=200, batch_size=100,
                     validation_data=(X_test, y_test),
                    verbose=1)
# evaluate the model
scores = model.evaluate(X_test, y_test, verbose=0)
print("%s:" % (model.metrics_names[1]))
```

```
Epoch 1/200
29/29 [==============================] - 1s 7ms/step - loss: 1321.8330 - ma
e: 1321.8330 - val_loss: 1312.9773 - val_mae: 1312.9774
Epoch 2/200
29/29 [==============================] - 0s 2ms/step - loss: 1241.4580 - ma
e: 1241.4580 - val_loss: 1044.0126 - val_mae: 1044.0126
Epoch 3/200
29/29 [==============================] - 0s 2ms/step - loss: 898.9895 - ma
e: 898.9895 - val_loss: 570.6832 - val_mae: 570.6832
Epoch 4/200
29/29 [==============================] - 0s 2ms/step - loss: 541.5541 - ma
e: 541.5541 - val_loss: 457.1435 - val_mae: 457.1435
Epoch 5/200
29/29 [==============================] - 0s 2ms/step - loss: 445.8793 - ma
e: 445.8793 - val_loss: 414.3849 - val_mae: 414.3849
Epoch 6/200
29/29 [==============================] - 0s 2ms/step - loss: 423.9984 - ma
e: 423.9984 - val_loss: 394.9117 - val_mae: 394.9117
Epoch 7/200
29/29 [==============================] - 0s 2ms/step - loss: 395.3664 - ma
e: 395.3664 - val_loss: 385.5625 - val_mae: 385.5625
Epoch 8/200
29/29 [==============================] - 0s 2ms/step - loss: 393.5070 - ma
e: 393.5070 - val_loss: 375.4124 - val_mae: 375.4124
Epoch 9/200
29/29 [==============================] - 0s 2ms/step - loss: 372.5546 - ma
e: 372.5546 - val_loss: 369.1357 - val_mae: 369.1357
Epoch 10/200
29/29 [==============================] - 0s 2ms/step - loss: 373.4144 - ma
e: 373.4144 - val_loss: 366.2620 - val_mae: 366.2620
```

```
Epoch 11/200
29/29 [==============================] - 0s 2ms/step - loss: 361.5205 - ma
e: 361.5205 - val_loss: 360.6183 - val_mae: 360.6183
Epoch 12/200
29/29 [==============================] - 0s 2ms/step - loss: 375.1317 - ma
e: 375.1317 - val_loss: 357.8358 - val_mae: 357.8358
Epoch 13/200
29/29 [==============================] - 0s 2ms/step - loss: 366.6812 - ma
e: 366.6812 - val_loss: 353.6728 - val_mae: 353.6728
Epoch 14/200
29/29 [==============================] - 0s 2ms/step - loss: 362.7484 - ma
e: 362.7484 - val_loss: 350.1714 - val_mae: 350.1714
Epoch 15/200
29/29 [==============================] - 0s 2ms/step - loss: 359.5532 - ma
e: 359.5532 - val_loss: 349.8632 - val_mae: 349.8632
Epoch 16/200
29/29 [==============================] - 0s 2ms/step - loss: 365.1108 - ma
e: 365.1108 - val_loss: 347.1161 - val_mae: 347.1161
Epoch 17/200
29/29 [==============================] - 0s 2ms/step - loss: 351.9534 - ma
e: 351.9534 - val_loss: 342.2820 - val_mae: 342.2820
Epoch 18/200
29/29 [==============================] - 0s 2ms/step - loss: 360.0468 - ma
e: 360.0468 - val_loss: 339.4390 - val_mae: 339.4390
Epoch 19/200
29/29 [==============================] - 0s 2ms/step - loss: 349.7781 - ma
e: 349.7781 - val_loss: 337.0977 - val_mae: 337.0977
Epoch 20/200
29/29 [==============================] - 0s 2ms/step - loss: 351.5255 - ma
e: 351.5255 - val_loss: 344.0683 - val_mae: 344.0683
Epoch 21/200
29/29 [==============================] - 0s 2ms/step - loss: 347.0518 - ma
e: 347.0518 - val_loss: 336.2761 - val_mae: 336.2761
Epoch 22/200
29/29 [==============================] - 0s 2ms/step - loss: 341.8795 - ma
e: 341.8795 - val_loss: 332.3392 - val_mae: 332.3392
Epoch 23/200
29/29 [==============================] - 0s 2ms/step - loss: 346.9397 - ma
e: 346.9396 - val_loss: 331.4354 - val_mae: 331.4354
Epoch 24/200
29/29 [==============================] - 0s 2ms/step - loss: 333.6759 - ma
e: 333.6759 - val_loss: 329.6468 - val_mae: 329.6468
Epoch 25/200
29/29 [==============================] - 0s 2ms/step - loss: 346.6793 - ma
e: 346.6793 - val_loss: 327.4880 - val_mae: 327.4880
Epoch 26/200
29/29 [==============================] - 0s 2ms/step - loss: 344.4411 - ma
e: 344.4411 - val_loss: 329.1262 - val_mae: 329.1262
Epoch 27/200
29/29 [==============================] - 0s 2ms/step - loss: 326.9577 - ma
e: 326.9577 - val_loss: 325.8958 - val_mae: 325.8958
Epoch 28/200
29/29 [==============================] - 0s 2ms/step - loss: 341.0396 - ma
e: 341.0396 - val_loss: 326.6912 - val_mae: 326.6912
Epoch 29/200
29/29 [==============================] - 0s 2ms/step - loss: 325.8117 - ma
e: 325.8117 - val_loss: 326.3834 - val_mae: 326.3834
Epoch 30/200
29/29 [==============================] - 0s 2ms/step - loss: 332.7764 - ma
e: 332.7764 - val_loss: 322.9972 - val_mae: 322.9972
Epoch 31/200
29/29 [==============================] - 0s 2ms/step - loss: 341.7166 - ma
e: 341.7166 - val_loss: 322.2048 - val_mae: 322.2048
Epoch 32/200
```

```
29/29 [==============================] - 0s 2ms/step - loss: 337.9061 - ma
e: 337.9061 - val_loss: 322.1075 - val_mae: 322.1075
Epoch 33/200
29/29 [==============================] - 0s 2ms/step - loss: 331.3986 - ma
e: 331.3986 - val_loss: 323.2071 - val_mae: 323.2071
Epoch 34/200
29/29 [==============================] - 0s 2ms/step - loss: 333.0525 - ma
e: 333.0525 - val_loss: 324.1192 - val_mae: 324.1192
Epoch 35/200
29/29 [==============================] - 0s 2ms/step - loss: 333.5655 - ma
e: 333.5655 - val_loss: 321.2472 - val_mae: 321.2472
Epoch 36/200
29/29 [==============================] - 0s 2ms/step - loss: 326.4668 - ma
e: 326.4668 - val_loss: 320.6242 - val_mae: 320.6242
Epoch 37/200
29/29 [==============================] - 0s 2ms/step - loss: 318.0150 - ma
e: 318.0150 - val_loss: 319.8421 - val_mae: 319.8421
Epoch 38/200
29/29 [==============================] - 0s 2ms/step - loss: 335.4658 - ma
e: 335.4658 - val_loss: 321.2374 - val_mae: 321.2374
Epoch 39/200
29/29 [==============================] - 0s 2ms/step - loss: 325.7424 - ma
e: 325.7424 - val_loss: 330.6827 - val_mae: 330.6826
Epoch 40/200
29/29 [==============================] - 0s 2ms/step - loss: 326.7814 - ma
e: 326.7814 - val_loss: 320.3814 - val_mae: 320.3814
Epoch 41/200
29/29 [==============================] - 0s 2ms/step - loss: 323.5118 - ma
e: 323.5118 - val_loss: 319.7118 - val_mae: 319.7118
Epoch 42/200
29/29 [==============================] - 0s 2ms/step - loss: 324.9710 - ma
e: 324.9710 - val_loss: 318.6366 - val_mae: 318.6366
Epoch 43/200
29/29 [==============================] - 0s 2ms/step - loss: 325.1526 - ma
e: 325.1526 - val_loss: 318.9670 - val_mae: 318.9670
Epoch 44/200
29/29 [==============================] - 0s 2ms/step - loss: 328.8987 - ma
e: 328.8987 - val_loss: 318.0964 - val_mae: 318.0964
Epoch 45/200
29/29 [==============================] - 0s 2ms/step - loss: 346.5080 - ma
e: 346.5080 - val_loss: 318.0948 - val_mae: 318.0948
Epoch 46/200
29/29 [==============================] - 0s 2ms/step - loss: 330.1352 - ma
e: 330.1352 - val_loss: 318.5973 - val_mae: 318.5973
Epoch 47/200
29/29 [==============================] - 0s 2ms/step - loss: 317.2659 - ma
e: 317.2659 - val_loss: 317.0535 - val_mae: 317.0535
Epoch 48/200
29/29 [==============================] - 0s 2ms/step - loss: 323.7609 - ma
e: 323.7609 - val_loss: 318.7151 - val_mae: 318.7152
Epoch 49/200
29/29 [==============================] - 0s 2ms/step - loss: 333.8454 - ma
e: 333.8454 - val_loss: 316.1389 - val_mae: 316.1389
Epoch 50/200
29/29 [==============================] - 0s 2ms/step - loss: 322.0183 - ma
e: 322.0183 - val_loss: 317.6796 - val_mae: 317.6796
Epoch 51/200
29/29 [==============================] - 0s 2ms/step - loss: 329.6547 - ma
e: 329.6547 - val_loss: 317.9353 - val_mae: 317.9353
Epoch 52/200
29/29 [==============================] - 0s 2ms/step - loss: 323.9151 - ma
e: 323.9151 - val_loss: 316.4948 - val_mae: 316.4948
Epoch 53/200
29/29 [==============================] - 0s 2ms/step - loss: 324.5670 - ma
```

```
e: 324.5670 - val_loss: 318.5711 - val_mae: 318.5711
Epoch 54/200
29/29 [==============================] - 0s 2ms/step - loss: 330.4295 - ma
e: 330.4295 - val_loss: 316.2730 - val_mae: 316.2730
Epoch 55/200
29/29 [==============================] - 0s 2ms/step - loss: 320.3203 - ma
e: 320.3203 - val_loss: 315.1126 - val_mae: 315.1127
Epoch 56/200
29/29 [==============================] - 0s 2ms/step - loss: 317.4527 - ma
e: 317.4527 - val_loss: 326.5543 - val_mae: 326.5543
Epoch 57/200
29/29 [==============================] - 0s 2ms/step - loss: 323.0927 - ma
e: 323.0927 - val_loss: 315.4386 - val_mae: 315.4386
Epoch 58/200
29/29 [==============================] - 0s 2ms/step - loss: 328.1424 - ma
e: 328.1424 - val_loss: 317.2000 - val_mae: 317.2000
Epoch 59/200
29/29 [==============================] - 0s 2ms/step - loss: 321.3136 - ma
e: 321.3136 - val_loss: 315.0144 - val_mae: 315.0144
Epoch 60/200
29/29 [==============================] - 0s 2ms/step - loss: 312.6042 - ma
e: 312.6042 - val_loss: 315.0782 - val_mae: 315.0783
Epoch 61/200
29/29 [==============================] - 0s 2ms/step - loss: 326.5270 - ma
e: 326.5270 - val_loss: 315.1234 - val_mae: 315.1234
Epoch 62/200
29/29 [==============================] - 0s 2ms/step - loss: 315.2720 - ma
e: 315.2720 - val_loss: 315.2585 - val_mae: 315.2585
Epoch 63/200
29/29 [==============================] - 0s 2ms/step - loss: 325.5984 - ma
e: 325.5984 - val_loss: 315.8672 - val_mae: 315.8672
Epoch 64/200
29/29 [==============================] - 0s 2ms/step - loss: 327.6295 - ma
e: 327.6295 - val_loss: 316.8097 - val_mae: 316.8097
Epoch 65/200
29/29 [==============================] - 0s 2ms/step - loss: 328.4208 - ma
e: 328.4208 - val_loss: 313.4890 - val_mae: 313.4890
Epoch 66/200
29/29 [==============================] - 0s 2ms/step - loss: 317.8282 - ma
e: 317.8282 - val_loss: 313.6523 - val_mae: 313.6523
Epoch 67/200
29/29 [==============================] - 0s 2ms/step - loss: 315.6314 - ma
e: 315.6314 - val_loss: 313.9176 - val_mae: 313.9176
Epoch 68/200
29/29 [==============================] - 0s 2ms/step - loss: 320.2567 - ma
e: 320.2567 - val_loss: 313.2576 - val_mae: 313.2576
Epoch 69/200
29/29 [==============================] - 0s 2ms/step - loss: 326.5765 - ma
e: 326.5765 - val_loss: 314.4983 - val_mae: 314.4983
Epoch 70/200
29/29 [==============================] - 0s 2ms/step - loss: 324.1825 - ma
e: 324.1825 - val_loss: 312.7388 - val_mae: 312.7388
Epoch 71/200
29/29 [==============================] - 0s 2ms/step - loss: 321.2176 - ma
e: 321.2176 - val_loss: 312.7823 - val_mae: 312.7823
Epoch 72/200
29/29 [==============================] - 0s 2ms/step - loss: 321.1901 - ma
e: 321.1901 - val_loss: 314.7500 - val_mae: 314.7500
Epoch 73/200
29/29 [==============================] - 0s 2ms/step - loss: 323.5779 - ma
e: 323.5779 - val_loss: 312.6456 - val_mae: 312.6456
Epoch 74/200
29/29 [==============================] - 0s 2ms/step - loss: 304.8816 - ma
e: 304.8816 - val_loss: 313.5128 - val_mae: 313.5128
```

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Epoch 75/200
29/29 [==============================] - 0s 2ms/step - loss: 317.2227 - ma
e: 317.2227 - val_loss: 312.0528 - val_mae: 312.0528
Epoch 76/200
29/29 [==============================] - 0s 2ms/step - loss: 320.9475 - ma
e: 320.9475 - val_loss: 311.6820 - val_mae: 311.6820
Epoch 77/200
29/29 [==============================] - 0s 2ms/step - loss: 316.1557 - ma
e: 316.1557 - val_loss: 315.8517 - val_mae: 315.8517
Epoch 78/200
29/29 [==============================] - 0s 2ms/step - loss: 311.8714 - ma
e: 311.8714 - val_loss: 313.1668 - val_mae: 313.1668
Epoch 79/200
29/29 [==============================] - 0s 2ms/step - loss: 313.2642 - ma
e: 313.2642 - val_loss: 313.3619 - val_mae: 313.3619
Epoch 80/200
29/29 [==============================] - 0s 2ms/step - loss: 315.3700 - ma
e: 315.3700 - val_loss: 314.0073 - val_mae: 314.0073
Epoch 81/200
29/29 [==============================] - 0s 2ms/step - loss: 297.1491 - ma
e: 297.1491 - val_loss: 311.5197 - val_mae: 311.5197
Epoch 82/200
29/29 [==============================] - 0s 2ms/step - loss: 313.7235 - ma
e: 313.7235 - val_loss: 312.5720 - val_mae: 312.5720
Epoch 83/200
29/29 [==============================] - 0s 2ms/step - loss: 311.0009 - ma
e: 311.0009 - val_loss: 312.5115 - val_mae: 312.5115
Epoch 84/200
29/29 [==============================] - 0s 2ms/step - loss: 310.3665 - ma
e: 310.3665 - val_loss: 318.6797 - val_mae: 318.6797
Epoch 85/200
29/29 [==============================] - 0s 2ms/step - loss: 319.4122 - ma
e: 319.4122 - val_loss: 312.1553 - val_mae: 312.1553
Epoch 86/200
29/29 [==============================] - 0s 2ms/step - loss: 316.5613 - ma
e: 316.5613 - val_loss: 312.2453 - val_mae: 312.2453
Epoch 87/200
29/29 [==============================] - 0s 2ms/step - loss: 314.6265 - ma
e: 314.6265 - val_loss: 314.1346 - val_mae: 314.1346
Epoch 88/200
29/29 [==============================] - 0s 2ms/step - loss: 322.9356 - ma
e: 322.9356 - val_loss: 313.9586 - val_mae: 313.9586
Epoch 89/200
29/29 [==============================] - 0s 2ms/step - loss: 318.4474 - ma
e: 318.4474 - val_loss: 312.9817 - val_mae: 312.9817
Epoch 90/200
29/29 [==============================] - 0s 2ms/step - loss: 317.7863 - ma
e: 317.7864 - val_loss: 311.2268 - val_mae: 311.2268
Epoch 91/200
29/29 [==============================] - 0s 2ms/step - loss: 319.2909 - ma
e: 319.2909 - val_loss: 312.9185 - val_mae: 312.9185
Epoch 92/200
29/29 [==============================] - 0s 2ms/step - loss: 322.4619 - ma
e: 322.4619 - val_loss: 315.1061 - val_mae: 315.1061
Epoch 93/200
29/29 [==============================] - 0s 2ms/step - loss: 314.4851 - ma
e: 314.4851 - val_loss: 314.6669 - val_mae: 314.6669
Epoch 94/200
29/29 [==============================] - 0s 2ms/step - loss: 311.6825 - ma
e: 311.6825 - val_loss: 315.5038 - val_mae: 315.5038
Epoch 95/200
29/29 [==============================] - 0s 2ms/step - loss: 315.0759 - ma
e: 315.0759 - val_loss: 312.2886 - val_mae: 312.2886
Epoch 96/200
```

```
29/29 [==============================] - 0s 2ms/step - loss: 305.4058 - ma
e: 305.4058 - val_loss: 311.6821 - val_mae: 311.6821
Epoch 97/200
29/29 [==============================] - 0s 2ms/step - loss: 323.0263 - ma
e: 323.0263 - val_loss: 311.6418 - val_mae: 311.6418
Epoch 98/200
29/29 [==============================] - 0s 2ms/step - loss: 298.1578 - ma
e: 298.1578 - val_loss: 311.3998 - val_mae: 311.3998
Epoch 99/200
29/29 [==============================] - 0s 2ms/step - loss: 332.4002 - ma
e: 332.4002 - val_loss: 312.9706 - val_mae: 312.9706
Epoch 100/200
29/29 [==============================] - 0s 2ms/step - loss: 323.1705 - ma
e: 323.1705 - val_loss: 311.5500 - val_mae: 311.5500
Epoch 101/200
29/29 [==============================] - 0s 2ms/step - loss: 312.8805 - ma
e: 312.8805 - val_loss: 311.8378 - val_mae: 311.8378
Epoch 102/200
29/29 [==============================] - 0s 2ms/step - loss: 307.8413 - ma
e: 307.8414 - val_loss: 312.1571 - val_mae: 312.1571
Epoch 103/200
29/29 [==============================] - 0s 2ms/step - loss: 311.3627 - ma
e: 311.3626 - val_loss: 314.2042 - val_mae: 314.2041
Epoch 104/200
29/29 [==============================] - 0s 2ms/step - loss: 316.2706 - ma
e: 316.2706 - val_loss: 312.1050 - val_mae: 312.1050
Epoch 105/200
29/29 [==============================] - 0s 2ms/step - loss: 317.0660 - ma
e: 317.0659 - val_loss: 311.7670 - val_mae: 311.7670
Epoch 106/200
29/29 [==============================] - 0s 2ms/step - loss: 306.2700 - ma
e: 306.2700 - val_loss: 311.8951 - val_mae: 311.8951
Epoch 107/200
29/29 [==============================] - 0s 2ms/step - loss: 292.9186 - ma
e: 292.9186 - val_loss: 311.8120 - val_mae: 311.8120
Epoch 108/200
29/29 [==============================] - 0s 2ms/step - loss: 311.8847 - ma
e: 311.8847 - val_loss: 312.2263 - val_mae: 312.2263
Epoch 109/200
29/29 [==============================] - 0s 2ms/step - loss: 308.3614 - ma
e: 308.3614 - val_loss: 312.3921 - val_mae: 312.3921
Epoch 110/200
29/29 [==============================] - 0s 2ms/step - loss: 312.8383 - ma
e: 312.8383 - val_loss: 311.7451 - val_mae: 311.7451
Epoch 111/200
29/29 [==============================] - 0s 2ms/step - loss: 313.0771 - ma
e: 313.0771 - val_loss: 318.8123 - val_mae: 318.8123
Epoch 112/200
29/29 [==============================] - 0s 2ms/step - loss: 316.4959 - ma
e: 316.4959 - val_loss: 318.6669 - val_mae: 318.6669
Epoch 113/200
29/29 [==============================] - 0s 2ms/step - loss: 321.2065 - ma
e: 321.2065 - val_loss: 315.7310 - val_mae: 315.7310
Epoch 114/200
29/29 [==============================] - 0s 2ms/step - loss: 318.9031 - ma
e: 318.9031 - val_loss: 312.9064 - val_mae: 312.9064
Epoch 115/200
29/29 [==============================] - 0s 2ms/step - loss: 320.0401 - ma
e: 320.0401 - val_loss: 312.4046 - val_mae: 312.4046
Epoch 116/200
29/29 [==============================] - 0s 2ms/step - loss: 321.6594 - ma
e: 321.6594 - val_loss: 313.7177 - val_mae: 313.7177
Epoch 117/200
29/29 [==============================] - 0s 2ms/step - loss: 311.8461 - ma
```

```
e: 311.8461 - val_loss: 314.6604 - val_mae: 314.6604
Epoch 118/200
29/29 [==============================] - 0s 2ms/step - loss: 306.1966 - ma
e: 306.1966 - val_loss: 311.9359 - val_mae: 311.9359
Epoch 119/200
29/29 [==============================] - 0s 2ms/step - loss: 304.6532 - ma
e: 304.6532 - val_loss: 312.2290 - val_mae: 312.2290
Epoch 120/200
29/29 [==============================] - 0s 2ms/step - loss: 317.1112 - ma
e: 317.1112 - val_loss: 313.0789 - val_mae: 313.0789
Epoch 121/200
29/29 [==============================] - 0s 2ms/step - loss: 309.8670 - ma
e: 309.8670 - val_loss: 313.1803 - val_mae: 313.1803
Epoch 122/200
29/29 [==============================] - 0s 2ms/step - loss: 308.4555 - ma
e: 308.4556 - val_loss: 312.9465 - val_mae: 312.9465
Epoch 123/200
29/29 [==============================] - 0s 2ms/step - loss: 317.3573 - ma
e: 317.3573 - val_loss: 312.0298 - val_mae: 312.0298
Epoch 124/200
29/29 [==============================] - 0s 2ms/step - loss: 316.9791 - ma
e: 316.9791 - val_loss: 312.8944 - val_mae: 312.8944
Epoch 125/200
29/29 [==============================] - 0s 2ms/step - loss: 312.7494 - ma
e: 312.7494 - val_loss: 313.0903 - val_mae: 313.0903
Epoch 126/200
29/29 [==============================] - 0s 2ms/step - loss: 317.0015 - ma
e: 317.0015 - val_loss: 313.2946 - val_mae: 313.2946
Epoch 127/200
29/29 [==============================] - 0s 2ms/step - loss: 318.4482 - ma
e: 318.4482 - val_loss: 313.1601 - val_mae: 313.1601
Epoch 128/200
29/29 [==============================] - 0s 2ms/step - loss: 311.6035 - ma
e: 311.6035 - val_loss: 313.1756 - val_mae: 313.1756
Epoch 129/200
29/29 [==============================] - 0s 2ms/step - loss: 315.1252 - ma
e: 315.1252 - val_loss: 312.3178 - val_mae: 312.3178
Epoch 130/200
29/29 [==============================] - 0s 2ms/step - loss: 310.2222 - ma
e: 310.2222 - val_loss: 313.3598 - val_mae: 313.3598
Epoch 131/200
29/29 [==============================] - 0s 2ms/step - loss: 318.2928 - ma
e: 318.2928 - val_loss: 313.5220 - val_mae: 313.5220
Epoch 132/200
29/29 [==============================] - 0s 2ms/step - loss: 308.5728 - ma
e: 308.5728 - val_loss: 311.4137 - val_mae: 311.4137
Epoch 133/200
29/29 [==============================] - 0s 2ms/step - loss: 301.6787 - ma
e: 301.6787 - val_loss: 312.4032 - val_mae: 312.4032
Epoch 134/200
29/29 [==============================] - 0s 2ms/step - loss: 318.1683 - ma
e: 318.1683 - val_loss: 323.5783 - val_mae: 323.5783
Epoch 135/200
29/29 [==============================] - 0s 2ms/step - loss: 320.4320 - ma
e: 320.4320 - val_loss: 312.3421 - val_mae: 312.3421
Epoch 136/200
29/29 [==============================] - 0s 2ms/step - loss: 312.7608 - ma
e: 312.7608 - val_loss: 310.7161 - val_mae: 310.7161
Epoch 137/200
29/29 [==============================] - 0s 2ms/step - loss: 308.1154 - ma
e: 308.1154 - val_loss: 312.4596 - val_mae: 312.4596
Epoch 138/200
29/29 [==============================] - 0s 2ms/step - loss: 316.5467 - ma
e: 316.5467 - val_loss: 312.8258 - val_mae: 312.8258
```

```
Epoch 139/200
29/29 [==============================] - 0s 2ms/step - loss: 324.6939 - ma
e: 324.6939 - val_loss: 314.3152 - val_mae: 314.3152
Epoch 140/200
29/29 [==============================] - 0s 2ms/step - loss: 309.5861 - ma
e: 309.5861 - val_loss: 312.4939 - val_mae: 312.4939
Epoch 141/200
29/29 [==============================] - 0s 2ms/step - loss: 306.9751 - ma
e: 306.9751 - val_loss: 315.0424 - val_mae: 315.0424
Epoch 142/200
29/29 [==============================] - 0s 2ms/step - loss: 318.4790 - ma
e: 318.4790 - val_loss: 312.1799 - val_mae: 312.1799
Epoch 143/200
29/29 [==============================] - 0s 2ms/step - loss: 317.5862 - ma
e: 317.5862 - val_loss: 313.1071 - val_mae: 313.1071
Epoch 144/200
29/29 [==============================] - 0s 2ms/step - loss: 313.5496 - ma
e: 313.5496 - val_loss: 312.5420 - val_mae: 312.5420
Epoch 145/200
29/29 [==============================] - 0s 2ms/step - loss: 327.4318 - ma
e: 327.4318 - val_loss: 312.1828 - val_mae: 312.1828
Epoch 146/200
29/29 [==============================] - 0s 2ms/step - loss: 309.4702 - ma
e: 309.4702 - val_loss: 313.9972 - val_mae: 313.9972
Epoch 147/200
29/29 [==============================] - 0s 2ms/step - loss: 315.0657 - ma
e: 315.0657 - val_loss: 313.5005 - val_mae: 313.5005
Epoch 148/200
29/29 [==============================] - 0s 2ms/step - loss: 303.3955 - ma
e: 303.3955 - val_loss: 316.8821 - val_mae: 316.8821
Epoch 149/200
29/29 [==============================] - 0s 2ms/step - loss: 306.5889 - ma
e: 306.5889 - val_loss: 313.3159 - val_mae: 313.3159
Epoch 150/200
29/29 [==============================] - 0s 2ms/step - loss: 307.0544 - ma
e: 307.0544 - val_loss: 313.6750 - val_mae: 313.6750
Epoch 151/200
29/29 [==============================] - 0s 2ms/step - loss: 306.6993 - ma
e: 306.6993 - val_loss: 313.1047 - val_mae: 313.1047
Epoch 152/200
29/29 [==============================] - 0s 2ms/step - loss: 305.7809 - ma
e: 305.7809 - val_loss: 312.7703 - val_mae: 312.7703
Epoch 153/200
29/29 [==============================] - 0s 2ms/step - loss: 314.9317 - ma
e: 314.9317 - val_loss: 314.0162 - val_mae: 314.0162
Epoch 154/200
29/29 [==============================] - 0s 2ms/step - loss: 311.7301 - ma
e: 311.7301 - val_loss: 311.3447 - val_mae: 311.3447
Epoch 155/200
29/29 [==============================] - 0s 2ms/step - loss: 318.1554 - ma
e: 318.1554 - val_loss: 313.3901 - val_mae: 313.3901
Epoch 156/200
29/29 [==============================] - 0s 2ms/step - loss: 297.9330 - ma
e: 297.9330 - val_loss: 313.6499 - val_mae: 313.6500
Epoch 157/200
29/29 [==============================] - 0s 2ms/step - loss: 316.1889 - ma
e: 316.1889 - val_loss: 313.2504 - val_mae: 313.2504
Epoch 158/200
29/29 [==============================] - 0s 2ms/step - loss: 304.9591 - ma
e: 304.9591 - val_loss: 312.6682 - val_mae: 312.6682
Epoch 159/200
29/29 [==============================] - 0s 2ms/step - loss: 316.3063 - ma
e: 316.3063 - val_loss: 312.0679 - val_mae: 312.0679
Epoch 160/200
```

```
29/29 [==============================] - 0s 2ms/step - loss: 319.7957 - ma
e: 319.7957 - val_loss: 316.6716 - val_mae: 316.6716
Epoch 161/200
29/29 [==============================] - 0s 2ms/step - loss: 307.3738 - ma
e: 307.3738 - val_loss: 312.9336 - val_mae: 312.9336
Epoch 162/200
29/29 [==============================] - 0s 2ms/step - loss: 305.4614 - ma
e: 305.4614 - val_loss: 311.9902 - val_mae: 311.9902
Epoch 163/200
29/29 [==============================] - 0s 2ms/step - loss: 317.1571 - ma
e: 317.1571 - val_loss: 315.6899 - val_mae: 315.6899
Epoch 164/200
29/29 [==============================] - 0s 2ms/step - loss: 311.2755 - ma
e: 311.2756 - val_loss: 312.4877 - val_mae: 312.4877
Epoch 165/200
29/29 [==============================] - 0s 2ms/step - loss: 321.4162 - ma
e: 321.4161 - val_loss: 313.0511 - val_mae: 313.0511
Epoch 166/200
29/29 [==============================] - 0s 2ms/step - loss: 313.7146 - ma
e: 313.7146 - val_loss: 314.4171 - val_mae: 314.4171
Epoch 167/200
29/29 [==============================] - 0s 2ms/step - loss: 305.9766 - ma
e: 305.9766 - val_loss: 314.0941 - val_mae: 314.0941
Epoch 168/200
29/29 [==============================] - 0s 2ms/step - loss: 303.2224 - ma
e: 303.2224 - val_loss: 315.4606 - val_mae: 315.4606
Epoch 169/200
29/29 [==============================] - 0s 2ms/step - loss: 321.1621 - ma
e: 321.1621 - val_loss: 311.9155 - val_mae: 311.9155
Epoch 170/200
29/29 [==============================] - 0s 2ms/step - loss: 312.0436 - ma
e: 312.0436 - val_loss: 312.2388 - val_mae: 312.2387
Epoch 171/200
29/29 [==============================] - 0s 2ms/step - loss: 298.5884 - ma
e: 298.5884 - val_loss: 313.9656 - val_mae: 313.9656
Epoch 172/200
29/29 [==============================] - 0s 2ms/step - loss: 319.9362 - ma
e: 319.9362 - val_loss: 313.7073 - val_mae: 313.7073
Epoch 173/200
29/29 [==============================] - 0s 2ms/step - loss: 302.8285 - ma
e: 302.8285 - val_loss: 313.1014 - val_mae: 313.1014
Epoch 174/200
29/29 [==============================] - 0s 2ms/step - loss: 303.5065 - ma
e: 303.5065 - val_loss: 315.3252 - val_mae: 315.3252
Epoch 175/200
29/29 [==============================] - 0s 2ms/step - loss: 314.7163 - ma
e: 314.7163 - val_loss: 312.6152 - val_mae: 312.6152
Epoch 176/200
29/29 [==============================] - 0s 2ms/step - loss: 310.7756 - ma
e: 310.7756 - val_loss: 311.2538 - val_mae: 311.2538
Epoch 177/200
29/29 [==============================] - 0s 2ms/step - loss: 302.8976 - ma
e: 302.8976 - val_loss: 313.3276 - val_mae: 313.3276
Epoch 178/200
29/29 [==============================] - 0s 2ms/step - loss: 322.9221 - ma
e: 322.9221 - val_loss: 313.4740 - val_mae: 313.4740
Epoch 179/200
29/29 [==============================] - 0s 2ms/step - loss: 306.8902 - ma
e: 306.8902 - val_loss: 314.0660 - val_mae: 314.0660
Epoch 180/200
29/29 [==============================] - 0s 2ms/step - loss: 317.0709 - ma
e: 317.0709 - val_loss: 314.1300 - val_mae: 314.1300
Epoch 181/200
29/29 [==============================] - 0s 2ms/step - loss: 301.5213 - ma
```

```
e: 301.5213 - val_loss: 312.3725 - val_mae: 312.3725
Epoch 182/200
29/29 [==============================] - 0s 2ms/step - loss: 305.3459 - ma
e: 305.3459 - val_loss: 313.3723 - val_mae: 313.3723
Epoch 183/200
29/29 [==============================] - 0s 2ms/step - loss: 314.0921 - ma
e: 314.0921 - val_loss: 314.3200 - val_mae: 314.3200
Epoch 184/200
29/29 [==============================] - 0s 2ms/step - loss: 319.1175 - ma
e: 319.1175 - val_loss: 316.3937 - val_mae: 316.3937
Epoch 185/200
29/29 [==============================] - 0s 2ms/step - loss: 299.1478 - ma
e: 299.1478 - val_loss: 312.4559 - val_mae: 312.4559
Epoch 186/200
29/29 [==============================] - 0s 2ms/step - loss: 304.4889 - ma
e: 304.4889 - val_loss: 313.5106 - val_mae: 313.5106
Epoch 187/200
29/29 [==============================] - 0s 2ms/step - loss: 306.5190 - ma
e: 306.5190 - val_loss: 312.5008 - val_mae: 312.5008
Epoch 188/200
29/29 [==============================] - 0s 2ms/step - loss: 315.5713 - ma
e: 315.5713 - val_loss: 314.4028 - val_mae: 314.4028
Epoch 189/200
29/29 [==============================] - 0s 2ms/step - loss: 319.4303 - ma
e: 319.4303 - val_loss: 312.5297 - val_mae: 312.5297
Epoch 190/200
29/29 [==============================] - 0s 2ms/step - loss: 307.3483 - ma
e: 307.3483 - val_loss: 312.9057 - val_mae: 312.9057
Epoch 191/200
29/29 [==============================] - 0s 2ms/step - loss: 312.0963 - ma
e: 312.0963 - val_loss: 313.6368 - val_mae: 313.6368
Epoch 192/200
29/29 [==============================] - 0s 2ms/step - loss: 307.8772 - ma
e: 307.8772 - val_loss: 313.3136 - val_mae: 313.3136
Epoch 193/200
29/29 [==============================] - 0s 2ms/step - loss: 312.9593 - ma
e: 312.9593 - val_loss: 312.4965 - val_mae: 312.4965
Epoch 194/200
29/29 [==============================] - 0s 2ms/step - loss: 306.7068 - ma
e: 306.7068 - val_loss: 313.8052 - val_mae: 313.8052
Epoch 195/200
29/29 [==============================] - 0s 2ms/step - loss: 309.7735 - ma
e: 309.7735 - val_loss: 313.4124 - val_mae: 313.4124
Epoch 196/200
29/29 [==============================] - 0s 2ms/step - loss: 309.0648 - ma
e: 309.0647 - val_loss: 315.7021 - val_mae: 315.7021
Epoch 197/200
29/29 [==============================] - 0s 2ms/step - loss: 323.6757 - ma
e: 323.6757 - val_loss: 312.7341 - val_mae: 312.7341
Epoch 198/200
29/29 [==============================] - 0s 2ms/step - loss: 315.4148 - ma
e: 315.4148 - val_loss: 313.8771 - val_mae: 313.8771
Epoch 199/200
29/29 [==============================] - 0s 2ms/step - loss: 321.5677 - ma
e: 321.5677 - val_loss: 313.3227 - val_mae: 313.3227
Epoch 200/200
29/29 [==============================] - 0s 2ms/step - loss: 316.9951 - ma
```

In [210…

```
model = Sequential()
d_rate = 0.8
reg = 0
model.add(Dense(256, activation='relu',kernel_regularizer=regularizers.l2(
Dropout(d_rate)
model.add(Dense(128,activation='relu',kernel_regularizer=regularizers.l2(r
Dropout(d_rate)
model.add(Dense(128,activation='relu',kernel_regularizer=regularizers.l2(r
Dropout(d_rate)
model.add(Dense(16,activation='relu',kernel_regularizer=regularizers.l2(reg
model.add(Dense(1, activation='relu'))


# Compile model
model.compile(loss='mae', optimizer='adam', metrics=['mae'])
# Fit the model
history = model.fit(X_train, y_train, epochs=50, batch_size=100,
                     validation_data=(X_test, y_test),
                    verbose=1)
# evaluate the model
scores = model.evaluate(X_test, y_test, verbose=0)
print("%s:" % (model.metrics_names[1]))
```

```
Epoch 1/50
29/29 [==============================] - 1s 7ms/step - loss: 1311.8399 - ma
e: 1311.8399 - val_loss: 1315.0153 - val_mae: 1315.0153
Epoch 2/50
29/29 [==============================] - 0s 2ms/step - loss: 1258.0613 - ma
e: 1258.0613 - val_loss: 1082.3937 - val_mae: 1082.3937
Epoch 3/50
29/29 [==============================] - 0s 2ms/step - loss: 887.2685 - ma
e: 887.2685 - val_loss: 602.7976 - val_mae: 602.7976
Epoch 4/50
29/29 [==============================] - 0s 2ms/step - loss: 551.9157 - ma
e: 551.9157 - val_loss: 472.1908 - val_mae: 472.1908
Epoch 5/50
29/29 [==============================] - 0s 2ms/step - loss: 474.1234 - ma
e: 474.1234 - val_loss: 424.9754 - val_mae: 424.9754
Epoch 6/50
29/29 [==============================] - 0s 2ms/step - loss: 448.5887 - ma
e: 448.5887 - val_loss: 399.6656 - val_mae: 399.6656
Epoch 7/50
29/29 [==============================] - 0s 2ms/step - loss: 398.7947 - ma
e: 398.7947 - val_loss: 386.5592 - val_mae: 386.5592
Epoch 8/50
29/29 [==============================] - 0s 2ms/step - loss: 380.4276 - ma
e: 380.4276 - val_loss: 382.0818 - val_mae: 382.0818
Epoch 9/50
29/29 [==============================] - 0s 2ms/step - loss: 384.9023 - ma
e: 384.9023 - val_loss: 371.1081 - val_mae: 371.1081
Epoch 10/50
29/29 [==============================] - 0s 2ms/step - loss: 373.5423 - ma
e: 373.5423 - val_loss: 365.7001 - val_mae: 365.7001
Epoch 11/50
29/29 [==============================] - 0s 2ms/step - loss: 377.4002 - ma
e: 377.4002 - val_loss: 361.4830 - val_mae: 361.4830
Epoch 12/50
29/29 [==============================] - 0s 2ms/step - loss: 375.5995 - ma
e: 375.5995 - val_loss: 357.9482 - val_mae: 357.9482
Epoch 13/50
29/29 [==============================] - 0s 2ms/step - loss: 365.5706 - ma
e: 365.5706 - val_loss: 356.0213 - val_mae: 356.0213
Epoch 14/50
```

```
29/29 [==============================] - 0s 2ms/step - loss: 359.5289 - ma
e: 359.5289 - val_loss: 352.7064 - val_mae: 352.7064
Epoch 15/50
29/29 [==============================] - 0s 2ms/step - loss: 354.9705 - ma
e: 354.9705 - val_loss: 349.8869 - val_mae: 349.8869
Epoch 16/50
29/29 [==============================] - 0s 2ms/step - loss: 367.9488 - ma
e: 367.9488 - val_loss: 348.3979 - val_mae: 348.3979
Epoch 17/50
29/29 [==============================] - 0s 2ms/step - loss: 345.9170 - ma
e: 345.9170 - val_loss: 343.0591 - val_mae: 343.0591
Epoch 18/50
29/29 [==============================] - 0s 2ms/step - loss: 365.3685 - ma
e: 365.3685 - val_loss: 341.3705 - val_mae: 341.3706
Epoch 19/50
29/29 [==============================] - 0s 2ms/step - loss: 354.5482 - ma
e: 354.5482 - val_loss: 340.5789 - val_mae: 340.5789
Epoch 20/50
29/29 [==============================] - 0s 2ms/step - loss: 353.6139 - ma
e: 353.6139 - val_loss: 338.6929 - val_mae: 338.6929
Epoch 21/50
29/29 [==============================] - 0s 2ms/step - loss: 346.5011 - ma
e: 346.5011 - val_loss: 337.4329 - val_mae: 337.4329
Epoch 22/50
29/29 [==============================] - 0s 2ms/step - loss: 352.2891 - ma
e: 352.2891 - val_loss: 334.9860 - val_mae: 334.9861
Epoch 23/50
29/29 [==============================] - 0s 2ms/step - loss: 360.6500 - ma
e: 360.6500 - val_loss: 334.6175 - val_mae: 334.6175
Epoch 24/50
29/29 [==============================] - 0s 2ms/step - loss: 346.0458 - ma
e: 346.0458 - val_loss: 335.3712 - val_mae: 335.3712
Epoch 25/50
29/29 [==============================] - 0s 2ms/step - loss: 349.6846 - ma
e: 349.6846 - val_loss: 332.7960 - val_mae: 332.7960
Epoch 26/50
29/29 [==============================] - 0s 2ms/step - loss: 344.5929 - ma
e: 344.5929 - val_loss: 332.4522 - val_mae: 332.4522
Epoch 27/50
29/29 [==============================] - 0s 2ms/step - loss: 333.7929 - ma
e: 333.7929 - val_loss: 330.9138 - val_mae: 330.9138
Epoch 28/50
29/29 [==============================] - 0s 2ms/step - loss: 330.0481 - ma
e: 330.0481 - val_loss: 331.6291 - val_mae: 331.6290
Epoch 29/50
29/29 [==============================] - 0s 2ms/step - loss: 354.0622 - ma
e: 354.0622 - val_loss: 330.1112 - val_mae: 330.1112
Epoch 30/50
29/29 [==============================] - 0s 2ms/step - loss: 340.2755 - ma
e: 340.2755 - val_loss: 327.7443 - val_mae: 327.7443
Epoch 31/50
29/29 [==============================] - 0s 2ms/step - loss: 328.6991 - ma
e: 328.6991 - val_loss: 325.5136 - val_mae: 325.5136
Epoch 32/50
29/29 [==============================] - 0s 2ms/step - loss: 346.1663 - ma
e: 346.1663 - val_loss: 331.1355 - val_mae: 331.1355
Epoch 33/50
29/29 [==============================] - 0s 2ms/step - loss: 323.6632 - ma
e: 323.6632 - val_loss: 328.5889 - val_mae: 328.5889
Epoch 34/50
29/29 [==============================] - 0s 2ms/step - loss: 340.1898 - ma
e: 340.1898 - val_loss: 325.4608 - val_mae: 325.4608
Epoch 35/50
29/29 [==============================] - 0s 2ms/step - loss: 331.9442 - ma
```

```
e: 331.9442 - val_loss: 325.4066 - val_mae: 325.4066
Epoch 36/50
29/29 [==============================] - 0s 2ms/step - loss: 330.9615 - ma
e: 330.9615 - val_loss: 322.2797 - val_mae: 322.2797
Epoch 37/50
29/29 [==============================] - 0s 2ms/step - loss: 346.8907 - ma
e: 346.8907 - val_loss: 321.6904 - val_mae: 321.6904
Epoch 38/50
29/29 [==============================] - 0s 2ms/step - loss: 337.3550 - ma
e: 337.3550 - val_loss: 322.7086 - val_mae: 322.7086
Epoch 39/50
29/29 [==============================] - 0s 2ms/step - loss: 331.0273 - ma
e: 331.0273 - val_loss: 323.8998 - val_mae: 323.8998
Epoch 40/50
29/29 [==============================] - 0s 2ms/step - loss: 324.9168 - ma
e: 324.9168 - val_loss: 320.7634 - val_mae: 320.7634
Epoch 41/50
29/29 [==============================] - 0s 2ms/step - loss: 330.1388 - ma
e: 330.1388 - val_loss: 319.5902 - val_mae: 319.5902
Epoch 42/50
29/29 [==============================] - 0s 2ms/step - loss: 327.9298 - ma
e: 327.9298 - val_loss: 325.8666 - val_mae: 325.8666
Epoch 43/50
29/29 [==============================] - 0s 2ms/step - loss: 329.0054 - ma
e: 329.0054 - val_loss: 319.6252 - val_mae: 319.6252
Epoch 44/50
29/29 [==============================] - 0s 2ms/step - loss: 332.3099 - ma
e: 332.3099 - val_loss: 320.5648 - val_mae: 320.5648
Epoch 45/50
29/29 [==============================] - 0s 2ms/step - loss: 329.9113 - ma
e: 329.9113 - val_loss: 319.8901 - val_mae: 319.8901
Epoch 46/50
29/29 [==============================] - 0s 2ms/step - loss: 325.6853 - ma
e: 325.6853 - val_loss: 322.2478 - val_mae: 322.2478
Epoch 47/50
29/29 [==============================] - 0s 2ms/step - loss: 339.2200 - ma
e: 339.2200 - val_loss: 322.2568 - val_mae: 322.2568
Epoch 48/50
29/29 [==============================] - 0s 2ms/step - loss: 328.1887 - ma
e: 328.1887 - val_loss: 317.7568 - val_mae: 317.7568
Epoch 49/50
29/29 [==============================] - 0s 2ms/step - loss: 338.9527 - ma
e: 338.9527 - val_loss: 318.4319 - val_mae: 318.4319
Epoch 50/50
29/29 [==============================] - 0s 2ms/step - loss: 335.9918 - ma
e: 335.9918 - val_loss: 317.7234 - val_mae: 317.7234
```

In [198…

```
model.evaluate(X_test, y_test)
```

```
45/45 [==============================] - 0s 484us/step - loss: 318.9459 - m
ae: 318.9459
```

Out[198…

```
[318.9458923339844, 318.9458923339844]
```

In [199…

```
model.evaluate(X_train, y_train)
```

```
91/91 [==============================] - 0s 418us/step - loss: 326.8013 - m
ae: 326.8013
```

Out[199…

```
[326.8013000488281, 326.8013000488281]
```

Comparision with Regression

In [206…

```
regr = linear_model.LinearRegression()
regr.fit(X_train, y_train)
y_predictions = regr.predict(X_test)
print('Mean absolute error: %.2f'
      % mean_absolute_error(y_test, y_predictions))
```

```
Mean absolute error: 597.42
```

In [208…

```
print(y_train.describe())
```

```
         pageviews
count  2881.000000
mean   1307.810135
std    1150.558002
min     104.000000
25%     554.000000
50%     936.000000
75%    1520.000000
max    7395.000000
```

Conclusion

The mean absolute error with the neural network approach is around 318. The average value for the page views is 1307, this results in an accuracy of around 80% 1307/(1307+318) = 0.804. This result seems acceptable, and is far better than a 'basic' multivariate regression.

The factors wind direction and wind gusts did not seem to be very helpful, and removing them increased the performance.

The model was trained with the factors wind speed, air temperature and location. A further improvement could be the inclusion of the date as an input.

In [ ]: