

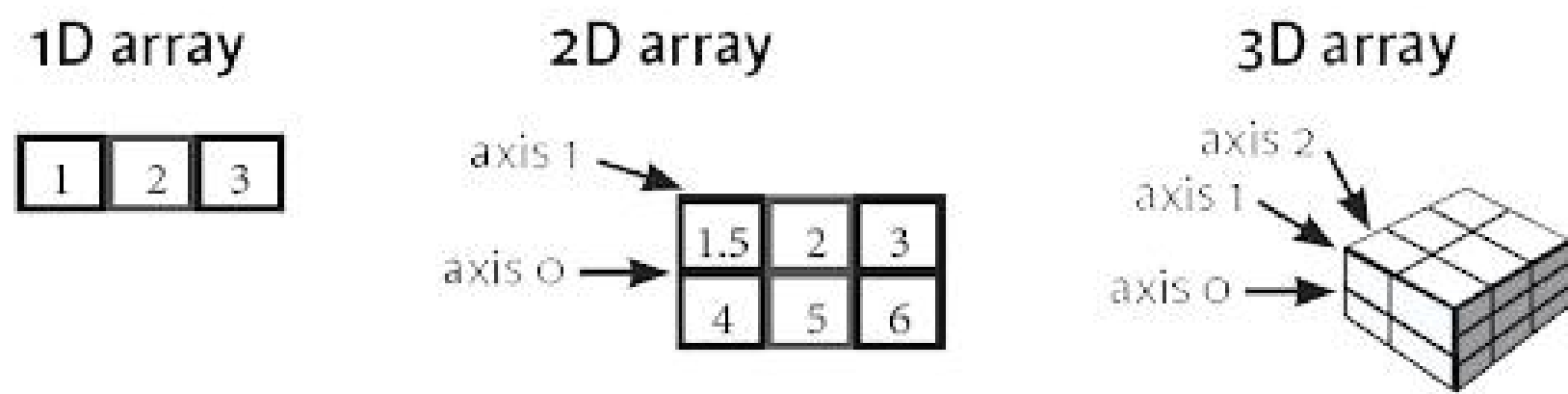
Numpy

The NumPy library is the core library for scientific computing in Python. It provides a high-performance multidimensional array object, and tools for working with these arrays

Use the following import convention:

```
>>> import numpy as np
```

NumPy Arrays



> Creating Arrays

```
>>> a = np.array([1,2,3])
>>> b = np.array([(1.5,2,3), (4,5,6)], dtype = float)
>>> c = np.array([(1.5,2,3), (4,5,6)],[(3,2,1), (4,5,6)]], dtype = float)
```

Initial Placeholders

```
>>> np.zeros((3,4)) #Create an array of zeros
>>> np.ones((2,3,4),dtype=np.int16) #Create an array of ones
>>> d = np.arange(10,25,5) #Create an array of evenly spaced values (step value)
>>> np.linspace(0,2,9) #Create an array of evenly spaced values (number of samples)
>>> e = np.full((2,2),7) #Create a constant array
>>> f = np.eye(2) #Create a 2X2 identity matrix
>>> np.random.random((2,2)) #Create an array with random values
>>> np.empty((3,2)) #Create an empty array
```

> I/O

Saving & Loading On Disk

```
>>> np.save('my_array', a)
>>> np savez('array.npz', a, b)
>>> np.load('my_array.npy')
```

Saving & Loading Text Files

```
>>> np.loadtxt("myfile.txt")
>>> np.genfromtxt("my_file.csv", delimiter=',')
>>> np.savetxt("myarray.txt", a, delimiter=" ")
```

> Asking For Help

```
>>> np.info(np.ndarray.dtype)
```

> Inspecting Your Array

```
>>> a.shape #Array dimensions
>>> len(a) #Length of array
>>> b.ndim #Number of array dimensions
>>> e.size #Number of array elements
>>> b.dtype #Data type of array elements
>>> b.dtype.name #Name of data type
>>> b.astype(int) #Convert an array to a different type
```

> Data Types

```
>>> np.int64 #Signed 64-bit integer types
>>> np.float32 #Standard double-precision floating point
>>> np.complex #Complex numbers represented by 128 floats
>>> np.bool #Boolean type storing TRUE and FALSE values
>>> np.object #Python object type
>>> np.string_ #Fixed-length string type
>>> np.unicode_ #Fixed-length unicode type
```

> Array Mathematics

Arithmetic Operations

```
>>> g = a - b #Subtraction
array([[ -0.5,  0. ,  0. ],
       [ -3. , -3. , -3. ]])
>>> np.subtract(a,b) #Subtraction
>>> b + a #Addition
array([[ 2.5,  4. ,  6. ],
       [ 5. ,  7. ,  9. ]])
>>> np.add(b,a) #Addition
>>> a / b #Division
array([[ 0.66666667,  1. ,  1. ],
       [ 0.25 ,  0.4 ,  0.5 ]])
>>> np.divide(a,b) #Division
>>> a * b #Multiplication
array([[ 1.5,  4. ,  9. ],
       [ 4. , 10. , 18. ]])
>>> np.multiply(a,b) #Multiplication
>>> np.exp(b) #Exponentiation
>>> np.sqrt(b) #Square root
>>> np.sin(a) #Print sines of an array
>>> np.cos(b) #Element-wise cosine
>>> np.log(a) #Element-wise natural logarithm
>>> e.dot(f) #Dot product
array([[ 7. ,  7. ],
       [ 7. ,  7.]])
```

Comparison

```
>>> a = b #Element-wise comparison
array([[False,  True,  True],
       [False, False, False]], dtype=bool)
>>> a < 2 #Element-wise comparison
array([[True, False, False], dtype=bool)
>>> np.array_equal(a, b) #Array-wise comparison
```

Aggregate Functions

```
>>> a.sum() #Array-wise sum
>>> a.min() #Array-wise minimum value
>>> b.max(axis=0) #Maximum value of an array row
>>> b.cumsum(axis=1) #Cumulative sum of the elements
>>> a.mean() #Mean
>>> np.median(b) #Median
>>> np.corrcoef(a) #Correlation coefficient
>>> np.std(b) #Standard deviation
```

> Copying Arrays

```
>>> h = a.view() #Create a view of the array with the same data
>>> np.copy(a) #Create a copy of the array
>>> h = a.copy() #Create a deep copy of the array
```

> Sorting Arrays

```
>>> a.sort() #Sort an array
>>> c.sort(axis=0) #Sort the elements of an array's axis
```

> Subsetting, Slicing, Indexing

Subsetting

```
>>> a[2] #Select the element at the 2nd index
3
>>> b[1,2] #Select the element at row 1 column 2 (equivalent to b[1][2])
6.0
```

1	2	3
1.5	2	3
4	5	6

Slicing

```
>>> a[0:2] #Select items at index 0 and 1
array([1, 2])
>>> b[0:2,1] #Select items at rows 0 and 1 in column 1
array([ 2. ,  5.])
>>> b[:1] #Select all items at row 0 (equivalent to b[0:1, :])
array([[1.5,  2. ,  3.]])
>>> c[1,...] #Same as [1,:,:)
array([[ 3. ,  2. ,  1. ],
       [ 4. ,  5. ,  6.]])
>>> a[ : :-1] #Reversed array a
array([3, 2, 1])
```

1	2	3
1.5	2	3
4	5	6
1.5	2	3
4	5	6

Boolean Indexing

```
>>> a[a<2] #Select elements from a less than 2
array([1])
```

1	2	3
---	---	---

Fancy Indexing

```
>>> b[[1, 0, 1, 0],[0, 1, 2, 0]] #Select elements (1,0),(0,1),(1,2) and (0,0)
array([ 4. ,  2. ,  6. ,  1.5])
>>> b[[1, 0, 1, 0]][:,[0,1,2,0]] #Select a subset of the matrix's rows and columns
array([[ 4. ,  5. ,  6. ,  4. ],
       [ 1.5,  2. ,  3. ,  1.5],
       [ 4. ,  5. ,  6. ,  4. ],
       [ 1.5,  2. ,  3. ,  1.5]])
```

> Array Manipulation

Transposing Array

```
>>> i = np.transpose(b) #Permute array dimensions
>>> i.T #Permute array dimensions
```

Changing Array Shape

```
>>> b.ravel() #Flatten the array
>>> g.reshape(3,-2) #Reshape, but don't change data
```

Adding/Removing Elements

```
>>> h.resize((2,6)) #Return a new array with shape (2,6)
>>> np.append(h,g) #Append items to an array
>>> np.insert(a, 1, 5) #Insert items in an array
>>> np.delete(a,[1]) #Delete items from an array
```

Combining Arrays

```
>>> np.concatenate((a,d),axis=0) #Concatenate arrays
array([ 1,  2,  3, 10, 15, 20])
>>> np.vstack((a,b)) #Stack arrays vertically (row-wise)
array([[ 1. ,  2. ,  3. ],
       [ 1.5,  2. ,  3. ],
       [ 4. ,  5. ,  6. ]])
>>> np.r_[e,f] #Stack arrays vertically (row-wise)
>>> np.hstack((e,f)) #Stack arrays horizontally (column-wise)
array([[ 7. ,  7. ,  1. ,  0. ],
       [ 7. ,  7. ,  0. ,  1.]])
>>> np.column_stack((a,d)) #Create stacked column-wise arrays
array([[ 1, 10],
       [ 2, 15],
       [ 3, 20]])
>>> np.c_[a,d] #Create stacked column-wise arrays
```

Splitting Arrays

```
>>> np.hsplit(a,3) #Split the array horizontally at the 3rd index
[array([1]),array([2]),array([3])]
>>> np.vsplit(c,2) #Split the array vertically at the 2nd index
[array([[ 1.5,  2. ,  1. ],
       [ 4. ,  5. ,  6. ]]),
array([[ 3. ,  2. ,  3. ],
       [ 4. ,  5. ,  6.]])]
```

