neurtu Documentation

Release 0.3.0

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Contents:

Simple performance measurement tool

neurtu is a Python package providing a common interface for multi-metric benchmarks (including time and memory measurements). It can can be used to estimate time and space complexity of algorithms, while pandas integration allows quick analysis and visualization of the results.

Setting the number of threads at runtime in OpenBlas, and MKL is also supported on Linux and MacOS.

neurtu means "to measure / evaluate" in Basque language.

CHAPTER 1

Installation

neurtu requires Python 2.7 or 3.4+, it can be installed with,

```
pip install neurtu
```

pandas is an optional (but highly recommended) dependency.

Note: the above command will install memory_profiler, shutil (to measure memory use) and tqdm (to make progress bars) mostly for convinience. However, neurtu does not have any hard depedencies, it you don't need these functionalites, you can install it with `pip install --no-deps neurtu`

CHAPTER 2

Quickstart

To illustrate neurtu usage, will will benchmark array sorting in numpy. First, we will generator of cases,

```
import numpy as np
import neurtu

def cases()
    rng = np.random.RandomState(42)

    for N in [1000, 10000, 100000]:
        X = rng.rand(N)
        tags = {'N' : N}
        yield neurtu.delayed(X, tags=tags).sort()
```

that yields a sequence of delayed calculations, each tagged with the parameters defining individual runs.

We can evaluate the run time with,

```
>>> df = neurtu.timeit(cases())
>>> print(df)
        wall_time
N
1000     0.000014
10000    0.000134
100000   0.001474
```

which will internally use `timeit` module with a sufficient number of evaluation to work around the timer precision limitations (similarly to IPython's `%timeit`). It will also display a progress bar for long running benchmarks, and return the results as a `pandas.DataFrame` (if pandas is installed).

By default, all evaluations are run with `repeat=1`. If more statistical confidence is required, this value can be increased,

```
>>> neurtu.timeit(cases(), repeat=3)
       wall_time
            mean       max       std
```

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```
N
1000    0.000012  0.000014  0.000002
10000   0.000116  0.000149  0.000029
100000  0.001323  0.001714  0.000339
```

In this case we will get a frame with a pandas.MultiIndex for columns, where the first level represents the metric name (`wall_time`) and the second – the aggregation method. By default `neurtu.timeit` is called with `aggregate=['mean', 'max', 'std']` methods, as supported by the pandas aggregation API. To disable, aggregation and obtains timings for individual runs, use `aggregate=False`. See neurtu.timeit documentation for more details.

To evaluate the peak memory usage, one can use the `neurtu.memit` function with the same API,

```
>>> neurtu.memit(cases(), repeat=3)
        peak_memory
               mean  max  std
N
10000           0.0  0.0  0.0
100000          0.0  0.0  0.0
1000000         0.0  0.0  0.0
```

More generally `neurtu.Benchmark` supports a wide number of evaluation metrics,

```
>>> bench = neurtu.Benchmark(wall_time=True, cpu_time=True, peak_memory=True)
>>> bench(cases())
         cpu_time  peak_memory  wall_time
N
10000    0.000100          0.0   0.000142
100000   0.001149          0.0   0.001680
1000000  0.013677          0.0   0.018347
```

including [psutil process metrics](https://psutil.readthedocs.io/en/latest/#psutil.Process).

For more information see the *Examples*.

CHAPTER 3

Examples

The following examples illustrate neurtu usage

Note: Click *here* to download the full example code

3.1 Time complexity of numpy.sort

In this example we will look into the time complexity of `numpy.sort()`

```
import numpy as np
from neurtu import timeit, delayed


rng = np.random.RandomState(42)


df = timeit(delayed(np.sort, tags={'N': N, 'kind': kind})(rng.rand(N), kind=kind)
            for N in np.logspace(2, 5, num=5).astype('int')
            for kind in ["quicksort", "mergesort", "heapsort"])

print(df.to_string())
```

Out:

```
                wall_time
N      kind
100    quicksort   0.000005
       mergesort   0.000006
       heapsort    0.000006
562    quicksort   0.000010
       mergesort   0.000018
```

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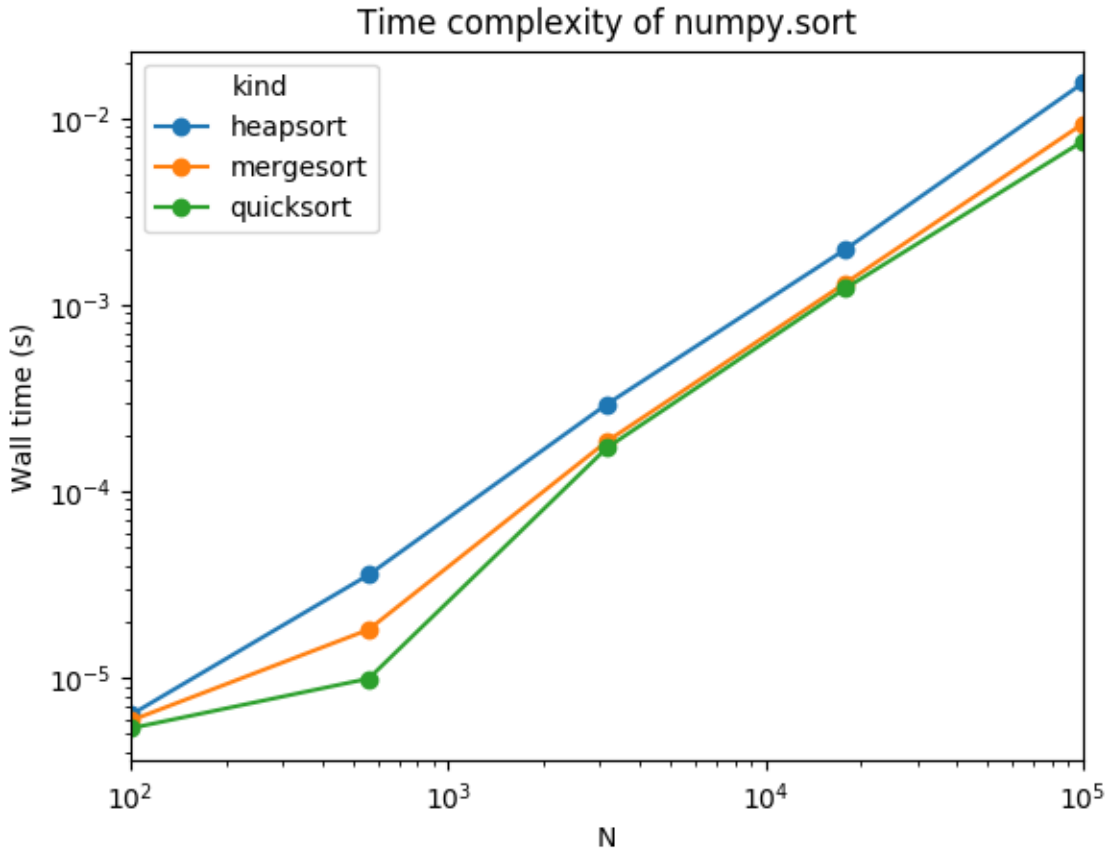
```
        heapsort    0.000036
3162    quicksort   0.000171
        mergesort   0.000185
        heapsort    0.000293
17782   quicksort   0.001220
        mergesort   0.001302
        heapsort    0.001975
100000  quicksort   0.007537
        mergesort   0.009352
        heapsort    0.015456
```

we can use the pandas plotting API (that requires matplotlib)

```
ax = df.wall_time.unstack().plot(marker='o')
ax.set_xscale('log')
ax.set_yscale('log')
ax.set_ylabel('Wall time (s)')
ax.set_title('Time complexity of numpy.sort')
```



Total running time of the script: (0 minutes 3.637 seconds)

Note: Click *here* to download the full example code

3.2 LogisticRegression scaling in scikit-learn

In this example we will look into the time and space complexity of `sklearn.linear_model.LogisticRegression`

```
from collections import OrderedDict

import numpy as np
from sklearn.linear_model import LogisticRegression
from neurtu import Benchmark, delayed


rng = np.random.RandomState(42)

n_samples, n_features = 50000, 100


X = rng.rand(n_samples, n_features)
y = rng.randint(2, size=(n_samples))


def benchmark_cases():
    for N in np.logspace(np.log10(100), np.log10(n_samples), 5).astype('int'):
        for solver in ['newton-cg', 'lbfgs', 'liblinear', 'sag', 'saga']:
            tags = OrderedDict(N=N, solver=solver)
            model = delayed(LogisticRegression, tags=tags)(
                                solver=solver, random_state=rng)

            yield model.fit(X[:N], y[:N])


bench = Benchmark(wall_time=True, peak_memory=True)
df = bench(benchmark_cases())

print(df.tail())
```

Out:

```
  0%|          | 0/50 [00:00<?, ?it/s]
  4%|4         | 2/50 [00:00<00:09,  4.92it/s]
  6%|6         | 3/50 [00:00<00:12,  3.71it/s]
  8%|8         | 4/50 [00:01<00:12,  3.71it/s]
 10%|#         | 5/50 [00:01<00:12,  3.56it/s]
 12%|#2        | 6/50 [00:01<00:10,  4.19it/s]/home/docs/checkouts/readthedocs.org/
↪user_builds/neurtu/envs/latest/lib/python3.7/site-packages/sklearn/linear_model/sag.
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 58%|#####8    | 29/50 [00:09<00:07,  2.68it/s]
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 64%|######4   | 32/50 [00:09<00:05,  3.47it/s]
 66%|######6   | 33/50 [00:10<00:04,  3.44it/s]
 68%|######8   | 34/50 [00:10<00:04,  3.90it/s]
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 78%|#######8  | 39/50 [00:12<00:04,  2.52it/s]
 80%|########  | 40/50 [00:12<00:03,  2.56it/s]
 82%|########2 | 41/50 [00:13<00:05,  1.78it/s]
 84%|########4 | 42/50 [00:14<00:05,  1.36it/s]
 86%|########6 | 43/50 [00:15<00:05,  1.35it/s]
 88%|########8 | 44/50 [00:16<00:04,  1.33it/s]
 90%|######### | 45/50 [00:17<00:03,  1.33it/s]
 92%|#########2| 46/50 [00:17<00:03,  1.30it/s]
 94%|#########3| 47/50 [00:22<00:05,  1.87s/it]
 96%|#########6| 48/50 [00:26<00:04,  2.44s/it]
 98%|#########8| 49/50 [00:28<00:02,  2.33s/it]
100%|##########| 50/50 [00:30<00:00,  2.30s/it]

                wall_time  peak_memory
N     solver
49999 newton-cg   0.909621    65.433594
      lbfgs       0.662035     0.000000
      liblinear   0.625137    79.863281
      sag         4.358365     0.000000
      saga        2.037092     0.007812
```
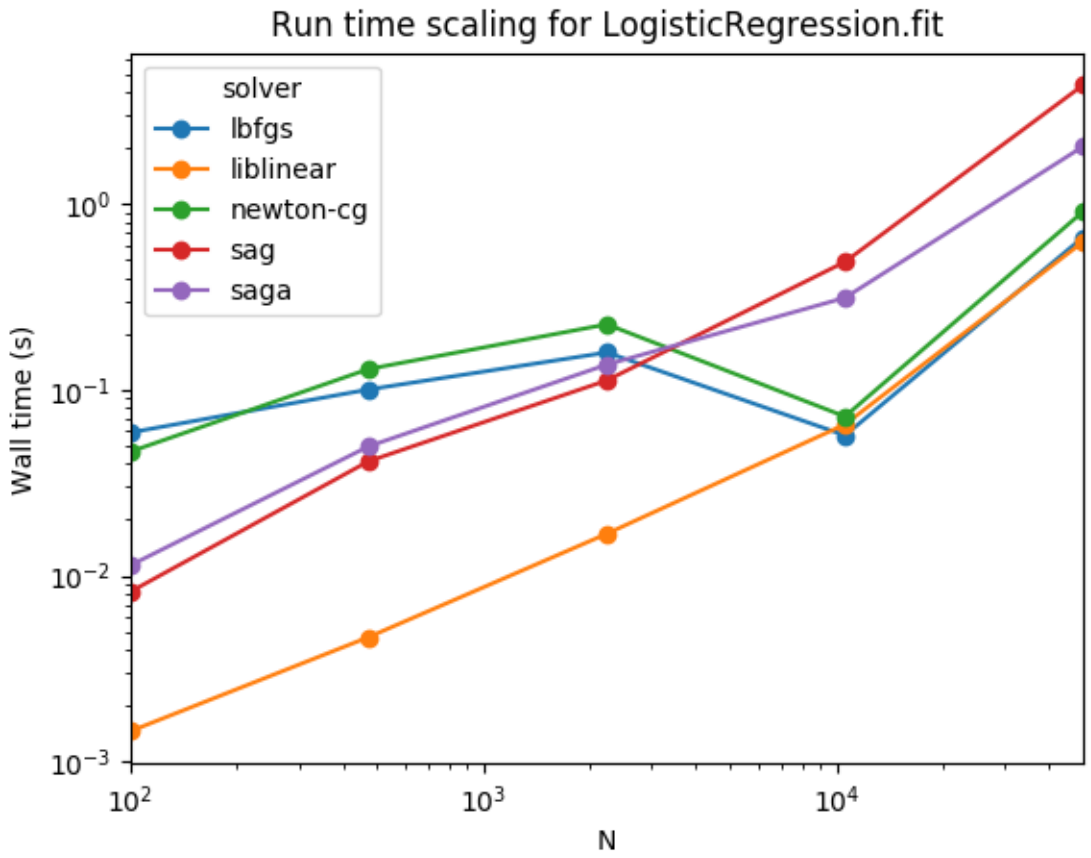

The above section will run in approximately 1min, a progress bar will be displayed.

We can use the pandas plotting API (that requires matplotlib) to visualize the results,

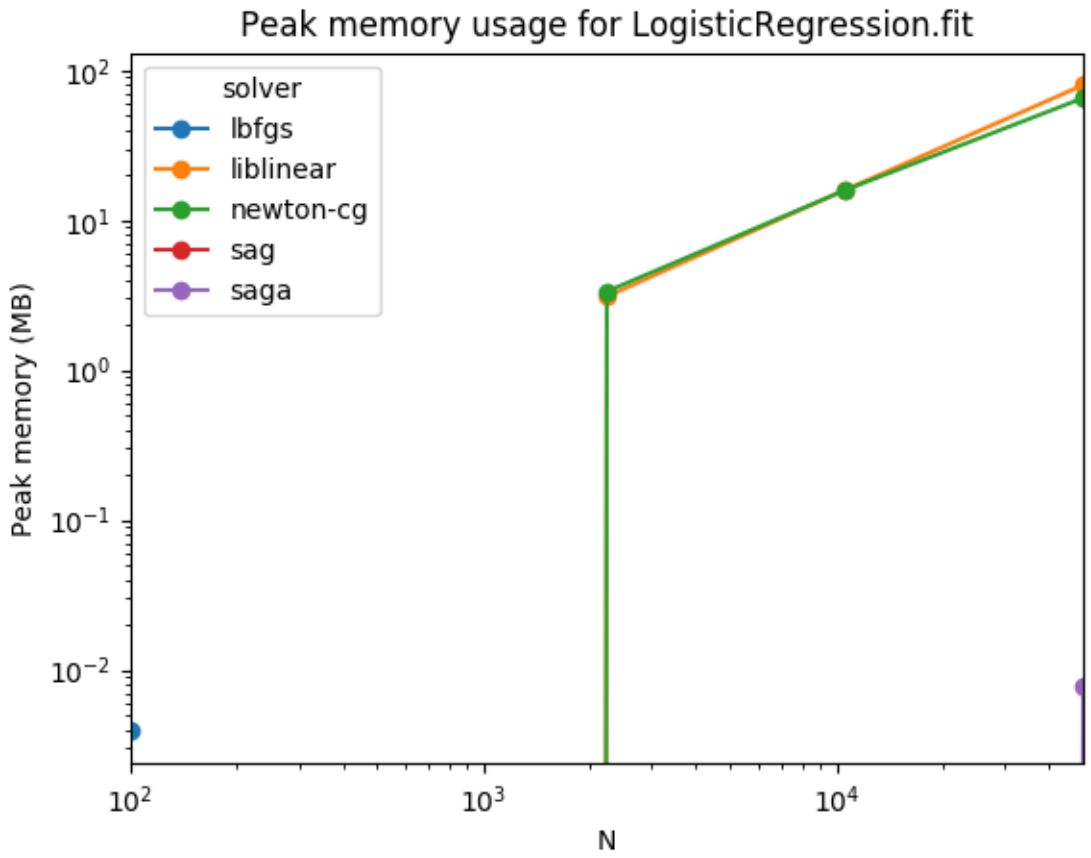
```
ax = df.wall_time.unstack().plot(marker='o')
ax.set_xscale('log')
ax.set_yscale('log')
ax.set_ylabel('Wall time (s)')
ax.set_title('Run time scaling for LogisticRegression.fit')
```



The solver with the best scalability in this example is “lbfgs”.

Similarly the memory scaling is represented below,

```
ax = df.peak_memory.unstack().plot(marker='o')
ax.set_xscale('log')
ax.set_yscale('log')
ax.set_ylabel('Peak memory (MB)')
ax.set_title('Peak memory usage for LogisticRegression.fit')
```



Peak memory usage for "liblinear" and "newton-cg" appear to be significant above 10000 samples, while the other solvers use less memory than the detection threshold. Note that these benchmarks do not account for the memory used by `X` and `y` arrays.

Total running time of the script: (0 minutes 32.213 seconds)

CHAPTER 4

API Reference

neurtu.timeit(obj[, timer, number, repeat, ...])	A benchmark decorator
neurtu.memit(obj[, repeat, aggregate, ...])	Measure the memory use.
neurtu.Benchmark([wall_time, cpu_time, ...])	Benchmark calculations
neurtu.delayed(obj[, tags, env])	Delayed object evaluation

4.1 neurtu.timeit

neurtu.**timeit**(*obj*, *timer='wall_time'*, *number=1*, *repeat=1*, *aggregate=('mean', 'max', 'std')*, *to_dataframe=None*, *progress_bar=5.0*)

A benchmark decorator

This is an alias for *Benchmark* with *wall_time=True*.

Parameters

- **obj** (*{Delayed, iterable of Delayed}*) – delayed object to compute, or an iterable of Delayed objects
- **number** (*int, default=1*) – number of runs to pass to `timeit.Timer`
- **repeat** (*int, default=1*) – number of repeated measurements
- **aggregate** (*{collection, False}, default=('mean', 'max', 'std')*) – when repeat > 1, different runs are indexed by the `runid` key. If pandas is installed and aggregate is a collection, aggregate repeated runs with the provided methods.
- **to_dataframe** (*bool, default=None*) – whether to convert parametric results to a daframe. By default convert to dataframe is pandas is installed.
- **progress_bar** (*{bool, float}, default=5.0*) – if a number, and tqdm is installed, display the progress bar when the estimated benchmark time is larger than the given number of seconds. If False, the progress bar will not be displayed.

Returns **res** – computed timing

Return type dict, list or pandas.DataFrame

4.2 neurtu.memit

neurtu.**memit**(*obj*, *repeat=1*, *aggregate=('mean', 'max', 'std')*, *interval=0.01*, *to_dataframe=None*, *progress_bar=5.0*)

Measure the memory use.

This is an alias for `Benchmark` with *peak_memory=True)*.

Parameters

- **repeat** (*int, default=1*) – number of repeated measurements
- **aggregate** (*{collection, False}, default=('mean', 'max', 'std')*) – when repeat > 1, different runs are indexed by the `runid` key. If pandas is installed and aggregate is a collection, aggregate repeated runs with the provided methods.
- **to_dataframe** (*bool, default=None*) – whether to convert parametric results to a daframe. By default convert to dataframe is pandas is installed.
- **progress_bar** (*{bool, float}, default=5.0*) – if a number, and tqdm is installed, display the progress bar when the estimated benchmark time is larger than the given number of seconds. If False, the progress bar will not be displayed.

Returns **res** – computed memory usage

Return type dict, list or pandas.DataFrame

4.3 neurtu.Benchmark

class neurtu.**Benchmark**(*wall_time=None*, *cpu_time=False*, *peak_memory=False*, *repeat=1*, *aggregate=('mean', 'max', 'std')*, *to_dataframe=None*, *progress_bar=5.0*, ***kwargs*)

Benchmark calculations

Parameters

- **wall_time** (*{bool, dict}, default=None*) – measure wall time. When a dictionary, it is passed as parameters to the *func:measure_wall_time* function. Will default to True, unless some other metric is enabled.
- **cpu_time** (*{bool, dict}, default=False*) – measure CPU time. When a dictionary, it is passed as parameters to the `measure_cpu_time()` function.
- **peak_memory** (*{bool, dict}, default=False*) – measure peak memory usage. When a dictionary, it is passed as parameters to the `measure_peak_memory()` function.
- **repeat** (*int, default=1*) – number of repeated measurements
- **aggregate** (*{collection, False}, default=('mean', 'max', 'std')*) – when repeat > 1, different runs are indexed by the `runid` key. If pandas is installed and aggregate is a collection, aggregate repeated runs with the provided methods.
- **to_dataframe** (*bool, default=None*) – whether to convert parametric results to a daframe. By default convert to dataframe is pandas is installed.

- **progress_bar** (*{bool, float}, default=5.0*) – if a number, and tqdm is installed, display the progress bar when the estimated benchmark time is larger than the given number of seconds. If False, the progress bar will not be displayed.
- ****kwargs** (*dict*) – custom evaluation metrics of the form `key=func`, where `key` is the metric name, and the `func` is the evaluation metric that accepts a `Delayed` object: `func(obj)`.

__init__(*wall_time=None*, *cpu_time=False*, *peak_memory=False*, *repeat=1*, *aggregate=('mean', 'max', 'std')*, *to_dataframe=None*, *progress_bar=5.0*, ***kwargs*)
Initialize self. See help(type(self)) for accurate signature.

Methods

__init__([wall_time, cpu_time, peak_memory, ...])	Initialize self.

4.4 neurtu.delayed

neurtu.**delayed**(*obj*, *tags=None*, *env=None*)
Delayed object evaluation

Parameters

- **obj** (*object*) – object or function to wrap
- **tags** (*dict*) – optional tags for the produced delayed object
- **env** (*dict*) – optional environment variables to set when evaluating the delayed object

Returns **result** – a delayed object

Return type *class:neurtu.Delayed*

Example

```
>>> x = delayed('some string').split(' ')[::-1]
>>> x
<Delayed('some string').split(' ')[slice(None, None, -1)]>
>>> x.compute()
['string', 'some']
```

Using tags

```
>>> x = delayed([2, 3], tags={'a': 0}).sum()
>>> x.get_tags()
{'a': 0}
```

CHAPTER 5

Release notes

5.1 Version 0.3

July 21, 2019

5.1.1 API changes

- Functions to set the number of BLAS threads at runtime were removed in favour of using threadpoolctl.

5.1.2 Enhancements

- Add `get_args` and `get_kwargs` to `Delayed` object.
- Better progress bars in Jupyter notebooks with the `tqdm.auto` backend.

5.1.3 Bug fixes

- Fix progress bar rendering when `repeat>1`.
- Fix warnings due to `collection.abc`.

5.2 Version 0.2

August 28, 2018

5.2.1 New features

- Runtime detection of the BLAS used by numpy #14
- Ability to set the number of threads in OpenBlas and MKL BLAS at runtime on Linux. #15.

5.2.2 Enhancements

- Better test coverage
- Documentation improvements
- In depth refactoring of the benchmarking code

5.2.3 API changes

- The API of `timeit`, `memit`, `Benchmark` changed significantly with respect to v0.1

5.3 Version 0.1

March 4, 2018

First release, with support for,

- wall time, cpu time and peak memory measurements
- parametric benchmarks using delayed objects

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