MLPRegressor_v2_1

November 7, 2022

1 MLPRegressor

[ ]:
```
import numpy as np
import pandas as pd

import matplotlib.pyplot as plt

from sklearn.model_selection import train_test_split, RandomizedSearchCV
from sklearn.preprocessing import StandardScaler
from sklearn.pipeline import Pipeline
from sklearn.neural_network import MLPRegressor
from sklearn.feature_selection import SelectFromModel
from sklearn.metrics import r2_score, mean_absolute_percentage_error,␣
↪mean_absolute_error, mean_squared_error
from statsmodels.tools.eval_measures import stde

import kerastuner as kt
import tensorflow as tf
```

[ ]:
```
from tensorflow.python.client import device_lib

print('Default GPU Device: {}'.format(tf.test.gpu_device_name()))
```

```
Default GPU Device: /device:GPU:0
```

```
2022-11-06 21:12:45.962030: I
tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:980] successful NUMA node
read from SysFS had negative value (-1), but there must be at least one NUMA
node, so returning NUMA node zero
2022-11-06 21:12:45.962248: I
tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:980] successful NUMA node
read from SysFS had negative value (-1), but there must be at least one NUMA
node, so returning NUMA node zero
2022-11-06 21:12:45.962403: I
tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:980] successful NUMA node
read from SysFS had negative value (-1), but there must be at least one NUMA
node, so returning NUMA node zero
2022-11-06 21:12:45.962598: I
```

```
tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:980] successful NUMA node
read from SysFS had negative value (-1), but there must be at least one NUMA
node, so returning NUMA node zero
2022-11-06 21:12:45.962753: I
tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:980] successful NUMA node
read from SysFS had negative value (-1), but there must be at least one NUMA
node, so returning NUMA node zero
2022-11-06 21:12:45.962874: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1616] Created device
/device:GPU:0 with 4051 MB memory:  -> device: 0, name: NVIDIA GeForce RTX 2060,
pci bus id: 0000:08:00.0, compute capability: 7.5
```

1.1 Read the etl info results

[ ]:
```
df_info = pd.read_csv('../dataset_clean/options_csv_v1_etl.csv')
df_info
```

[ ]:
```
   remove_time_features  generic_features  remove_atypical_values  \
0                 False             False                   False

   feature_combination  remove_feature_selection  \
0                False                     False

   remove_invalid_correlated_features
0                               False
```

1.2 Read the dataset

[ ]:
```
df = pd.read_csv('../dataset_clean/PlatteRiverWeir_features_v1_clean.csv')
df
```

[ ]:
```
                SensorTime          CaptureTime  Stage  Discharge    grayMean  \
0      2012-06-09 13:15:00  2012-06-09T13:09:07   2.99      916.0   97.405096
1      2012-06-09 13:15:00  2012-06-09T13:10:29   2.99      916.0  104.066757
2      2012-06-09 13:45:00  2012-06-09T13:44:01   2.96      873.0  105.636831
3      2012-06-09 14:45:00  2012-06-09T14:44:30   2.94      846.0  104.418949
4      2012-06-09 15:45:00  2012-06-09T15:44:59   2.94      846.0  106.763541
…                      …                    …    …          …           …
42054  2019-10-11 09:00:00  2019-10-11T08:59:53   2.54      434.0   82.872720
42055  2019-10-11 10:00:00  2019-10-11T09:59:52   2.54      434.0   89.028383
42056  2019-10-11 11:00:00  2019-10-11T10:59:52   2.54      434.0   94.722097
42057  2019-10-11 12:00:00  2019-10-11T11:59:53   2.54      434.0   96.693270
42058  2019-10-11 12:45:00  2019-10-11T12:59:52   2.54      434.0   98.738399

       graySigma  entropyMean  entropySigma       hMean     hSigma  …  \
0      39.623303     0.203417      0.979825  105.368375  41.572939  …
1      40.179745     0.206835      1.002624  112.399458  41.795584  …
```

2	40.533218	0.204756	0.994246	114.021526	42.145582	…
3	41.752678	0.202428	0.983170	112.612830	43.575351	…
4	44.442097	0.202661	0.989625	114.839424	46.302008	…
…	…	…	…	…	…	…
42054	57.702652	0.221708	1.076393	87.260572	61.485334	…
42055	55.840861	0.233168	1.124774	94.175906	59.006132	…
42056	54.355753	0.240722	1.151833	100.534577	56.921028	…
42057	52.787629	0.244789	1.171987	102.891159	55.083532	…
42058	52.025453	0.252812	1.213278	105.292067	53.994155	…

	WeirPt2X	WeirPt2Y	WwRawLineMin	WwRawLineMax	WwRawLineMean \
0	-1	-1	0.0	0.0	0.000000
1	-1	-1	0.0	0.0	0.000000
2	-1	-1	0.0	0.0	0.000000
3	-1	-1	0.0	0.0	0.000000
4	-1	-1	0.0	0.0	0.000000
…	…	…	…	…	…
42054	2446	1900	9284.0	77521.0	38385.370066
42055	2440	1900	10092.0	74614.0	40162.989292
42056	2447	1900	7067.0	83260.0	42095.946590
42057	2443	1900	6283.0	83045.0	45345.490954
42058	2436	1900	7375.0	89813.0	47877.870782

	WwRawLineSigma	WwCurveLineMin	WwCurveLineMax	WwCurveLineMean \
0	0.000000	0.0	0.0	0.000000
1	0.000000	0.0	0.0	0.000000
2	0.000000	0.0	0.0	0.000000
3	0.000000	0.0	0.0	0.000000
4	0.000000	0.0	0.0	0.000000
…	…	…	…	…
42054	15952.029728	0.0	70085.0	37550.894823
42055	15467.708856	0.0	70061.0	39397.339095
42056	16770.357949	0.0	76335.0	41350.006568
42057	17498.432849	0.0	78882.0	44553.920296
42058	19963.166359	0.0	82630.0	47280.270559

	WwCurveLineSigma
0	0.000000
1	0.000000
2	0.000000
3	0.000000
4	0.000000
…	…
42054	16444.401209
42055	16009.008049
42056	17489.374617
42057	18268.294896

```
42058      20559.358767

[42059 rows x 48 columns]
```

[ ]:
```
df['SensorTime'] = pd.to_datetime(df['SensorTime'])
df['Year'] = df['SensorTime'].dt.year
```

[ ]:
```
df.dtypes
```

[ ]:
```
SensorTime          datetime64[ns]
CaptureTime                 object
Stage                      float64
Discharge                  float64
grayMean                   float64
graySigma                  float64
entropyMean                float64
entropySigma               float64
hMean                      float64
hSigma                     float64
sMean                      float64
sSigma                     float64
vMean                      float64
vSigma                     float64
areaFeatCount                int64
grayMean0                  float64
graySigma0                 float64
entropyMean0               float64
entropySigma0              float64
hMean0                     float64
hSigma0                    float64
sMean0                     float64
sSigma0                    float64
vMean0                     float64
vSigma0                    float64
grayMean1                  float64
graySigma1                 float64
entropyMean1               float64
entropySigma1              float64
hMean1                     float64
hSigma1                    float64
sMean1                     float64
sSigma1                    float64
vMean1                     float64
vSigma1                    float64
WeirAngle                  float64
WeirPt1X                     int64
WeirPt1Y                     int64
```

```
WeirPt2X                          int64
WeirPt2Y                          int64
WwRawLineMin                    float64
WwRawLineMax                    float64
WwRawLineMean                   float64
WwRawLineSigma                  float64
WwCurveLineMin                  float64
WwCurveLineMax                  float64
WwCurveLineMean                 float64
WwCurveLineSigma                float64
Year                              int64
dtype: object
```

1.3 Divide dataset to X and Y

[ ]:
```
df_train = df[(df.Year >= 2012) & (df.Year <= 2017)]
df_test = df[(df.Year >= 2018) & (df.Year <= 2019)]
```

[ ]:
```
df_train = df_train.drop(columns=["Year", "SensorTime", "CaptureTime"])
df_test = df_test.drop(columns=["Year", "SensorTime", "CaptureTime"])
```

[ ]:
```
np.random.seed(0)

y_train = df_train[["Stage", "Discharge"]]
X_train = df_train.drop(columns=["Stage", "Discharge"])

temp = list(zip(X_train.values, y_train.values))
np.random.shuffle(temp)
X_train, y_train = zip(*temp)
X_train, y_train = np.array(X_train), np.array(y_train)

y_test = df_test[["Stage", "Discharge"]]
X_test = df_test.drop(columns=["Stage", "Discharge"])

temp = list(zip(X_test.values, y_test.values))
np.random.shuffle(temp)
X_test, y_test = zip(*temp)
X_test, y_test = np.array(X_test), np.array(y_test)
```

[ ]:
```
print(X_train.shape)
print(y_train.shape)
```

```
(28811, 44)
(28811, 2)
```

[ ]:
```
input_shape = X_train.shape[1]
output_shape = y_train.shape[1]
```

1.4 Train model

[ ]:
```
def model_builder(hp):
  model = tf.keras.Sequential()
  model.add(tf.keras.Input(shape=input_shape))

  # Tune the number of units in the first Dense layer
  # Choose an optimal value between 32-512
  hp_units = hp.Int('units', min_value = 128, max_value = 1024, step = 32)
  model.add(tf.keras.layers.Dense(units = hp_units, activation = 'relu'))
  hp_units_2 = hp.Int('units_2', min_value = 128, max_value = 512, step = 32)
  model.add(tf.keras.layers.Dense(units = hp_units_2, activation = 'relu'))
  hp_units_3 = hp.Int('units_3', min_value = 64, max_value = 512, step = 32)
  model.add(tf.keras.layers.Dense(units = hp_units_3, activation = 'relu'))
  hp_units_4 = hp.Int('units_4', min_value = 64, max_value = 512, step = 32)
  model.add(tf.keras.layers.Dense(units = hp_units_4, activation = 'relu'))
  """
  hp_units_5 = hp.Int('units_5', min_value = 128, max_value = 512, step = 32)
  model.add(tf.keras.layers.Dense(units = hp_units_5, activation = 'relu'))
  hp_units_6 = hp.Int('units_6', min_value = 64, max_value = 512, step = 32)
  model.add(tf.keras.layers.Dense(units = hp_units_6, activation = 'relu'))
  hp_units_7 = hp.Int('units_7', min_value = 64, max_value = 512, step = 32)
  model.add(tf.keras.layers.Dense(units = hp_units_7, activation = 'relu'))
  hp_units_8 = hp.Int('units_8', min_value = 32, max_value = 512, step = 32)
  model.add(tf.keras.layers.Dense(units = hp_units_8, activation = 'relu'))"""

  model.add(tf.keras.layers.Dense(output_shape))

  # Tune the learning rate for the optimizer
  # Choose an optimal value from 0.01, 0.001, or 0.0001
  hp_learning_rate = hp.Choice('learning_rate', values = [1e-2, 1e-3, 1e-4])

  model.compile(optimizer = tf.keras.optimizers.Adam(learning_rate =␣
↪hp_learning_rate), loss = 'mse', metrics = ['mse', tf.keras.metrics.
↪RootMeanSquaredError(name='rmse'), 'mae', 'mape'])

  return model
```

[ ]:
```
tuner = kt.RandomSearch(model_builder,
                        objective = 'val_loss',
                        max_trials = 10,
                        #directory = 'random_search_starter',
                        project_name = 'MLPtf')
```

[ ]:
```
tuner.search(X_train, y_train, epochs = 40, validation_data = (X_test, y_test))
```

```
Trial 10 Complete [00h 01m 18s]
val_loss: 109976.1796875
```

```
Best val_loss So Far: 104425.8203125
Total elapsed time: 00h 13m 04s
INFO:tensorflow:Oracle triggered exit
```

[ ]:
```
best_model = tuner.get_best_models(1)[0]
```

[ ]:
```
best_hyperparameters = tuner.get_best_hyperparameters(1)[0]
```

1.5 Test model

[ ]:
```
best_model.evaluate(X_test, y_test)
```

```
414/414 [==============================] - 1s 1ms/step - loss: 104425.8203 -
mse: 104425.8203 - rmse: 323.1498 - mae: 144.4191 - mape: 5165232640.0000
```

[ ]:
```
[104425.8203125,
 104425.8203125,
 323.14984130859375,
 144.4191131591797,
 5165232640.0]
```

[ ]:
```
y_pred = best_model.predict(X_test)
```

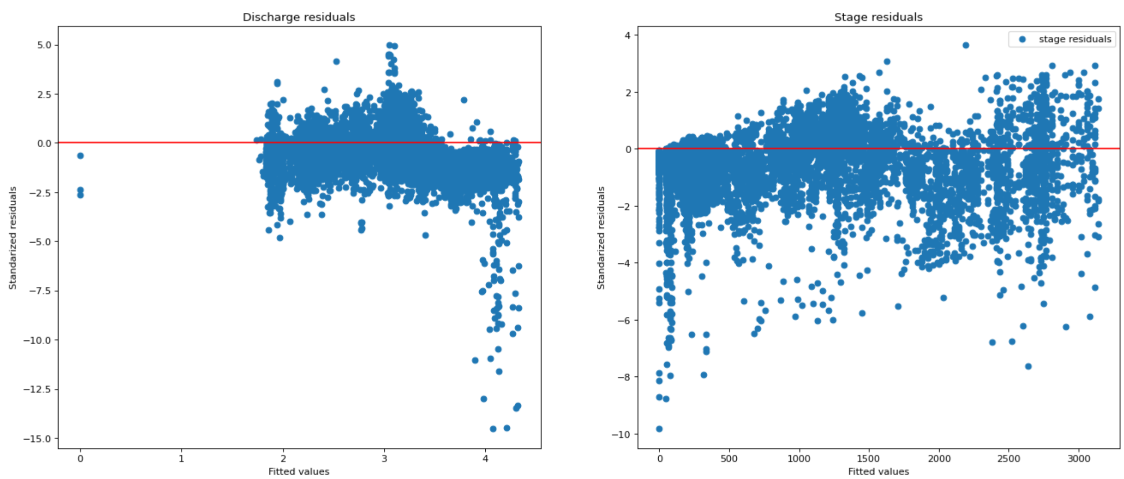
```
414/414 [==============================] - 0s 601us/step
```

[ ]:
```
print("R^2: ", r2_score(y_test, y_pred))
print("mse: ", mean_squared_error(y_test, y_pred))
print("rmse: ", mean_squared_error(y_test, y_pred, squared=False))
print("mae: ", mean_absolute_error(y_test, y_pred))
print("mape: ", mean_absolute_percentage_error(y_test, y_pred))
print("Error estandar: ", stde(y_test.squeeze(),
      y_pred.squeeze(), ddof=2))
```

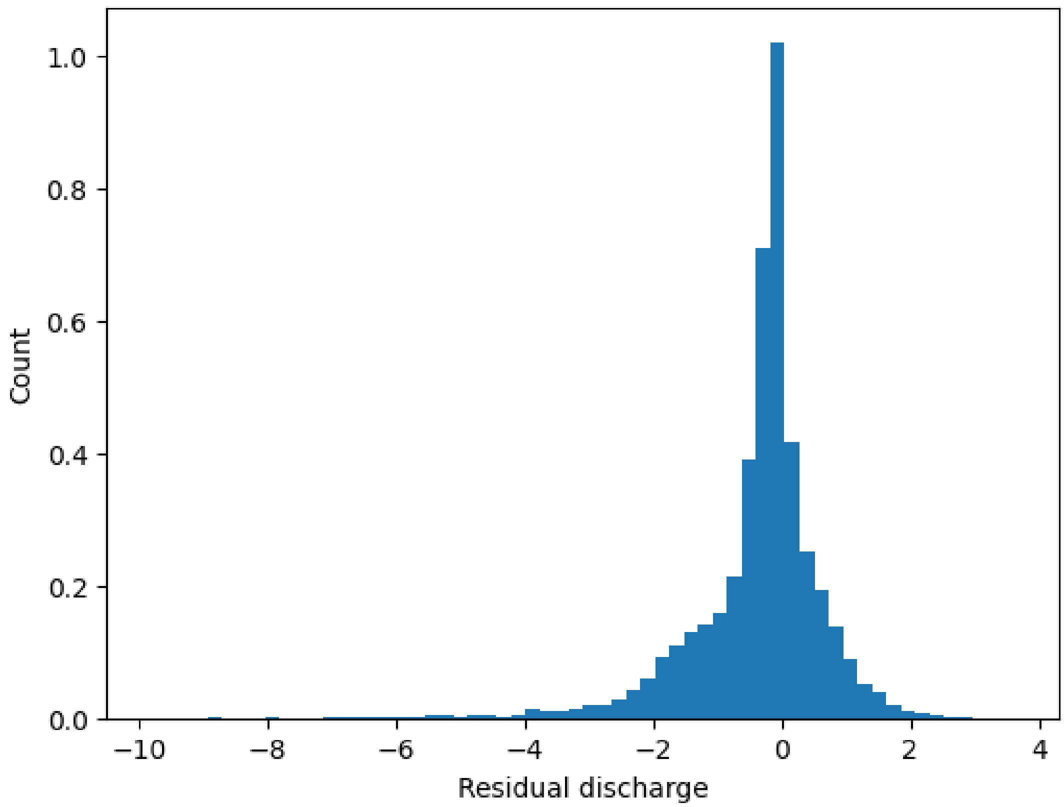
```
R^2:  -1.5115277087651755
mse:  104425.83337379005
rmse:  229.17087825115055
mae:  144.41915749977616
mape:  2.3262143641528052e+16
Error estandar:  [  1.21269654 431.11023937]
```

[ ]:
```
residuals = y_test - y_pred
residuals_std = residuals/residuals.std()

y_real_stage = np.array([i[-1] for i in y_test])
residual_stage = np.array([i[-1] for i in residuals])

y_real_discharge = np.array([i[0] for i in y_test])
```

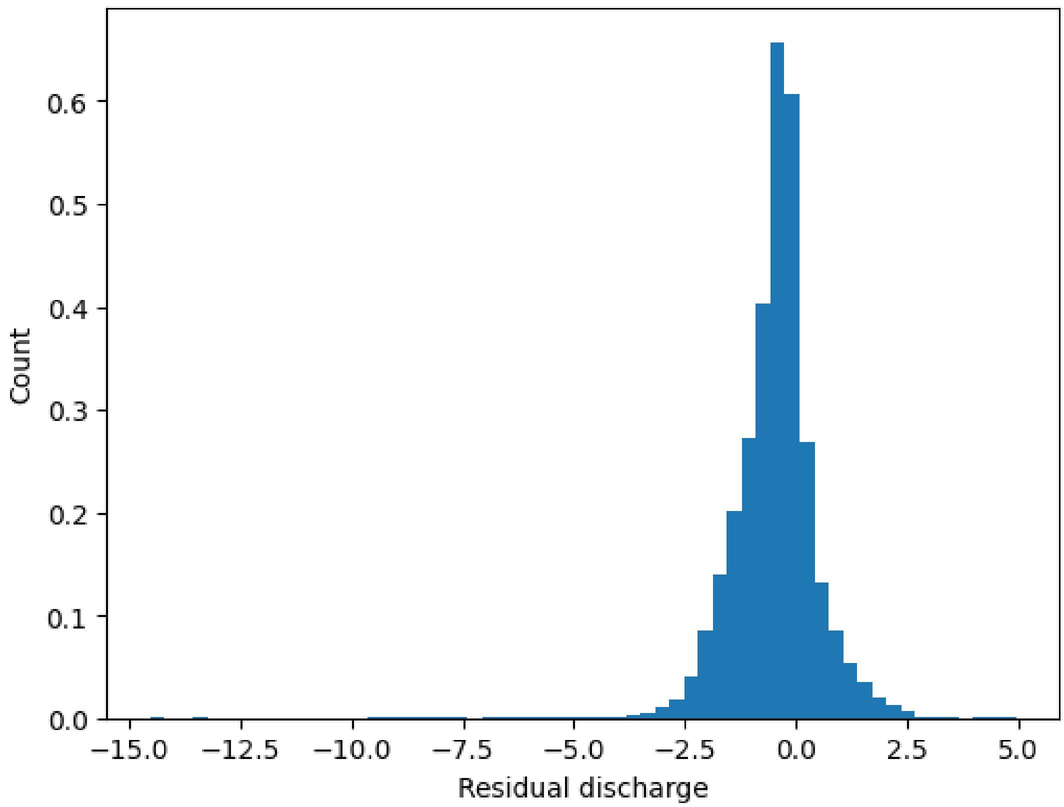
```
residual_discharge = np.array([i[0] for i in residuals])


figure, ax = plt.subplots(ncols=2, figsize=(20, 8), dpi=80)

ax[1].scatter(y_real_stage, residual_stage / residual_stage.std(), label="stage␣
↪residuals")
ax[0].scatter(y_real_discharge, residual_discharge / residual_discharge.std(),␣
↪label="discharge residuals")
ax[1].axhline(y=0.0, color='r', linestyle='-')
ax[0].axhline(y=0.0, color='r', linestyle='-')

ax[1].set_title("Stage residuals")
ax[0].set_title("Discharge residuals")

ax[1].set_xlabel("Fitted values")
ax[0].set_xlabel("Fitted values")
ax[1].set_ylabel("Standarized residuals")
ax[0].set_ylabel("Standarized residuals")

plt.legend()
plt.show()
```



[ ]:
```
plt.hist(residual_stage / residual_stage.std(), density=True, bins = 60)
plt.ylabel('Count')
plt.xlabel('Residual discharge');
plt.show()
```



[ ]:
```
plt.hist(residual_discharge / residual_discharge.std(), density=True, bins = 60)
plt.ylabel('Count')
plt.xlabel('Residual discharge');
plt.show()
```


0.6
0.5
0.4
0.3
0.2
0.1
0.0
Count
−15.0
−12.5
−10.0
−7.5
−5.0
−2.5
0.0
2.5
5.0
Residual discharge