MLPRegressor_v1_seg_4

November 24, 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
```

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              True                   False

   feature_combination remove_feature_selection  \
0                False                   Lasso

   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       hMean     hSigma
0      39.623303  105.368375  41.572939
1      40.179745  112.399458  41.795584
2      40.533218  114.021526  42.145582
3      41.752678  112.612830  43.575351
4      44.442097  114.839424  46.302008
…            …          …         …
42054  57.702652   87.260572  61.485334
42055  55.840861   94.175906  59.006132
42056  54.355753  100.534577  56.921028
42057  52.787629  102.891159  55.083532
42058  52.025453  105.292067  53.994155

[42059 rows x 8 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
hMean                 float64
hSigma                float64
Year                    int64
dtype: object
```

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

1.3 Divide dataset to X and Y

[ ]:
```
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)]
```

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

[ ]:
```
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=-0.524 total time=  33.8s
[CV 1/5] END clf__activation=tanh, clf__alpha=0.095,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.528 total time=  36.1s
```

```
[CV 3/5] END clf__activation=tanh, clf__alpha=0.095,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.537 total time=  37.2s
[CV 4/5] END clf__activation=tanh, clf__alpha=0.095,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.540 total time=  42.5s
[CV 5/5] END clf__activation=tanh, clf__alpha=0.095,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.531 total time=  43.5s
[CV 4/5] END clf__activation=tanh, clf__alpha=0.019000000000000003,
clf__hidden_layer_sizes=(256, 256, 128, 128, 64);, score=-0.511 total time=
2.7min
[CV 1/5] END clf__activation=tanh, clf__alpha=0.019000000000000003,
clf__hidden_layer_sizes=(256, 256, 128, 128, 64);, score=-0.489 total time=
3.1min
[CV 5/5] END clf__activation=tanh, clf__alpha=0.019000000000000003,
clf__hidden_layer_sizes=(256, 256, 128, 128, 64);, score=-0.510 total time=
3.3min
[CV 2/5] END clf__activation=tanh, clf__alpha=0.019000000000000003,
clf__hidden_layer_sizes=(256, 256, 128, 128, 64);, score=-0.498 total time=
3.6min
[CV 3/5] END clf__activation=tanh, clf__alpha=0.019000000000000003,
clf__hidden_layer_sizes=(256, 256, 128, 128, 64);, score=-0.500 total time=
4.5min
[CV 4/5] END clf__activation=tanh, clf__alpha=0.064,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.549 total time= 2.5min
[CV 2/5] END clf__activation=tanh, clf__alpha=0.026000000000000002,
clf__hidden_layer_sizes=(512, 256);, score=-0.560 total time= 2.9min
[CV 1/5] END clf__activation=tanh, clf__alpha=0.026000000000000002,
clf__hidden_layer_sizes=(512, 256);, score=-0.567 total time= 3.6min
[CV 3/5] END clf__activation=tanh, clf__alpha=0.026000000000000002,
clf__hidden_layer_sizes=(512, 256);, score=-0.575 total time= 2.5min
[CV 3/5] END clf__activation=tanh, clf__alpha=0.064,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.527 total time= 5.9min
[CV 1/5] END clf__activation=tanh, clf__alpha=0.064,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.516 total time= 7.0min
[CV 2/5] END clf__activation=tanh, clf__alpha=0.064,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.518 total time= 6.3min
[CV 4/5] END clf__activation=tanh, clf__alpha=0.026000000000000002,
clf__hidden_layer_sizes=(512, 256);, score=-0.586 total time= 2.4min
[CV 1/5] END clf__activation=tanh, clf__alpha=0.005,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.481 total time=  56.1s
[CV 3/5] END clf__activation=tanh, clf__alpha=0.005,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.503 total time=  48.9s
[CV 2/5] END clf__activation=tanh, clf__alpha=0.005,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.482 total time= 1.1min
[CV 5/5] END clf__activation=tanh, clf__alpha=0.005,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.495 total time=  59.8s
[CV 5/5] END clf__activation=tanh, clf__alpha=0.026000000000000002,
clf__hidden_layer_sizes=(512, 256);, score=-0.578 total time= 2.2min
[CV 4/5] END clf__activation=tanh, clf__alpha=0.005,
```

```
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.497 total time= 1.3min
[CV 4/5] END clf__activation=tanh, clf__alpha=0.014000000000000002,
clf__hidden_layer_sizes=(512, 256);, score=-0.586 total time= 2.1min
[CV 5/5] END clf__activation=tanh, clf__alpha=0.064,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.535 total time= 7.6min
[CV 3/5] END clf__activation=tanh, clf__alpha=0.014000000000000002,
clf__hidden_layer_sizes=(512, 256);, score=-0.562 total time= 3.0min
[CV 1/5] END clf__activation=tanh, clf__alpha=0.035,
clf__hidden_layer_sizes=(512, 256);, score=-0.577 total time= 2.4min
[CV 2/5] END clf__activation=tanh, clf__alpha=0.035,
clf__hidden_layer_sizes=(512, 256);, score=-0.569 total time= 2.3min
[CV 3/5] END clf__activation=tanh, clf__alpha=0.035,
clf__hidden_layer_sizes=(512, 256);, score=-0.591 total time= 2.3min
[CV 4/5] END clf__activation=tanh, clf__alpha=0.035,
clf__hidden_layer_sizes=(512, 256);, score=-0.594 total time= 2.0min
[CV 2/5] END clf__activation=tanh, clf__alpha=0.014000000000000002,
clf__hidden_layer_sizes=(512, 256);, score=-0.521 total time= 5.5min
[CV 5/5] END clf__activation=tanh, clf__alpha=0.035,
clf__hidden_layer_sizes=(512, 256);, score=-0.581 total time= 2.7min
[CV 1/5] END clf__activation=relu, clf__alpha=0.079,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.499 total time=  45.8s
[CV 2/5] END clf__activation=relu, clf__alpha=0.098,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.519 total time= 3.5min
[CV 5/5] END clf__activation=tanh, clf__alpha=0.014000000000000002,
clf__hidden_layer_sizes=(512, 256);, score=-0.536 total time= 6.3min
[CV 1/5] END clf__activation=tanh, clf__alpha=0.014000000000000002,
clf__hidden_layer_sizes=(512, 256);, score=-0.511 total time= 7.4min
[CV 2/5] END clf__activation=relu, clf__alpha=0.079,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.491 total time=  42.1s
[CV 3/5] END clf__activation=relu, clf__alpha=0.079,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.495 total time=  55.1s
[CV 4/5] END clf__activation=relu, clf__alpha=0.079,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.506 total time=  49.0s
[CV 5/5] END clf__activation=relu, clf__alpha=0.079,
clf__hidden_layer_sizes=(128, 64, 64, 32);, score=-0.515 total time=  52.6s
[CV 1/5] END clf__activation=relu, clf__alpha=0.098,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.508 total time= 5.7min
[CV 4/5] END clf__activation=relu, clf__alpha=0.098,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.514 total time= 4.3min
[CV 3/5] END clf__activation=relu, clf__alpha=0.098,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.509 total time= 4.5min
[CV 5/5] END clf__activation=relu, clf__alpha=0.098,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.516 total time= 4.8min
[CV 4/5] END clf__activation=tanh, clf__alpha=0.068,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.525 total time= 3.7min
[CV 1/5] END clf__activation=tanh, clf__alpha=0.068,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.513 total time= 5.2min
[CV 3/5] END clf__activation=tanh, clf__alpha=0.068,
```

```
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.524 total time= 4.7min
[CV 2/5] END clf__activation=tanh, clf__alpha=0.068,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.518 total time= 5.0min
[CV 5/5] END clf__activation=tanh, clf__alpha=0.068,
clf__hidden_layer_sizes=(512, 256, 128, 128);, score=-0.536 total time= 4.9min
```

[ ]:
```
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)
```

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

[ ]:
```
-0.49152447381613074
```

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

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

1.5 Test model

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

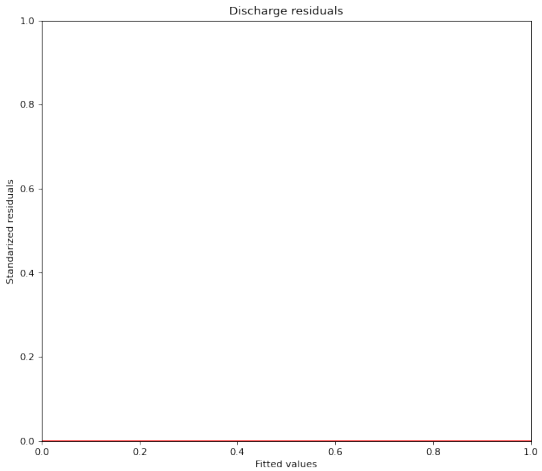
[ ]:
```
-0.3542243112154066
```

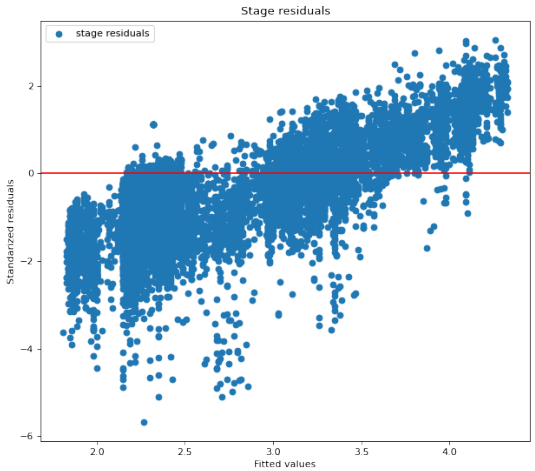
[ ]:
```
y_pred = clf.predict(X_test)
```

[ ]:
```
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))
```

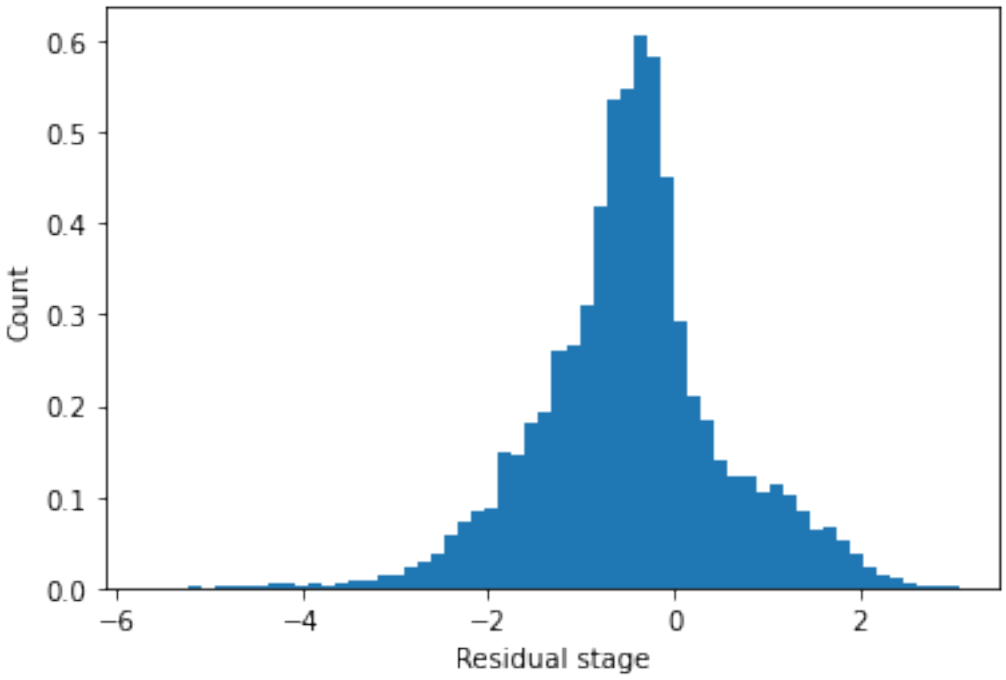
```
R^2:  0.09298597613232973
mse:  0.3542243112154066
rmse:  0.5951674648495217
mae:  0.46038871992222397
mape:  0.1806500295655998
Error estandar:  0.5416763198444101
```

[ ]:
```
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()
```



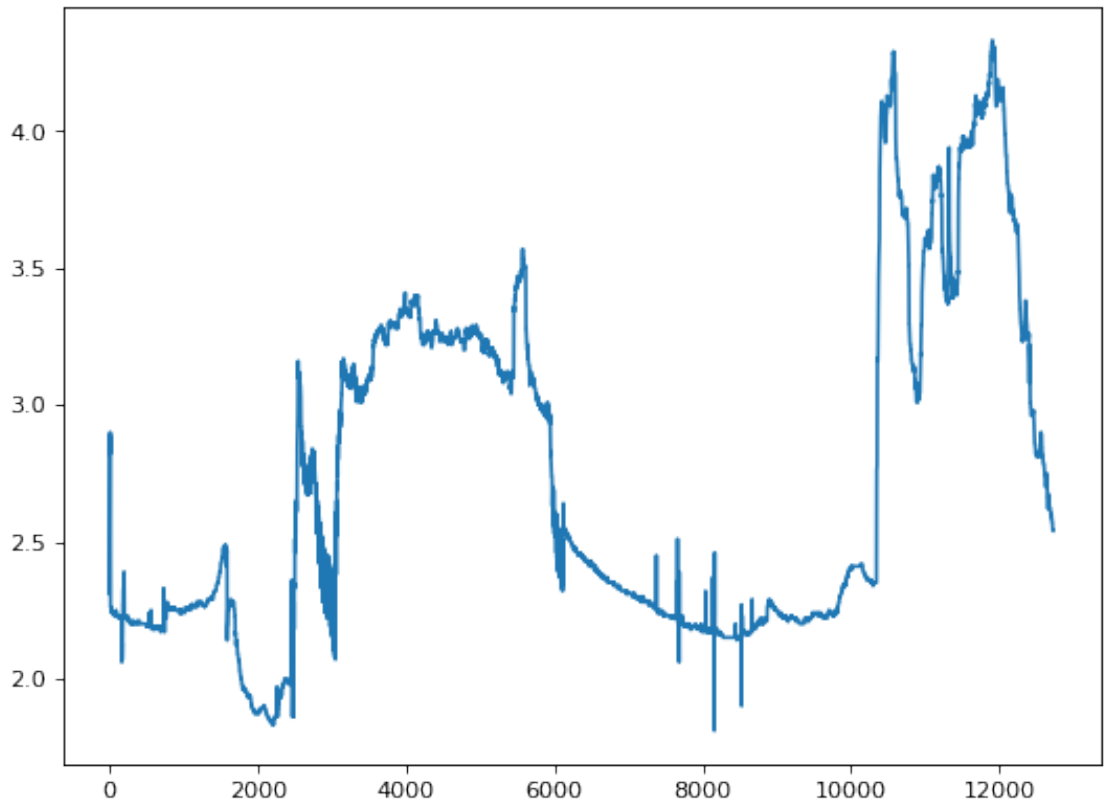
[ ]:
```
"""plt.hist(residual_discharge / residual_discharge.std(), density=True, bins =␣
↪60)
plt.ylabel('Count')
```

```
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 0x7f0d54a53a00>]
```



[ ]:
```
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")

plt.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.
```