OpenML in Python

OpenML is an online collaboration platform for machine learning:

- Find or share interesting, well-documented datasets
- Define research / modelling goals (tasks)
- Explore large amounts of machine learning algorithms, with APIs in Java, R, Python
- Log and share reproducible experiments, models, results
- Works seamlessly with scikit-learn and other libraries
- Large scale benchmarking, compare to state of the art

Installation

Install the OpenML developer version
'pip install openml' coming up (october 2017) pip install git+https://github.com/renatopp/liac-arff@master pip install git+https://github.com/openml/openml-python.git@develop

```
[1]: from IPython.display import set_matplotlib_formats, display, HTML
     HTML('''<style>html, body{overflow-y: visible !important} .CodeMirror{min-w
```

```
<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 'YOURKEY' with your API key.

```
[2]: # Uncomment and set your OpenML key. Don't share your key with others.
     import openml as oml
     #oml.config.apikey = 'YOURKEY'
```

It all starts with data

Explore thousands of datasets, or share your own

List datasets

```
[3]: import openml as oml
     openml_list = oml.datasets.list_datasets() # Returns a dict

     # Show a nice table with some key data properties
     import pandas as pd
     datalist = pd.DataFrame.from_dict(openml_list, orient='index')
     datalist = datalist[['did','name','NumberOfInstances',
                    'NumberOfFeatures','NumberOfClasses']]
     print("First 10 of %s datasets..." % len(datalist))
     datalist[:10]
```

```
First 10 of 19530 datasets...
```

```
    did             name  NumberOfInstances  NumberOfFeatures  NumberOfClasses
1     1           anneal              898.0              39.0              6.0
2     2           anneal              898.0              39.0              5.0
3     3         kr-vs-kp             3196.0              37.0              2.0
4     4            labor               57.0              17.0              2.0
5     5       arrhythmia              452.0             280.0             13.0
6     6           letter            20000.0              17.0             26.0
7     7        audiology              226.0              70.0             24.0
8     8  liver-disorders              345.0               7.0             -1.0
9     9            autos              205.0              26.0              6.0
10   10            lymph              148.0              19.0              4.0
```

Exercise

- Find datasets with more than 10000 examples
- Find a dataset called ‘eeg_eye_state’
- Find all datasets with more than 50 classes

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

```
         did                                  name  NumberOfInstances  \
23515  23515                                sulfur            10081.0
372      372                        internet_usage            10108.0
981      981                    kdd_internet_usage            10108.0
1536    1536                          volcanoes-b6            10130.0
4562    4562                         InternetUsage            10168.0
1531    1531                          volcanoes-b1            10176.0
1534    1534                          volcanoes-b4            10190.0
1459    1459                 artificial-characters            10218.0
1478    1478                                   har            10299.0
1533    1533                          volcanoes-b3            10386.0
1532    1532                          volcanoes-b2            10668.0
1053    1053                                   jm1            10885.0
1414    1414  Kaggle_bike_sharing_demand_challange            10886.0
1044    1044                         eye_movements            10936.0
32        32                             pendigits            10992.0
1019    1019                             pendigits            10992.0
4534    4534                      PhishingWebsites            11055.0
399      399                             ohscal.wc            11162.0
310      310                           mammography            11183.0
1568    1568                               nursery            12958.0

       NumberOfFeatures  NumberOfClasses
```

```
23515               7.0             -1.0
372                72.0             46.0
981                69.0              2.0
1536                4.0              5.0
4562               72.0             -1.0
1531                4.0              5.0
1534                4.0              5.0
1459                8.0             10.0
1478              562.0              6.0
1533                4.0              5.0
1532                4.0              5.0
1053               22.0              2.0
1414               12.0             -1.0
1044               28.0              3.0
32                 17.0             10.0
1019               17.0              2.0
4534               31.0              2.0
399             11466.0             10.0
310                 7.0              2.0
1568                9.0              4.0
```

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

```
       did            name  NumberOfInstances  NumberOfFeatures  \
1120  1120  MagicTelescope            19020.0              12.0

      NumberOfClasses
1120              2.0
```

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

```
         did                        name  NumberOfInstances  NumberOfFeatures  \
1491    1491   one-hundred-plants-margin             1600.0              65.0
1492    1492    one-hundred-plants-shape             1600.0              65.0
1493    1493  one-hundred-plants-texture             1599.0              65.0
4546    4546                      Plants            44940.0              16.0
4552    4552           BachChoralHarmony             5665.0              17.0
40753  40753     delays_zurich_transport          5465575.0              15.0

       NumberOfClasses
1491             100.0
1492             100.0
1493             100.0
4546              57.0
4552             102.0
40753           4082.0
```

Download datasets

This is done based on the dataset ID (‘did’).

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

     # Print a summary
     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**:

The data are MC generated (see below) to simulate registration of high energy ga
```

Get the actual data.
Returned as numpy array, with meta-info (e.g. target feature, feature names,...)

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

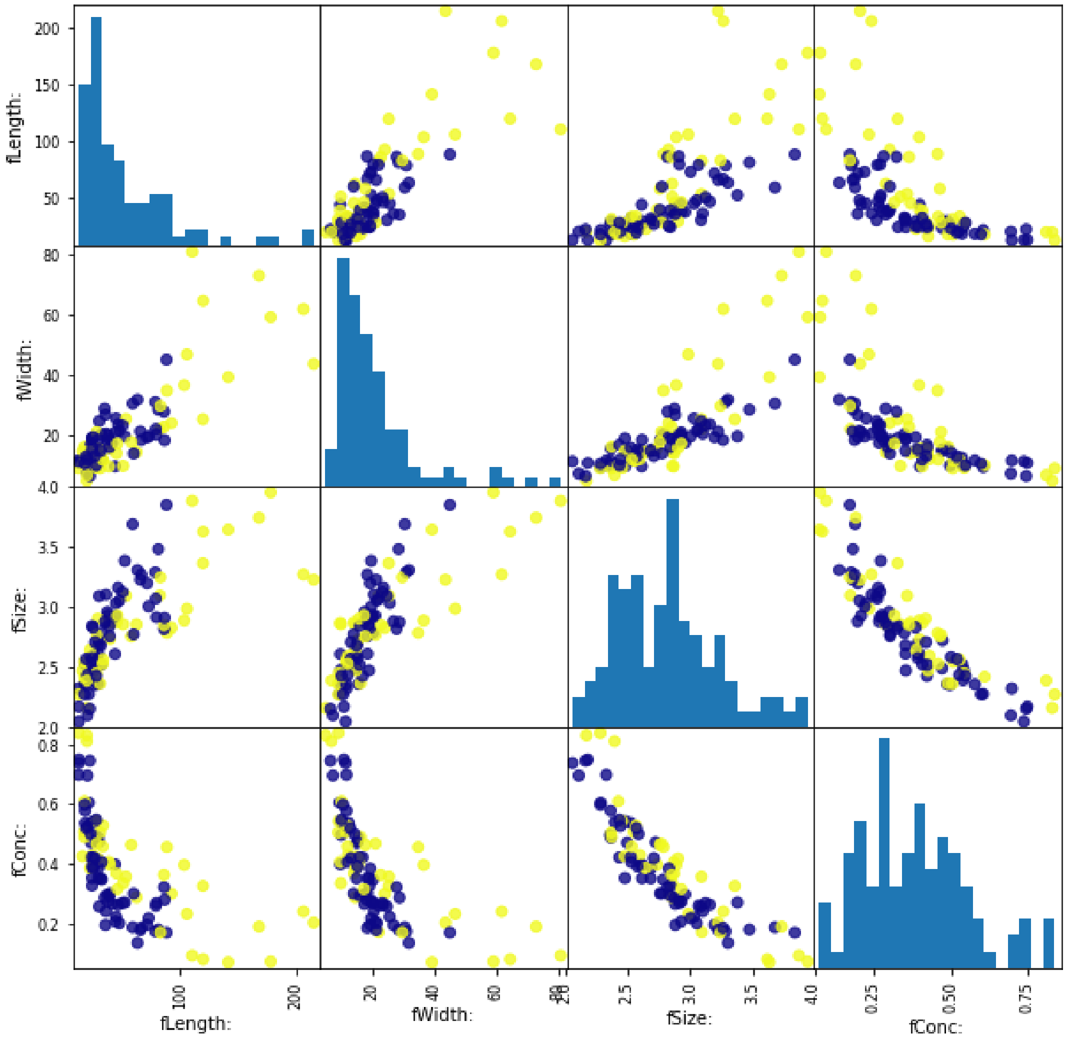
```
     fLength:     fWidth:  fSize:  fConc:  fConc1:      fAsym:   fM3Long:  \
0   28.796700   16.002100  2.6449  0.3918   0.1982   27.700399  22.011000
1   31.603600   11.723500  2.5185  0.5303   0.3773   26.272200  23.823799
2  162.052002  136.031006  4.0612  0.0374   0.0187  116.740997 -64.858002
3   23.817200    9.572800  2.3385  0.6147   0.3922   27.210699  -6.463300
4   75.136200   30.920500  3.1611  0.3168   0.1832   -5.527700  28.552500
5   51.624001   21.150200  2.9085  0.2420   0.1340   50.876099  43.188702
6   48.246799   17.356501  3.0332  0.2529   0.1515    8.573000  38.095699
7   26.789700   13.759500  2.5521  0.4236   0.2174   29.633900  20.455999
8   96.232697   46.516499  4.1540  0.0779   0.0390  110.355003  85.048599
9   46.761902   15.199300  2.5786  0.3377   0.1913   24.754801  43.877102

   fM3Trans:    fAlpha:      fDist:  class
0  -8.202700  40.091999   81.882797      0
1  -9.957400   6.360900  205.261002      0
2 -45.216000  76.959999  256.787994      0
3  -7.151300  10.449000  116.737000      0
4  21.839300   4.648000  356.462006      0
5   9.814500   3.613000  238.098007      0
6  10.586800   4.792000  219.087006      0
7  -2.929200   0.812000  237.134003      0
8  43.184399   4.854000  248.225998      0
9  -6.681200   7.875000  102.250999      0
```

Exercise

- Explore the data visually

```
[9]: %matplotlib inline
     eegs = eeg.sample(n=1000)
     pd.scatter_matrix(eegs.iloc[:100,:4], c=eegs[:100]['class'], figsize=(10, 1
                                marker='o', hist_kwds={'bins': 20},
                                alpha=.8, cmap='plasma');
```



Train machine learning models

Train a scikit-learn model on the data manually

```
[10]: from sklearn import neighbors

      dataset = oml.datasets.get_dataset(1120)
      X, y = dataset.get_data(target=dataset.default_target_attribute)
      clf = neighbors.KNeighborsClassifier(n_neighbors=1)
      clf.fit(X, y)
```

```
KNeighborsClassifier(algorithm='auto', leaf_size=30, metric='minkowski',
           metric_params=None, n_jobs=1, n_neighbors=1, p=2,
           weights='uniform')
```

You can also ask for meta-data to automatically preprocess the data - e.g. categorical features -> do feature encoding

```
[11]: from sklearn import preprocessing
      dataset = oml.datasets.get_dataset(10)
      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
```

```
KNeighborsClassifier(algorithm='auto', leaf_size=30, metric='minkowski',
           metric_params=None, n_jobs=1, n_neighbors=1, p=2,
           weights='uniform')
```

Tasks: set your own goals

and invite others to work on the same problem
Note: tasks are typically created in the web interface

Listing tasks

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

      mytasks = pd.DataFrame(task_list).transpose()
      mytasks = mytasks[['tid','did','name','task_type','estimation_procedure','
      #print(mytasks.columns)
      print("First 5 of %s tasks:" % len(mytasks))
      print(mytasks.head())
```

```
First 5 of 5000 tasks:
  tid did        name                    task_type     estimation_procedure  \
1   1   1      anneal  Supervised Classification  10-fold Crossvalidation
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

   evaluation_measures
1  predictive_accuracy
2  predictive_accuracy
```

```
3  predictive_accuracy
4  predictive_accuracy
5  predictive_accuracy
```

Exercise

Search for the tasks on the 'eeg-eye-state' dataset

```
[13]: 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  predictive_accuracy
4659   10 times 10-fold Crossvalidation  predictive_accuracy
7228         Interleaved Test then Train                  NaN
10067             10-fold Learning Curve                  NaN
```

Download tasks

```
[14]: from pprint import pprint
      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': 'predictive_accuracy',
 'split': None,
 'target_name': 'class:',
 'task_id': 3954,
 'task_type': 'Supervised Classification',
 'task_type_id': 1}
```

Runs: Easily explore models by running them on tasks

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

```
[15]: from sklearn import ensemble

      # Get a task
      task = oml.tasks.get_task(3954)

      # Build any classifier or pipeline
      clf = ensemble.RandomForestClassifier()

      # Create a flow
      flow = oml.flows.sklearn_to_flow(clf)

      # Run the flow
      run = oml.runs.run_flow_on_task(task, flow)
```

Share the run on the OpenML server

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

```
Uploaded to http://www.openml.org/r/6068436
```

It also works with pipelines

When you need to handle 'dirty' data, build pipelines to model then automatically

```
[17]: 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/6068437
```

Download previous results

You can download all your results anytime, as well as everybody else's

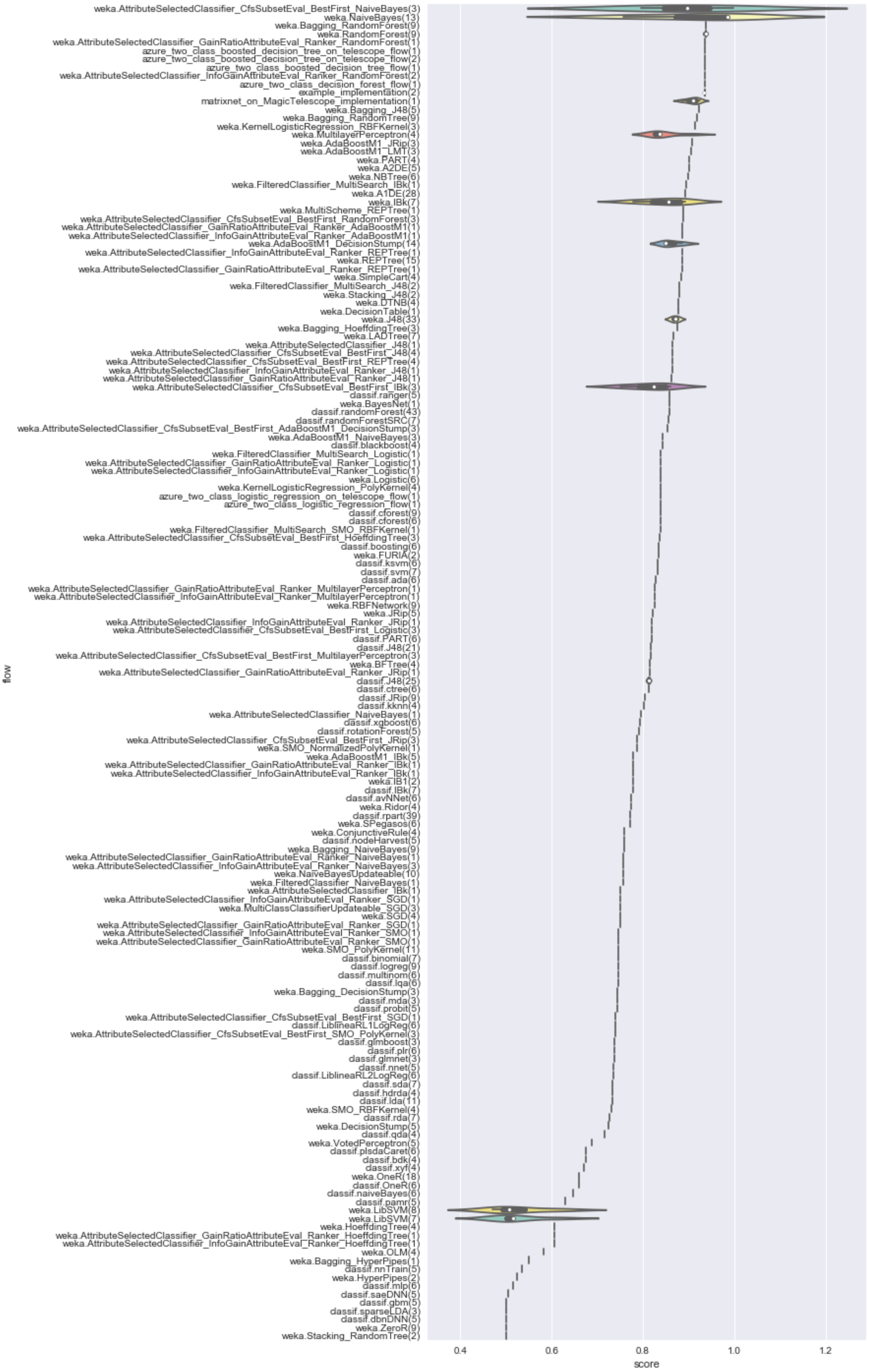
```
[40]: import seaborn as sns
      import pandas as pd
```

```
from matplotlib import pyplot
from openml import evaluations

# Get the list of runs for task 3954
evaluations = oml.evaluations.list_evaluations(task=[3954], function='area

# Download the tasks and plot the scores
scores = []
for id, e in evaluations.items():
    scores.append({"flow":e.flow_name, "score":e.value})

sorted_score = sorted(scores, key=lambda x: -x["score"])
fig, ax = pyplot.subplots(figsize=(8, 25))
sns.violinplot(ax=ax, x="score", y="flow", data=pd.DataFrame(sorted_score)
```



Easy benchmarking:

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

      for task_id in [14951,10103]:
          task = oml.tasks.get_task(task_id)
          data = oml.datasets.get_dataset(task.dataset_id)
          clf = neighbors.KNeighborsClassifier(n_neighbors=5)
          flow = oml.flows.sklearn_to_flow(clf)

          try:
              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.
          except oml.exceptions.PyOpenMLError as err:
              print("OpenML: {0}".format(err))
```

```
OpenML: Run already exists in server. Run id(s): {6068464}
OpenML: Run already exists in server. Run id(s): {6068467}
```

A Challenge

Try to build the best possible models on several OpenML tasks, and compare your results with the rest of the class, and learn from them. Some tasks you could try (or browse openml.org):

- EEG eye state: data_id:1471, task_id:14951
- Volcanoes on Venus: data_id:1527, task_id:10103
- Walking activity: data_id:1509, task_id: 9945, 150k instances
- Covertype (Satellite): data_id:150, task_id: 218. 500k instances
- Higgs (Physics): data_id:23512, task_id:52950. 100k instances, missing values