# Awkward Array

Jim Pivarski

Princeton University – IRIS-HEP

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# Awkward Array: NumPy-like idioms on JSON-like data

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    [],
    [{"x": 4.4, "y": [1, 2, 3, 4]}, {"x": 5.5, "y": [1, 2, 3, 4, 5]}]
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## equivalent Python

```
output = []
for sublist in python_objects:
    tmp1 = []
    for record in sublist:
        tmp2 = []
        for number in record["y"][1:]:
            tmp2.append(np.square(number))
        tmp1.append(tmp2)
    output.append(tmp1)
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**4.6 seconds to run (2 GB footprint)**

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**138 seconds to run (22 GB footprint)**

(single-threaded on a 2.2 GHz processor with a dataset 10 million times larger than the one shown)

# Extended example: histogram of intervals in Million Song Dataset

```
import awkward as ak, numpy as np

# read an 80 GB Parquet dataset as a lazy array (through pyarrow)
millionsongs = ak.from_parquet("s3://pivarski-princeton/millionsongs/", lazy=True)

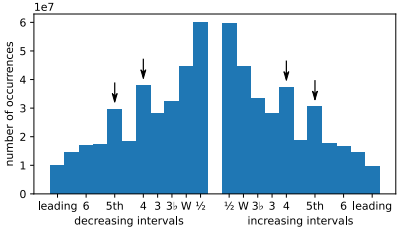
# volume of each half-step pitch (0-11) in each quarter-second segment of each song
pitches = millionsongs.analysis.segments.pitches
# <Array [[[0.294, 0.158, ... 0.083, 1, 0.078]]] type='1000000 * var * var * float64'>

# loudest pitch in each segment (axis=-1 applies to the deepest level of nesting)
loudest_pitches = ak.argmax(pitches, axis=-1)

# change in loudest-pitch from each segment to the next (list lengths vary with song)
intervals = loudest_pitches[:, 1:] - loudest_pitches[:, :-1]

# not including zero change (extremely variable)
nonzero_intervals = intervals[intervals != 0]

# histogram them
np.histogram(
    np.asarray(ak.flatten(nonzero_intervals)),
    bins=np.arange(-11.5, 12.5),
)
```



# Extended example: same thing in Numba (single pass)

```
import awkward as ak, numpy as np, numba as nb

@nb.jit                                          # Numba will JIT-compile this function
def collect_pitch_intervals(millionsongs):
    pitch_intervals = np.zeros(23, np.int64)     # histogram as an array to fill

    for song in millionsongs:                    # iteration over variable-length songs
        previous = None
        for segment in song.analysis.segments:
                                                 # cast as NumPy to use NumPy functions
            loudest_pitch = np.argmax(np.asarray(segment.pitches))

            if previous is not None:
                interval = loudest_pitch - previous
                if interval != 0:                # manually histogram non-zero changes
                    pitch_intervals[interval + 11] += 1

            previous = loudest_pitch             # remember previous for differences

    return pitch_intervals

millionsongs = ak.from_parquet("s3://pivarski-princeton/millionsongs/", lazy=True)
collect_pitch_intervals(millionsongs)            # run JIT-compiled function
```

# Actively extending beyond its original domain (particle physics)

**Variable-length, nested data is a common problem,** so Awkward Array is a general-purpose library for working with nested lists, records, and missing data.

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But scientists in other fields have revealed gaps in scope:

- Radio astronomers asked for complex numbers: #392, #421, #652, #857, #858
- Data scientists asked for date-times: #913, #911, #909, #835, #367
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... especially if it would lead to better integration with other scientific Python libraries and GPUs. (**Dask integration** and full **GPU support** are major parts of this project.)

# Documentation and contacts

**Install:** `pip install awkward` or
`conda install -c conda-forge awkward`

**Docs:** https://awkward-array.org

**GitHub:** https://github.com/scikit-hep/awkward-1.0

**Gitter:** https://gitter.im/Scikit-HEP/awkward-array

**Contact:** pivarski@princeton.edu

**Postdoc opportunity:** https://puwebp.princeton.edu/AcadHire/apply/application.xhtml?listingId=21021