

LECTURE 23

NUMPY II

MCS 275 Spring 2023

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LECTURE 23: NUMPY II

Reminders and announcements:

- **Project 3** due 6pm Friday 17 March.
- Project 3 autograder planned to open on Monday.

WHERE WE LEFT OFF

The `numpy` module is used for multidimensional typed arrays.

Vectors (1D arrays) and matrices (2D arrays) are the most frequently used.

Last time we explored ways to make arrays and access elements.

Let's continue working in the `numpy` introduction notebook.

MISSED LAST TIME

Demo of vector dot product.

Transpose of a matrix.

BOOL GOTCHA

```
np.array([5,0,1])==np.array([0,0,0])
```

evaluates to

```
np.array([False,True,False])
```

and numpy arrays *do not support boolean coercion* so this cannot appear in `if`.

To test if two arrays are equal, use one of:

```
np.all(A==B)  
np.array_equal(A,B)
```

UFUNCS

Numpy's "ufuncs" or **universal functions** are functions that can be applied directly to arrays, automatically acting on each element.

Numpy provides a *lot* of these. Some built-in Python operations work this way, too.

Usually, ufuncs allow you to avoid explicit iteration over array elements (which is much slower).

BROADCASTING

If an operation expects arrays of the same dimension, but different dimensions are given, numpy attempts to fix this by **broadcasting**—using duplication to extend an array to a higher dimension.

E.g. $A+1$ works when A is a numpy array. It adds 1 to each entry. But how?

Broadcasting first turns 1 into an array with the same shape as A where each entry is 1.

Details on the rules for broadcasting in [VanderPlas](#).

AGGREGATIONS

Numpy has operations like sum, product, max, min, all, any, that reduce array dimension.

MASKS

If A is an array and M is an array of `bool` of the same shape, then $A[M]$ refers to a 1D array that lists elements of A at positions where M is `True`.

Often used to test or modify elements of an array that meet certain criteria, e.g. $A[A > 5] = 5$.

REFERENCES

- *Python Data Science Handbook* by Jake VanderPlas
 - Chapter 2 contains the introduction to numpy.
 - There is also a print edition from O'Reilly.

REVISION HISTORY

- 2022-03-11 Last year's lecture on this topic finalized
- 2023-03-07 Updates for 2023

