OpenML in Python

OpenML is an online collaboration platform for machine learning:

- Share/reuse machine learning datasets, algorithms, models, experiments
- Well documented/annotated datasets, uniform access
- APIs in Java, R, Python*,… to download/upload everything
- Better reproducibility of experiments, reuse of machine learning models
- Works well with machine learning libraries such as scikit-learn
- Large scale benchmarking, compare to state of the art

```
<IPython.core.display.HTML object>
```

Authentication

- Create an OpenML account (free) on http://www.openml.org.
- After logging in, open your account page (avatar on the top right)
- Open 'Account Settings', then 'API authentication' to find your API key.

There are two ways to authenticate:

- Create a plain text file `~/.openml/config` with the line 'apikey=MYKEY', replacing MYKEY with your API key.
- Run the code below, replacing 'MYKEY' with your API key.

```
[67]: # If you don't keep your API key in the config file, you can also specify
      # oml.config.apikey = MYKEY
```

Data sets

We can list, select, and download all OpenML datasets

List datasets

```
[68]: datalist = oml.datasets.list_datasets() # Returns a dict
      datalist = pd.DataFrame.from_dict(datalist, orient='index') # Create a Dat
      print("First 10 of %s active datasets..." % len(datalist))
      datalist[:10][['did','name','NumberOfInstances',
                     'NumberOfFeatures','NumberOfClasses']]
```

```
First 10 of 2518 active datasets...
```

	did	name	NumberOfInstances	NumberOfFeatures	NumberOfClasses
2	2	anneal	898	39	5
3	3	kr-vs-kp	3196	37	2
4	4	labor	57	17	2
5	5	arrhythmia	452	280	13
6	6	letter	20000	17	26
7	7	audiology	226	70	24
8	8	liver-disorders	345	7	16
9	9	autos	205	26	6

```
10   10          lymph                148                19                 4
11   11    balance-scale              625                 5                 3
```

There are many properties that we can query

```
[69]: list(datalist)
      datalist = datalist[['did','name','NumberOfInstances',
                      'NumberOfFeatures','NumberOfClasses']]
```

```
['name',
 'NumberOfFeatures',
 'format',
 'NumberOfNumericFeatures',
 'NumberOfClasses',
 'NumberOfSymbolicFeatures',
 'NumberOfInstances',
 'MinorityClassSize',
 'NumberOfInstancesWithMissingValues',
 'MajorityClassSize',
 'did',
 'status',
 'NumberOfMissingValues',
 'MaxNominalAttDistinctValues']
```

and we can filter or sort on all of them

```
[70]: datalist[datalist.NumberOfInstances>10000
              ].sort(['NumberOfInstances'])[:20]
```

```
         did                                name  NumberOfInstances  \
23515  23515                              sulfur              10081
981      981                  kdd_internet_usage              10108
372      372                      internet_usage              10108
1536    1536                        volcanoes-b6              10130
4562    4562                       InternetUsage              10168
1531    1531                        volcanoes-b1              10176
1534    1534                        volcanoes-b4              10190
1459    1459               artificial-characters              10218
1478    1478                                 har              10299
1533    1533                        volcanoes-b3              10386
1532    1532                        volcanoes-b2              10668
1053    1053                                 jm1              10885
1414    1414  Kaggle_bike_sharing_demand_challange              10886
1044    1044                       eye_movements              10936
1019    1019                           pendigits              10992
32        32                           pendigits              10992
4534    4534                     PhishingWebsites              11055
399      399                           ohscal.wc              11162
310      310                         mammography              11183
1568    1568                             nursery              12958
```

```
       NumberOfFeatures  NumberOfClasses
23515                 7               -1
981                  69                2
372                  72               46
1536                  4                5
4562                 72               -1
1531                  4                5
1534                  4                5
1459                  8               10
1478                562                6
1533                  4                5
1532                  4                5
1053                 22                2
1414                 12              822
1044                 28                3
1019                 17                2
32                   17               10
4534                 31                2
399               11466               10
310                   7                2
1568                  9                4
```

or find specific ones

```
[71]: datalist.query('name == "MagicTelescope"')
```

```
       did            name  NumberOfInstances  NumberOfFeatures  \
1120  1120  MagicTelescope              19020                12

      NumberOfClasses
1120                2
```

```
[72]: datalist.query('NumberOfClasses > 50')
```

```
         did                                 name  NumberOfInstances  \
190      190                             mbagrade                 61
1092    1092                                Crash                352
1414    1414  Kaggle_bike_sharing_demand_challange              10886
1491    1491              one-hundred-plants-margin               1600
1492    1492               one-hundred-plants-shape               1600
1493    1493             one-hundred-plants-texture               1599
4546    4546                               Plants              44940
4552    4552                     BachChoralHarmony               5665
40601  40601                            RAM_price                333
40753  40753               delays_zurich_transport            5465575
40916  40916                     HappinessRank_2015                158
41021  41021                            Moneyball               1232
41022  41022              Short_Track_Speed_Skating               5125

       NumberOfFeatures  NumberOfClasses
```

```
190                 3          57
1092               14         307
1414               12         822
1491               65         100
1492               65         100
1493               65         100
4546               16          57
4552               17         102
40601               3         219
40753              15        4082
40916              12         157
41021              15          87
41022              27        2954
```

Download a specific dataset. This is done based on the dataset ID (called 'did').

```
[73]: dataset = oml.datasets.get_dataset(1120)

      print("This is dataset '%s', the target feature is '%s'" %
            (dataset.name, dataset.default_target_attribute))
      print("URL: %s" % dataset.url)
      print(dataset.description[:500])
```

```
This is dataset 'MagicTelescope', the target feature is 'class:'
URL: https://www.openml.org/data/v1/download/54003/MagicTelescope.arff
**Author**: R. K. Bock. Major Atmospheric Gamma Imaging Cherenkov Telescope proj
Donated by P. Savicky, Institute of Computer Science, AS of CR, Czech Republic
**Source**: [UCI](https://archive.ics.uci.edu/ml/datasets/magic+gamma+telescope)
**Please cite**: Bock, R.K., Chilingarian, A., Gaug, M., Hakl, F., Hengstebeck,
Methods for multidimensional event classification: a case stud
```

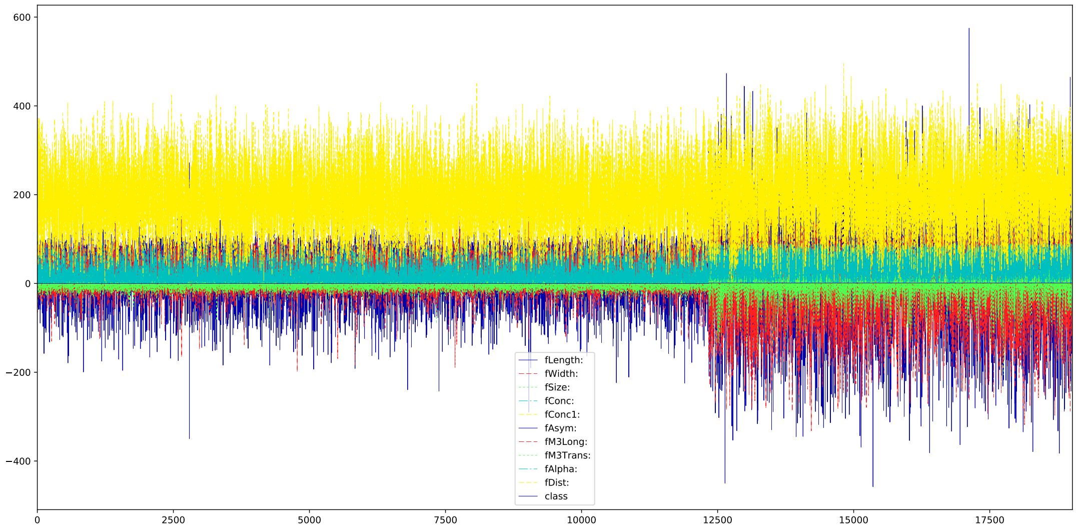
Convert the data to a DataFrame for easier processing/plotting

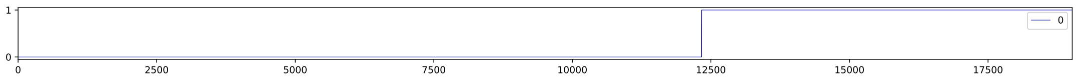
```
[74]: X, y, attribute_names = dataset.get_data(
          target=dataset.default_target_attribute,
          return_attribute_names=True)
      magic = pd.DataFrame(X, columns=attribute_names)
      magic['class'] = y
      print(magic[:10])
```

```
   fLength:  fWidth:  fSize:  fConc:  ...   fM3Trans:  fAlpha:  fDist:  class
0     28.80    16.00    2.64    0.39  ...       -8.20    40.09   81.88      0
1     31.60    11.72    2.52    0.53  ...       -9.96     6.36  205.26      0
2    162.05   136.03    4.06    0.04  ...      -45.22    76.96  256.79      0
3     23.82     9.57    2.34    0.61  ...       -7.15    10.45  116.74      0
4     75.14    30.92    3.16    0.32  ...       21.84     4.65  356.46      0
5     51.62    21.15    2.91    0.24  ...        9.81     3.61  238.10      0
6     48.25    17.36    3.03    0.25  ...       10.59     4.79  219.09      0
7     26.79    13.76    2.55    0.42  ...       -2.93     0.81  237.13      0
8     96.23    46.52    4.15    0.08  ...       43.18     4.85  248.23      0
9     46.76    15.20    2.58    0.34  ...       -6.68     7.88  102.25      0
```

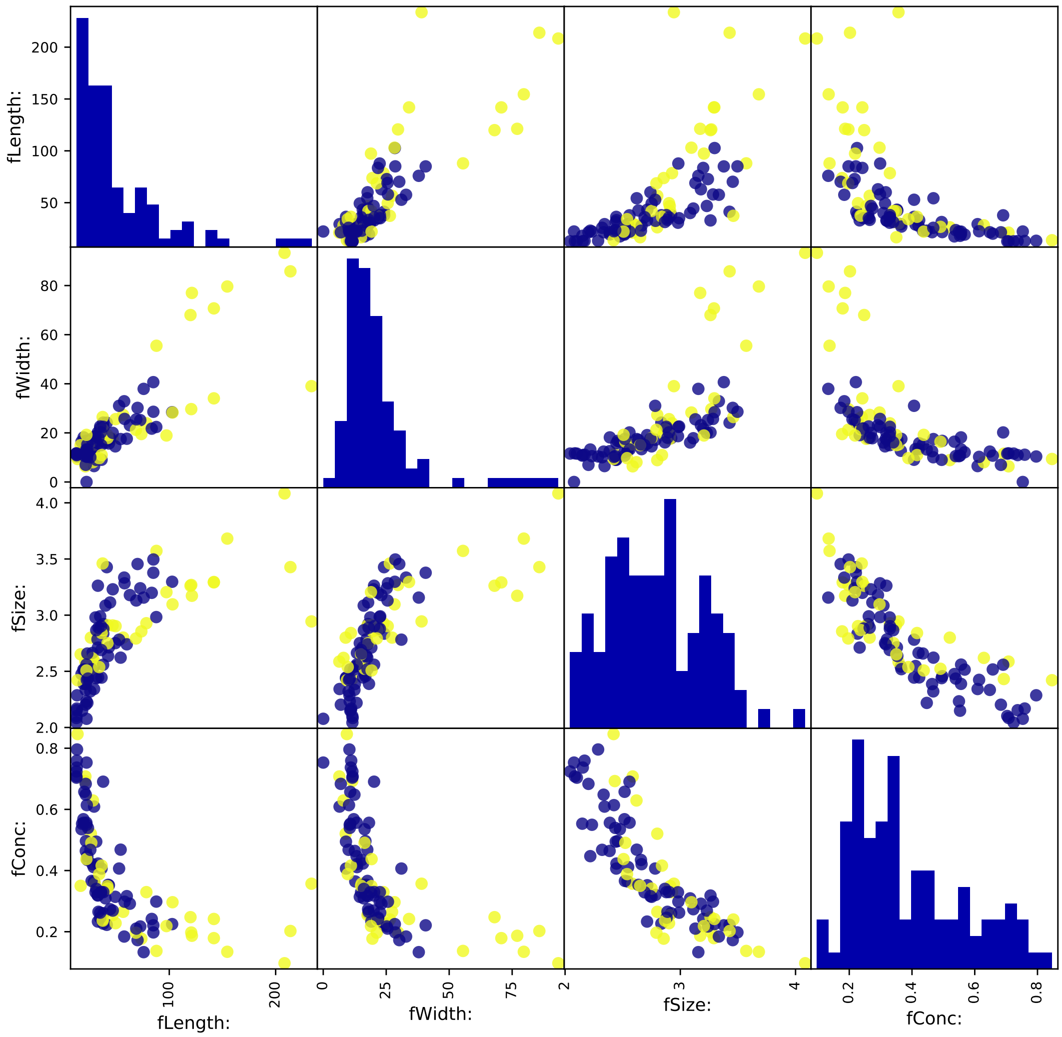
```
[10 rows x 11 columns]
```

[75]:
```python
magic.plot(figsize=(20,10))
pd.DataFrame(y).plot(figsize=(20,1));
```





[76]:
```python
magics = magic.sample(n=1000)
_ = pd.scatter_matrix(magics.iloc[:100,:4], c=magics[:100]['class'], figsi
                      marker='o', hist_kwds={'bins': 20},
                      alpha=.8, cmap='plasma')
```

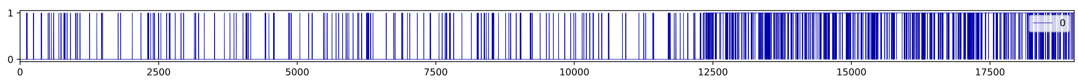


Train models

Train a scikit-learn model on the data manually

[77]:
```
from sklearn import ensemble
from sklearn import model_selection

X_train, X_test, y_train, y_test = model_selection.train_test_split(X, y)
clf = ensemble.RandomForestClassifier(n_estimators=100)
clf.fit(X_train, y_train)
pd.DataFrame(clf.predict(X)).plot(figsize=(20,1));
```



And evaluate

```
[78]: kfold = model_selection.StratifiedKFold(n_splits=5, shuffle=True, random_s
      results = model_selection.cross_val_score(clf, X, y, cv=kfold)
      print("Accuracy: %.3f%% (+- %.3f)" % (results.mean(), results.std()))
```

```
Accuracy: 0.880% (+- 0.002)
```

Note: You can also ask which features are categorical to do your own encoding

```
[79]: from sklearn import preprocessing
      dataset = oml.datasets.get_dataset(10) # Lymph dataset
      X, y, categorical = dataset.get_data(
          target=dataset.default_target_attribute,
          return_categorical_indicator=True)
      print("Categorical features: %s" % categorical)
      enc = preprocessing.OneHotEncoder(categorical_features=categorical)
      X = enc.fit_transform(X)
      clf.fit(X, y)
```

```
Categorical features: [True, True, True, True, True, True, True, True, False, Fa


RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',
            max_depth=None, max_features='auto', max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=2,
            min_weight_fraction_leaf=0.0, n_estimators=100, n_jobs=1,
            oob_score=False, random_state=None, verbose=0,
            warm_start=False)
```

Tasks

To run benchmarks consistently (also across studies and tools), OpenML offers Tasks, which include specific train-test splits and other information to define a scientific task. Tasks are typically created via the website by the dataset provider.

Listing tasks

```
[80]: task_list = oml.tasks.list_tasks(size=5000) # Get first 5000 tasks

      mytasks = pd.DataFrame(task_list).transpose()
      print("First 5 of %s tasks:" % len(mytasks))
      print(mytasks.columns)
```

```
First 5 of 5000 tasks:
Index(['MajorityClassSize', 'MaxNominalAttDistinctValues', 'MinorityClassSize',
       'NumberOfClasses', 'NumberOfFeatures', 'NumberOfInstances',
       'NumberOfInstancesWithMissingValues', 'NumberOfMissingValues',
       'NumberOfNumericFeatures', 'NumberOfSymbolicFeatures', 'cost_matrix',
       'did', 'estimation_procedure', 'evaluation_measures', 'name',
       'number_samples', 'quality_measure', 'source_data',
```

```
       'source_data_labeled', 'status', 'target_feature',
       'target_feature_event', 'target_feature_left', 'target_feature_right',
       'target_value', 'task_type', 'tid', 'ttid'],
      dtype='object')
```

```
[81]: mytasks = mytasks[['tid','did','name','task_type','estimation_procedure','
      print(mytasks.head())
```

```
  tid did        name                 task_type     estimation_procedure  \
2   2   2      anneal  Supervised Classification  10-fold Crossvalidation
3   3   3   kr-vs-kp  Supervised Classification  10-fold Crossvalidation
4   4   4       labor  Supervised Classification  10-fold Crossvalidation
5   5   5  arrhythmia  Supervised Classification  10-fold Crossvalidation
6   6   6      letter  Supervised Classification  10-fold Crossvalidation

   evaluation_measures
2  predictive_accuracy
3                  NaN
4  predictive_accuracy
5  predictive_accuracy
6                  NaN
```

Search for the tasks you need

```
[82]: print(mytasks.query('name=="MagicTelescope"'))
```

```
        tid   did            name                          task_type  \
3954   3954  1120  MagicTelescope            Supervised Classification
4659   4659  1120  MagicTelescope            Supervised Classification
7228   7228  1120  MagicTelescope  Supervised Data Stream Classification
10067 10067  1120  MagicTelescope                       Learning Curve

                  estimation_procedure  evaluation_measures
3954           10-fold Crossvalidation                  NaN
4659  10 times 10-fold Crossvalidation  predictive_accuracy
7228        Interleaved Test then Train                  NaN
10067           10-fold Learning Curve                  NaN
```

Download tasks

```
[83]: task = oml.tasks.get_task(3954)
      pprint(vars(task))
```

```
{'class_labels': ['g', 'h'],
 'cost_matrix': None,
 'dataset_id': 1120,
 'estimation_parameters': {'number_folds': '10',
                           'number_repeats': '1',
                           'percentage': '',
                           'stratified_sampling': 'true'},
```

```
 'estimation_procedure': {'data_splits_url': 'https://www.openml.org/api_splits/
                          'parameters': {'number_folds': '10',
                                         'number_repeats': '1',
                                         'percentage': '',
                                         'stratified_sampling': 'true'},
                          'type': 'crossvalidation'},
 'evaluation_measure': None,
 'split': None,
 'target_name': 'class:',
 'task_id': 3954,
 'task_type': 'Supervised Classification',
 'task_type_id': 1}
```

Runs: Train models on tasks

We can run (many) scikit-learn algorithms on (many) OpenML tasks.

```
[84]: task = oml.tasks.get_task(3954)
      clf = ensemble.RandomForestClassifier(n_estimators=100)
      flow = oml.flows.sklearn_to_flow(clf)
      run = oml.runs.run_flow_on_task(task, flow)
      run.model
```

```
RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',
            max_depth=None, max_features='auto', max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=2,
            min_weight_fraction_leaf=0.0, n_estimators=100, n_jobs=1,
            oob_score=False, random_state=38834, verbose=0,
            warm_start=False)
```

Share the run on the OpenML server * Note: if the exact same experiment has already been done (probably by you), it will just return the run ID from the previous run

```
[85]: myrun = run.publish()
      print("Uploaded to http://www.openml.org/r/" + str(myrun.run_id))
```

```
Uploaded to http://www.openml.org/r/8872325
```

It also works with pipelines

```
[86]: from sklearn import pipeline, ensemble, preprocessing
      from openml import tasks,runs, datasets
      task = tasks.get_task(59)
      pipe = pipeline.Pipeline(steps=[
                 ('Imputer', preprocessing.Imputer(strategy='median')),
                 ('OneHotEncoder', preprocessing.OneHotEncoder(sparse=False, ha
                 ('Classifier', ensemble.RandomForestClassifier())
                ])
```

```
flow = oml.flows.sklearn_to_flow(pipe)
run = oml.runs.run_flow_on_task(task, flow)
myrun = run.publish()
print("Uploaded to http://www.openml.org/r/" + str(myrun.run_id))
```

```
Uploaded to http://www.openml.org/r/8872326
```

All together

Train any model on any OpenML dataset and upload to OpenML in a few lines of code

```
[87]: from sklearn.linear_model import LogisticRegression

      task = oml.tasks.get_task(3954)
      clf = LogisticRegression()
      flow = oml.flows.sklearn_to_flow(clf)
      run = oml.runs.run_flow_on_task(task, flow)
      run.model
      myrun = run.publish()
      print("Uploaded to http://www.openml.org/r/" + str(myrun.run_id))
```

```
LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=True,
          intercept_scaling=1, max_iter=100, multi_class='ovr', n_jobs=1,
          penalty='l2', random_state=45647, solver='liblinear', tol=0.0001,
          verbose=0, warm_start=False)


Uploaded to http://www.openml.org/r/8872327
```

- You can (of course) evaluate models in a loop
- E.g. for easy benchmarking:

```
[89]: import openml as oml
      from sklearn import neighbors

      for task_id in [14951,10103,9945]:
          task = oml.tasks.get_task(task_id)
          data = oml.datasets.get_dataset(task.dataset_id)
          clf = neighbors.KNeighborsClassifier(n_neighbors=10)
          flow = oml.flows.sklearn_to_flow(clf)
          run = oml.runs.run_flow_on_task(task, flow)
          myrun = run.publish()
          print("kNN on %s: http://www.openml.org/r/%d" % (data.name, myrun.run_
```

```
kNN on eeg-eye-state: http://www.openml.org/r/8872328
kNN on volcanoes-a1: http://www.openml.org/r/8872329
kNN on walking-activity: http://www.openml.org/r/8872330
```

Download everyone else's results on the same dataset

Check whether other people built better models on the same task by downloading their evaluations (computed on the OpenML server) and comparing directly against them.

```
[90]: myruns = oml.runs.list_runs(task=[3954],size=10000) # This can take a whil
      scores = []
      for id, _ in myruns.items():
          run = oml.runs.get_run(id)
          if str.startswith(run.flow_name, 'sklearn'):
              scores.append({"flow":run.flow_name, "score":run.evaluations['pred
```

```
[94]: import seaborn as sns
      fig, ax = plt.subplots(figsize=(8, 12))
      sns.violinplot(x="score", y="flow", data=pd.DataFrame(scores), scale="widt
```