MLPRegressor_v1_stage_3

November 25, 2022

1 MLPRegressor

[ ]:
```python
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
```

1.1 Read the etl info results

[ ]:
```python
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                    Lasso

  remove_invalid_correlated_features
0                              False
```

1.2 Read the dataset

[ ]:
```python
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	hMean	hSigma	grayMean0	hMean0	entropyMean1 \
0	39.623303	105.368375	41.572939	97.084576	106.047217	0.092532
1	40.179745	112.399458	41.795584	105.668610	114.886049	0.090279
2	40.533218	114.021526	42.145582	106.786307	116.053131	0.090561
3	41.752678	112.612830	43.575351	107.674299	117.005027	0.095616
4	44.442097	114.839424	46.302008	114.858589	124.519271	0.101601
…	…	…	…	…	…	…
42054	57.702652	87.260572	61.485334	43.737485	46.616662	0.120668
42055	55.840861	94.175906	59.006132	46.268458	49.716207	0.113951
42056	54.355753	100.534577	56.921028	49.841325	53.984763	0.110346
42057	52.787629	102.891159	55.083532	53.912185	58.857575	0.112571
42058	52.025453	105.292067	53.994155	59.611803	65.697745	0.110247

	entropySigma1	hMean1	WwRawLineMean	WwRawLineSigma \
0	0.632319	169.963345	0.000000	0.000000
1	0.620077	175.220945	0.000000	0.000000
2	0.620853	179.554842	0.000000	0.000000
3	0.651642	180.921521	0.000000	0.000000
4	0.688024	183.131779	0.000000	0.000000
…	…	…	…	…
42054	0.824195	126.181417	38385.370066	15952.029728
42055	0.783437	131.754200	40162.989292	15467.708856
42056	0.766074	138.014068	42095.946590	16770.357949
42057	0.777376	146.470365	45345.490954	17498.432849
42058	0.760248	156.957374	47877.870782	19963.166359

	WwCurveLineMean	WwCurveLineSigma
0	0.000000	0.000000
1	0.000000	0.000000
2	0.000000	0.000000
3	0.000000	0.000000
4	0.000000	0.000000
…	…	…
42054	37550.894823	16444.401209
42055	39397.339095	16009.008049
42056	41350.006568	17489.374617

```
42057     44553.920296     18268.294896
42058     47280.270559     20559.358767

[42059 rows x 17 columns]
```

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

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

[ ]:
```
SensorTime          datetime64[ns]
CaptureTime                 object
Stage                      float64
Discharge                  float64
grayMean                   float64
graySigma                  float64
hMean                      float64
hSigma                     float64
grayMean0                  float64
hMean0                     float64
entropyMean1               float64
entropySigma1              float64
hMean1                     float64
WwRawLineMean              float64
WwRawLineSigma             float64
WwCurveLineMean            float64
WwCurveLineSigma           float64
Year                         int64
dtype: object
```

[ ]:
```python
df = df[(df.Stage > 0) & (df.Discharge > 0)]
```

1.3 Divide dataset to X and Y

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

df_train = df[(df.Year >= 2012) & (df.Year <= 2017)]
df_train = df_train.iloc[np.random.permutation(len(df_train))]

df_test = df[(df.Year >= 2018) & (df.Year <= 2019)]
```

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

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

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

[ ]:
```
#X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33,␣
↪random_state=0)
```

1.4 Train model

[ ]:
```
pipeline = Pipeline([
    ('scaler', StandardScaler()),
    ('clf', MLPRegressor(shuffle=False, max_iter=2000))
])

#param_grid = {'clf__hidden_layer_sizes': [(10), (10, 20), (10, 5, 15), (20,␣
↪30, 10, 15)], 'clf__alpha': np.arange(1e-3, 1, 0.001),␣
↪'clf__learning_rate_init': np.arange(1e-3, 0.1, 0.001), 'clf__activation':␣
↪['tanh', 'relu']}

param_grid = {'clf__hidden_layer_sizes': [(256, 256, 128, 128, 64), (512, 256),␣
↪(128, 64, 64, 32), (512, 256, 128, 128)], 'clf__alpha': np.arange(1e-3, 0.1,␣
↪0.001), 'clf__activation': ['tanh', 'relu']}

clf = RandomizedSearchCV(pipeline, param_distributions=param_grid, n_iter=10,␣
↪n_jobs=8, verbose=3, scoring="neg_mean_squared_error")
```

[ ]:
```
clf.fit(X_train, y_train)
```

```
Fitting 5 folds for each of 10 candidates, totalling 50 fits
[CV 2/5] END clf__activation=tanh, clf__alpha=0.095,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.135 total time=  35.4s
[CV 3/5] END clf__activation=tanh, clf__alpha=0.095,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.136 total time=  37.2s
[CV 1/5] END clf__activation=tanh, clf__alpha=0.095,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.137 total time=  42.7s
[CV 4/5] END clf__activation=tanh, clf__alpha=0.095,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.150 total time=  34.4s
[CV 5/5] END clf__activation=tanh, clf__alpha=0.095,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.131 total time=  37.8s
[CV 2/5] END clf__activation=tanh, clf__alpha=0.019000000000000003,
clf__hidden_layer_sizes=(256, 256, 128, 128, 64);, score=-0.132 total time=
1.8min
[CV 3/5] END clf__activation=tanh, clf__alpha=0.019000000000000003,
clf__hidden_layer_sizes=(256, 256, 128, 128, 64);, score=-0.147 total time=
2.0min
[CV 1/5] END clf__activation=tanh, clf__alpha=0.019000000000000003,
clf__hidden_layer_sizes=(256, 256, 128, 128, 64);, score=-0.134 total time=
2.9min
```

```
[CV 4/5] END clf__activation=tanh, clf__alpha=0.019000000000000003,
clf__hidden_layer_sizes=(256, 256, 128, 128, 64);, score=-0.149 total time=
3.2min
[CV 5/5] END clf__activation=tanh, clf__alpha=0.019000000000000003,
clf__hidden_layer_sizes=(256, 256, 128, 128, 64);, score=-0.136 total time=
3.5min
[CV 1/5] END clf__activation=tanh, clf__alpha=0.064,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.133 total time= 4.1min
[CV 3/5] END clf__activation=tanh, clf__alpha=0.064,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.129 total time= 4.4min
[CV 2/5] END clf__activation=tanh, clf__alpha=0.064,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.123 total time= 5.0min
[CV 3/5] END clf__activation=tanh, clf__alpha=0.026000000000000002,
clf__hidden_layer_sizes=(512, 256);, score=-0.137 total time= 3.3min
[CV 5/5] END clf__activation=tanh, clf__alpha=0.064,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.133 total time= 4.8min
[CV 2/5] END clf__activation=tanh, clf__alpha=0.026000000000000002,
clf__hidden_layer_sizes=(512, 256);, score=-0.129 total time= 3.9min
[CV 1/5] END clf__activation=tanh, clf__alpha=0.005,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.135 total time= 1.1min
[CV 1/5] END clf__activation=tanh, clf__alpha=0.026000000000000002,
clf__hidden_layer_sizes=(512, 256);, score=-0.134 total time= 4.6min
[CV 2/5] END clf__activation=tanh, clf__alpha=0.005,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.116 total time=  47.6s
[CV 3/5] END clf__activation=tanh, clf__alpha=0.005,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.116 total time=  55.7s
[CV 4/5] END clf__activation=tanh, clf__alpha=0.064,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.141 total time= 5.9min
[CV 4/5] END clf__activation=tanh, clf__alpha=0.005,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.133 total time=  59.6s
[CV 5/5] END clf__activation=tanh, clf__alpha=0.005,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.128 total time=  59.2s
[CV 4/5] END clf__activation=tanh, clf__alpha=0.026000000000000002,
clf__hidden_layer_sizes=(512, 256);, score=-0.140 total time= 3.8min
[CV 5/5] END clf__activation=tanh, clf__alpha=0.026000000000000002,
clf__hidden_layer_sizes=(512, 256);, score=-0.129 total time= 3.3min
[CV 4/5] END clf__activation=tanh, clf__alpha=0.014000000000000002,
clf__hidden_layer_sizes=(512, 256);, score=-0.134 total time= 3.4min
[CV 5/5] END clf__activation=tanh, clf__alpha=0.014000000000000002,
clf__hidden_layer_sizes=(512, 256);, score=-0.126 total time= 4.0min
[CV 3/5] END clf__activation=tanh, clf__alpha=0.035,
clf__hidden_layer_sizes=(512, 256);, score=-0.138 total time= 3.4min
[CV 2/5] END clf__activation=tanh, clf__alpha=0.014000000000000002,
clf__hidden_layer_sizes=(512, 256);, score=-0.125 total time= 4.9min
[CV 3/5] END clf__activation=tanh, clf__alpha=0.014000000000000002,
clf__hidden_layer_sizes=(512, 256);, score=-0.130 total time= 4.8min
[CV 2/5] END clf__activation=tanh, clf__alpha=0.035,
clf__hidden_layer_sizes=(512, 256);, score=-0.134 total time= 3.9min
```

```
[CV 1/5] END clf__activation=tanh, clf__alpha=0.035,
clf__hidden_layer_sizes=(512, 256);, score=-0.139 total time= 4.6min
[CV 1/5] END clf__activation=tanh, clf__alpha=0.014000000000000002,
clf__hidden_layer_sizes=(512, 256);, score=-0.129 total time= 5.9min
[CV 1/5] END clf__activation=relu, clf__alpha=0.079,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.137 total time=  58.8s
[CV 2/5] END clf__activation=relu, clf__alpha=0.079,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.122 total time=  54.5s
[CV 4/5] END clf__activation=tanh, clf__alpha=0.035,
clf__hidden_layer_sizes=(512, 256);, score=-0.140 total time= 4.5min
[CV 5/5] END clf__activation=tanh, clf__alpha=0.035,
clf__hidden_layer_sizes=(512, 256);, score=-0.134 total time= 3.7min
[CV 3/5] END clf__activation=relu, clf__alpha=0.079,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.125 total time=  51.2s
[CV 4/5] END clf__activation=relu, clf__alpha=0.079,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.129 total time=  28.5s
[CV 5/5] END clf__activation=relu, clf__alpha=0.079,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.121 total time=  58.5s
[CV 3/5] END clf__activation=relu, clf__alpha=0.098,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.124 total time= 4.4min
[CV 4/5] END clf__activation=relu, clf__alpha=0.098,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.128 total time= 5.4min
[CV 5/5] END clf__activation=relu, clf__alpha=0.098,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.130 total time= 5.2min
[CV 1/5] END clf__activation=relu, clf__alpha=0.098,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.130 total time= 5.8min
[CV 2/5] END clf__activation=relu, clf__alpha=0.098,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.120 total time= 6.1min
[CV 4/5] END clf__activation=tanh, clf__alpha=0.068,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.148 total time= 3.1min
[CV 1/5] END clf__activation=tanh, clf__alpha=0.068,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.131 total time= 3.9min
[CV 3/5] END clf__activation=tanh, clf__alpha=0.068,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.130 total time= 3.4min
[CV 2/5] END clf__activation=tanh, clf__alpha=0.068,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.121 total time= 4.8min
[CV 5/5] END clf__activation=tanh, clf__alpha=0.068,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.130 total time= 3.1min
```

[ ]:

```
RandomizedSearchCV(estimator=Pipeline(steps=[('scaler', StandardScaler()),
                                              ('clf',
                                               MLPRegressor(max_iter=2000,
                                                            shuffle=False))]),
                   n_jobs=8,
                   param_distributions={'clf__activation': ['tanh', 'relu'],
                                        'clf__alpha': array([0.001, 0.002,
0.003, 0.004, 0.005, 0.006, 0.007, 0.008, 0.009,
```

```
        0.01 , 0.011, 0.012, 0.013, 0.014, 0.015, 0.016, 0.017, 0.018,
        0.019, 0.02 , 0.021, 0.022, 0.023, 0.024…
        0.064, 0.065, 0.066, 0.067, 0.068, 0.069, 0.07 , 0.071, 0.072,
        0.073, 0.074, 0.075, 0.076, 0.077, 0.078, 0.079, 0.08 , 0.081,
        0.082, 0.083, 0.084, 0.085, 0.086, 0.087, 0.088, 0.089, 0.09 ,
        0.091, 0.092, 0.093, 0.094, 0.095, 0.096, 0.097, 0.098, 0.099]),
                                         'clf__hidden_layer_sizes': [(256, 256,
                                                                       128, 128,
                                                                       64),
                                                                      (512, 256),
                                                                      (128, 64,
                                                                       64, 32),
                                                                      (512, 256,
                                                                       128,
                                                                       128)]},
                    scoring='neg_mean_squared_error', verbose=3)
```

[ ]:
```python
clf.best_score_
```

[ ]:
```
-0.12564252541286405
```

[ ]:
```python
clf.best_params_
```

[ ]:
```
{'clf__hidden_layer_sizes': (128, 64, 64, 32),
 'clf__alpha': 0.005,
 'clf__activation': 'tanh'}
```

1.5 Test model

[ ]:
```python
clf.score(X_test, y_test)
```

[ ]:
```
-0.2048234530139613
```

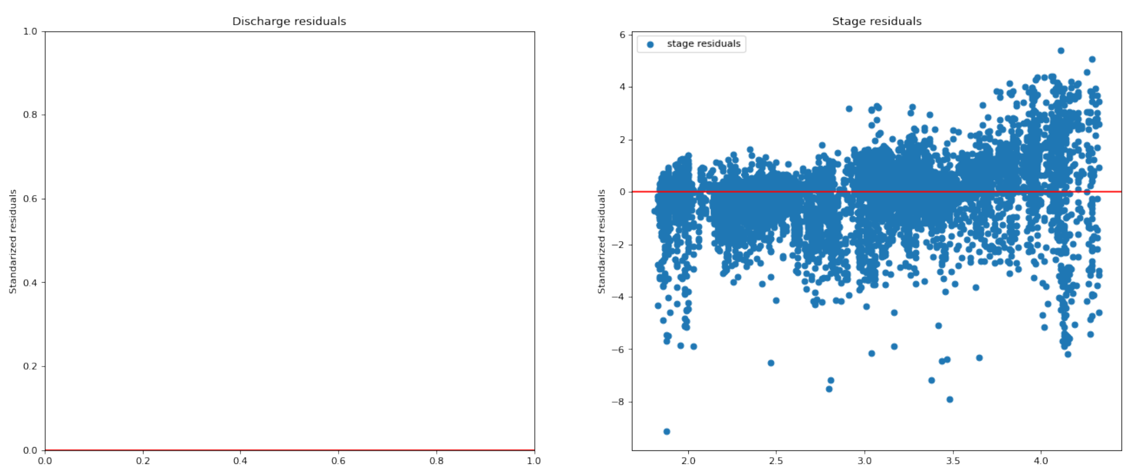
[ ]:
```python
y_pred = clf.predict(X_test)
```

[ ]:
```python
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))
```

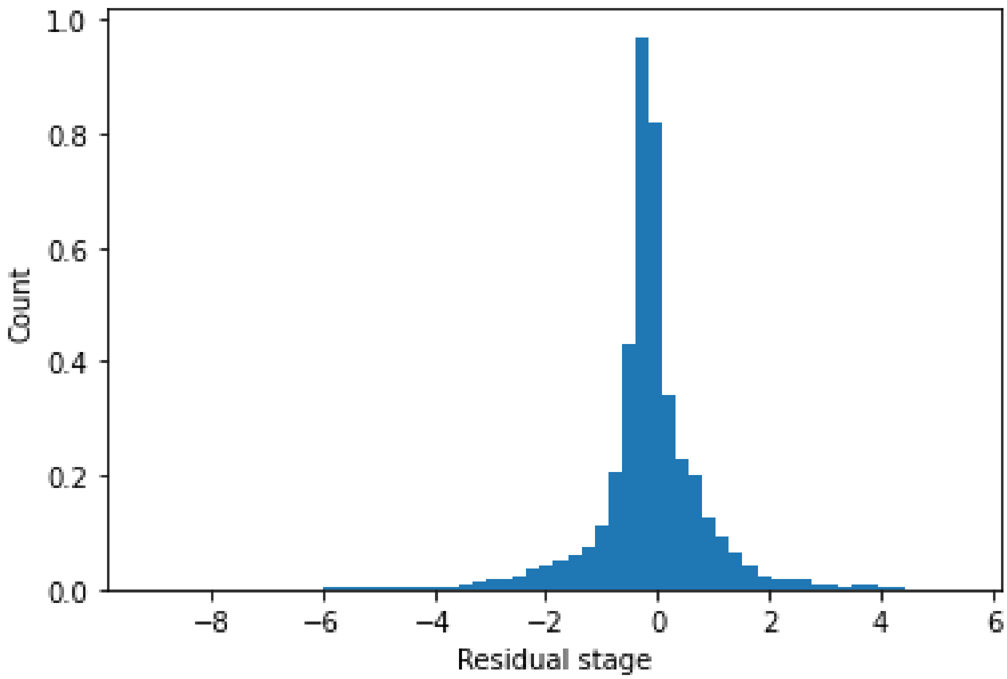
```
R^2:  0.4755364371710477
mse:  0.2048234530139613
rmse:  0.4525742513819818
mae:  0.2871773460912934
```

```
mape:  0.10087996276424001
Error estandar:  0.44767144126579655
```

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

y_real_stage = y_test
residual_stage = residuals

#y_real_discharge = np.array([i[-1] for i in y_test])
#residual_discharge = np.array([i[-1] 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 stage');
plt.show()
```

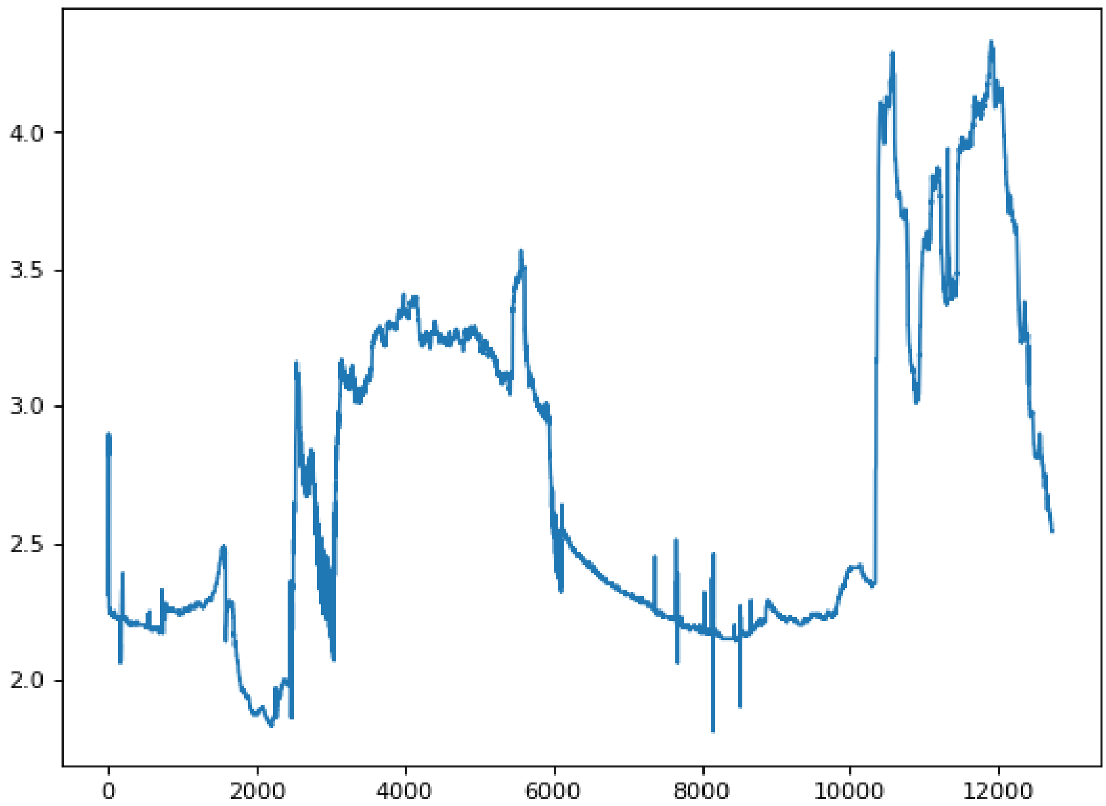



```
[ ]: """plt.hist(residual_discharge / residual_discharge.std(), density=True, bins =␣
 ↪60)
plt.ylabel('Count')
plt.xlabel('Residual discharge');
plt.show()"""
```

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

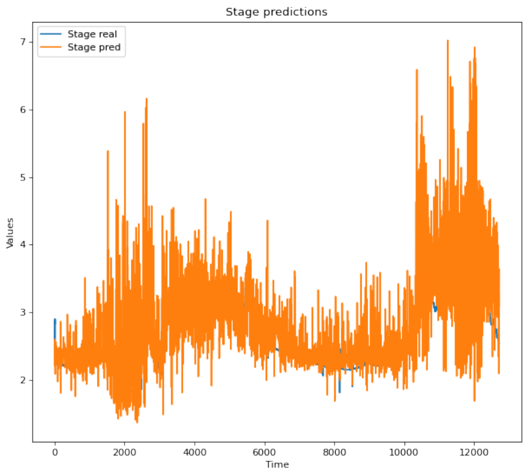
```
[ ]: plt.figure(figsize=(8, 6), dpi=80)
plt.plot(np.arange(len(y_test)), y_test, label="Stage real")
```

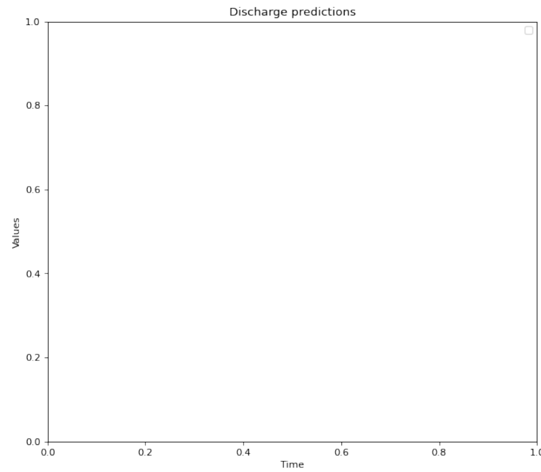
```
[ ]: [<matplotlib.lines.Line2D at 0x7fc114f04eb0>]
```




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

ax[0].plot(np.arange(len(y_test)), y_test, label="Stage real")
ax[0].plot(np.arange(len(y_test)), y_pred, label="Stage pred")

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

ax[1].set_ylabel("Values")
ax[0].set_ylabel("Values")
ax[1].set_xlabel("Time")
ax[0].set_xlabel("Time")

ax[0].legend()
ax[1].legend()
plt.show()
```

```
No artists with labels found to put in legend.  Note that artists whose label
start with an underscore are ignored when legend() is called with no argument.
```


Stage predictions
Stage real
Stage pred
Values
Time
7
6
5
4
3
2
0
2000
4000
6000
8000
10000
12000


Discharge predictions
Values
Time
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0