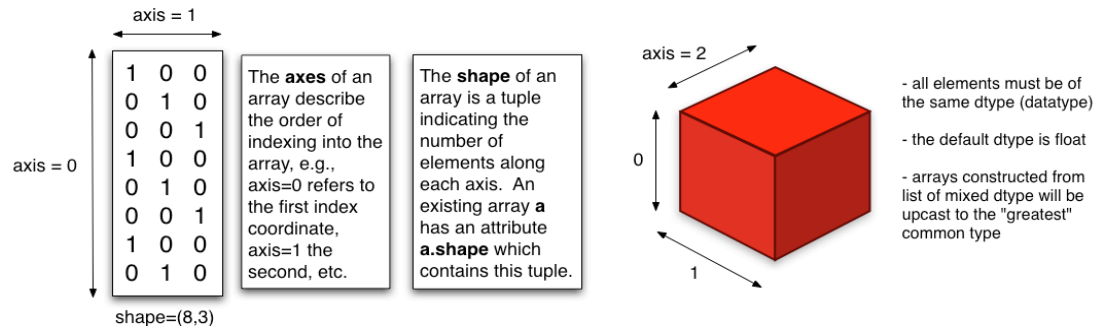


numpy/scipy array tip sheet

Arrays are the central datatype introduced in the NumPy and SciPy packages. (Technically, the objects are of type `ndarray`, presumably for "n-dimensional array".) The array interface is accessible either via `import numpy` or via `import scipy`. (The examples below all use the former.) Arrays are similar in some respects to Python lists, but are multidimensional, homogeneous in type, and support compact and efficient array-level manipulations. Documentation can be found online at www.scipy.org/Documentation, which also includes links to [NumPy Examples](#) (sample usage for many functions) and [NumPy for MATLAB Users](#), if you're so inclined.

Anatomy of an array



Constructing arrays

- `numpy.array(alist)`: construct an n-dimensional array from a Python list (all elements of list must be of same length)

```
a = numpy.array([[1,2,3],[4,5,6]])
b = numpy.array([i*i for i in range(100) if i%2==1])
c = b.tolist() # convert array back to Python list
```

- `numpy.zeros(shape, dtype=float)`: construct an n-dimensional array of the specified shape, filled with zeros of the specified dtype; e.g.,

```
a = numpy.zeros(100) # a 100-element array of float zeros
b = numpy.zeros((2,8), int) # a 2x8 array of int zeros
c = numpy.zeros((N,M,L), complex) # a NxMxL array of complex zeros
```

- `numpy.ones(shape, dtype=float)`: construct an n-dimensional array of the specified shape, filled with ones of the specified dtype; e.g.,

```
a = numpy.ones(10, int) # a 10-element array of int ones
b = numpy.pi * numpy.ones((5,5)) # a useful way to fill up an array with a specified value
```

- `numpy.eye(shape, dtype=float)`

```
id = numpy.eye(10,10, int) # 10x10 identity matrix (1's on diagonal)
offdiag = numpy.eye(10,10,1)+numpy.eye(10,10,-1) # off diagonal elements = 1
```

- `numpy.transpose(a)`

```
b = numpy.transpose(a) # reverse dimensions of a (even for dim > 2)
b = a.T # equivalent to numpy.transpose(a)
c = numpy.swapaxes(a, axis1, axis2) # swap specified axes
```

- `numpy.arange` and `numpy.linspace`

```
a = numpy.arange(start, stop, increment) # like Python range, but with (potentially) real-valued arrays
b = numpy.linspace(start, stop, num_elements) # create array of equally-spaced points based on specified number of points
```

- Random array constructors in `numpy.random`

```
a = numpy.random.random((100,100)) # 100x100 array of floats uniform on [0.,1.)
b = numpy.random.randint(0,10, (100,)) # 100 random ints uniform on [0, 10), i.e., not including the upper bound 10
c = numpy.random.standard_normal((5,5,5)) # zero-mean, unit-variance Gaussian random numbers in a 5x5x5 array
```

Indexing arrays

- Multidimensional indexing

```
elem = a[i,j,k] # equiv. to a[i][j][k] but presumably more efficient
```

- "Negative" indexing (wrap around the end of the array)

```
last_elem = a[-1]    # the last element of the array
```

- Arrays as indices

```
i = numpy.array([0,1,2,1])    # array of indices for the first axis
j = numpy.array([1,2,3,4])    # array of indices for the second axis
a[i,j]                        # return array([a[0,1], a[1,2], a[2,3], a[1,4]])
b = numpy.array([True, False, True, False])
a[b]                           # return array([a[0], a[2]]) since only b[0] and b[2] are True
```

Slicing arrays (extracting subsections)

- Slice a defined subblock:

```
section = a[10:20, 30:40]    # 10x10 subblock starting at [10,30]
```

- Grab everything up to the beginning/end of the array:

```
asection = a[10:, 30:]      # missing stop index implies until end of array
bsection = b[:10, :30]     # missing start index implies until start of array
```

- Grab an entire column(s)

```
x = a[:, 0]                # get everything in the 0th column (missing start and stop)
y = a[:, 1]                # get everything in the 1st column
```

- Slice off the tail end of an array

```
tail = a[-10:]            # grab the last 10 elements of the array
slab = b[:, -10:]        # grab a slab of width 10 off the "side" of the array
interior = c[1:-1, 1:-1, 1:-1] # slice out everything but the outer shell
```

Element-wise functions on arrays

- Arithmetic operations

```
c = a + b    # add a and b element-wise (must be same shape)
d = e * f    # multiply e and f element-wise (NOT matrix multiplication)
g = -h       # negate every element of h
y = (x+1)%2  # swap 0's and 1's in binary array x
z = w > 0.0  # return boolean array indicating which elements are > 0.0
logspace = 10.**numpy.linspace(-6.0, -1.0, 50) # 50 equally-spaced-in-log points between 1.e-06 and 1.0e-01
```

- Trigonometric operations

```
y = numpy.sin(x)                # sin of every element of x
w = numpy.sin([i*i for i in range(100) if i%2==1]) # conversion from list to array as part of function application
z = numpy.exp((0.+1.j) * theta) # exp(i * theta) where i = sqrt(-1) = 0.+1.j
```

Summation of arrays

- Simple sums

```
s = numpy.sum(a)                # sum all elements in a, returning a scalar
s0 = numpy.sum(a, axis=0)       # sum elements along specified axis (=0), returning an array of remaining shape, e.g.,
a = numpy.ones((10,20,30))     # s0 has shape (20,30)
s0 = numpy.sum(a, axis=0)
```

- Averaging, etc.

```
m = numpy.mean(a, axis)        # compute mean along the specified axis (over entire array if axis=None)
s = numpy.std(a, axis)         # compute standard deviation along the specified axis (over entire array if axis=None)
```

- Cumulative sums

```
s0 = numpy.cumsum(a, axis=0)    # cumulatively sum over 0 axis, returning array with same shape as a
s0 = numpy.cumsum(a)           # cumulatively sum over 0 axis, returning 1D array of length shape[0]*shape[1]*...*shape[dim-1]
```

Various other useful functions and methods (see [NumPy Examples at www.scipy.org/NumPy_Example_List_With_Doc](http://www.scipy.org/NumPy_Example_List_With_Doc))

Many of these work both as separate functions (`numpy.blah(a)`) as well as array methods (`a.blah()`).

- `numpy.any(a)`: return True if any element of a is True
- `numpy.all(a)`: return True if all elements of a are True

- `numpy.alltrue(a, axis)`: perform logical_and along given axis of a
- `numpy.append(a, values, axis)`: append values to a along specified axis
- `numpy.concatenate((a1, a2, ...), axis)`: concatenate tuple of arrays along specified axis
- `numpy.min(a, axis=None)`, `numpy.max(a, axis=None)`: get min/max values of a along specified axis (global min/max if axis=None)
- `numpy.argmin(a, axis=None)`, `numpy.argmax(a, axis=None)`: get indices of min/max of a along specified axis (global min/max if axis=None)
- `numpy.reshape(a, newshape)`: reshape a to newshape (must conserve total number of elements)
- `numpy.matrix(a)`: create matrix from 2D array a (matrices implement matrix multiplication rather than element-wise multiplication)
- `numpy.histogram`, `numpy.histogram2d`, `numpy.histogramdd`: 1-dimensional, 2-dimensional, and d-dimensional histograms, respectively
- `numpy.round(a, decimals=0)`: round elements of matrix a to specified number of decimals
- `numpy.sign(a)`: return array of same shape as a, with -1 where a < 0, 0 where a = 0, and +1 where a > 0
- `a.tofile(fid, sep="", format="%s")`: write a to specified file (fid), in either binary or ascii format depending on options
- `numpy.fromfile(file=, dtype=float, count=-1, sep='')`: read array from specified file (binary or ascii)
- `numpy.unique(a)`: return sorted unique elements of array a
- `numpy.where(condition, x, y)`: return array with same shape as condition, where values from x are inserted in positions where condition is True, and values from y where condition is False