

What is NumPy?

NumPy is a Python library used for working with arrays.

It also has functions for working in domain of linear algebra, fourier transform, and matrices.

NumPy was created in 2005 by Travis Oliphant. It is an open source project and you can use it freely.

NumPy stands for Numerical Python.

Why Use NumPy?

In Python we have lists that serve the purpose of arrays, but they are slow to process.

NumPy aims to provide an array object that is up to 50x faster than traditional Python lists.

The array object in NumPy is called `ndarray`, it provides a lot of supporting functions that make working with `ndarray` very easy.

Arrays are very frequently used in data science, where speed and resources are very important.

Data Science: is a branch of computer science where we study how to store, use and analyze data for deriving information from it.

Why is NumPy Faster Than Lists?

NumPy arrays are stored at one continuous place in memory unlike lists, so processes can access and manipulate them very efficiently.

This behavior is called locality of reference in computer science.

This is the main reason why NumPy is faster than lists. Also it is optimized to work with latest CPU architectures.

Which Language is NumPy written in?

NumPy is a Python library and is written partially in Python, but most of the parts that require fast computation are written in C or C++.

Create a NumPy ndarray Object

NumPy is used to work with arrays. The array object in NumPy is called `ndarray`.

We can create a NumPy `ndarray` object by using the `array()` function.

Example

```
import numpy as np

arr = np.array([1, 2, 3, 4, 5])

print(arr)

print(type(arr))
```

type(): This built-in Python function tells us the type of the object passed to it. Like in above code it shows that `arr` is `numpy.ndarray` type.

To create an `ndarray`, we can pass a list, tuple or any array-like object into the `array()` method, and it will be converted into an `ndarray`:

Example

Use a tuple to create a NumPy array:

```
import numpy as np

arr = np.array((1, 2, 3, 4, 5))

print(arr)
```

Dimensions in Arrays

A dimension in arrays is one level of array depth (nested arrays).

nested array: are arrays that have arrays as their elements.

0-D Arrays

0-D arrays, or Scalars, are the elements in an array. Each value in an array is a 0-D array.

Example

Create a 0-D array with value 42

```
import numpy as np
```

```
arr = np.array(42)
```

```
print(arr)
```

1-D Arrays

An array that has 0-D arrays as its elements is called uni-dimensional or 1-D array.

These are the most common and basic arrays.

Example

Create a 1-D array containing the values 1,2,3,4,5:

```
import numpy as np
```

```
arr = np.array([1, 2, 3, 4, 5])
```

```
print(arr)
```

2-D Arrays

An array that has 1-D arrays as its elements is called a 2-D array.

These are often used to represent matrix or 2nd order tensors.

NumPy has a whole sub module dedicated towards matrix operations called `numpy.mat`

Example

Create a 2-D array containing two arrays with the values 1,2,3 and 4,5,6:

```
import numpy as np

arr = np.array([[1, 2, 3], [4, 5, 6]])

print(arr)
```

3-D arrays

An array that has 2-D arrays (matrices) as its elements is called 3-D array.

These are often used to represent a 3rd order tensor.

Example

Create a 3-D array with two 2-D arrays, both containing two arrays with the values 1,2,3 and 4,5,6:

```
import numpy as np

arr = np.array([[[1, 2, 3], [4, 5, 6]], [[1, 2, 3], [4, 5, 6]]])

print(arr)
```

Check Number of Dimensions?

NumPy Arrays provides the `ndim` attribute that returns an integer that tells us how many dimensions the array have.

Example

Check how many dimensions the arrays have:

```
import numpy as np

a = np.array(42)
b = np.array([1, 2, 3, 4, 5])
c = np.array([[1, 2, 3], [4, 5, 6]])
d = np.array([[[1, 2, 3], [4, 5, 6]], [[1, 2, 3], [4, 5, 6]]])

print(a.ndim)
print(b.ndim)
print(c.ndim)
print(d.ndim)
```

Higher Dimensional Arrays

An array can have any number of dimensions.

When the array is created, you can define the number of dimensions by using the `ndmin` argument.

Example

Create an array with 5 dimensions and verify that it has 5 dimensions:

```
import numpy as np

arr = np.array([1, 2, 3, 4], ndmin=5)

print(arr)
print('number of dimensions :', arr.ndim)
```

In this array the innermost dimension (5th dim) has 4 elements, the 4th dim has 1 element that is the vector, the 3rd dim has 1 element that is the matrix with the vector, the 2nd dim has 1 element that is 3D array and 1st dim has 1 element that is a 4D array.

NumPy Array Indexing

Access Array Elements

Array indexing is the same as accessing an array element.

You can access an array element by referring to its index number.

The indexes in NumPy arrays start with 0, meaning that the first element has index 0, and the second has index 1 etc.

Example

Get the first element from the following array:

```
import numpy as np

arr = np.array([1, 2, 3, 4])

print(arr[0])
```

Example

Get the second element from the following array.

```
import numpy as np

arr = np.array([1, 2, 3, 4])

print(arr[1])
```

Example

Get third and fourth elements from the following array and add them.

```
import numpy as np

arr = np.array([1, 2, 3, 4])

print(arr[2] + arr[3])
```

Access 2-D Arrays

To access elements from 2-D arrays we can use comma separated integers representing the dimension and the index of the element.

Think of 2-D arrays like a table with rows and columns, where the dimension represents the row and the index represents the column.

Example

Access the element on the first row, second column:

```
import numpy as np

arr = np.array([[1,2,3,4,5], [6,7,8,9,10]])

print('2nd element on 1st row: ', arr[0, 1])
```

Example

Access the element on the 2nd row, 5th column:

```
import numpy as np

arr = np.array([[1,2,3,4,5], [6,7,8,9,10]])

print('5th element on 2nd row: ', arr[1, 4])
```

Access 3-D Arrays

To access elements from 3-D arrays we can use comma separated integers representing the dimensions and the index of the element.

Example

Access the third element of the second array of the first array:

```
import numpy as np
```

```
arr = np.array([[1, 2, 3], [4, 5, 6]], [[7, 8, 9], [10, 11, 12]])  
  
print(arr[0, 1, 2])
```

Example Explained

`arr[0, 1, 2]` prints the value 6.

And this is why:

The first number represents the first dimension, which contains two arrays:
[[1, 2, 3], [4, 5, 6]]
and:
[[7, 8, 9], [10, 11, 12]]
Since we selected 0, we are left with the first array:
[[1, 2, 3], [4, 5, 6]]

The second number represents the second dimension, which also contains two arrays:
[1, 2, 3]
and:
[4, 5, 6]
Since we selected 1, we are left with the second array:
[4, 5, 6]

The third number represents the third dimension, which contains three values:
4
5
6
Since we selected 2, we end up with the third value:
6

Negative Indexing

Use negative indexing to access an array from the end.

Example

Print the last element from the 2nd dim:

```
import numpy as np
```



```
arr = np.array([[1,2,3,4,5], [6,7,8,9,10]])  
  
print('Last element from 2nd dim: ', arr[1, -1])
```

NumPy Array Slicing

Slicing arrays

Slicing in python means taking elements from one given index to another given index.

We pass slice instead of index like this: `[start:end]`.

We can also define the step, like this: `[start:end:step]`.

If we don't pass start its considered 0

If we don't pass end its considered length of array in that dimension

If we don't pass step its considered 1

Example

Slice elements from index 1 to index 5 from the following array:

```
import numpy as np  
  
arr = np.array([1, 2, 3, 4, 5, 6, 7])  
  
print(arr[1:5])
```

Note: The result *includes* the start index, but *excludes* the end index.

Example

Slice elements from index 4 to the end of the array:

```
import numpy as np  
  
arr = np.array([1, 2, 3, 4, 5, 6, 7])  
  
print(arr[4:])
```

Example

Slice elements from the beginning to index 4 (not included):

```
import numpy as np

arr = np.array([1, 2, 3, 4, 5, 6, 7])

print(arr[:4])
```

Negative Slicing

Use the minus operator to refer to an index from the end:

Example

Slice from the index 3 from the end to index 1 from the end:

```
import numpy as np

arr = np.array([1, 2, 3, 4, 5, 6, 7])

print(arr[-3:-1])
```

STEP

Use the **step** value to determine the step of the slicing:

Example

Return every other element from index 1 to index 5:

```
import numpy as np

arr = np.array([1, 2, 3, 4, 5, 6, 7])
```

```
print(arr[1:5:2])
```

Example

Return every other element from the entire array:

```
import numpy as np

arr = np.array([1, 2, 3, 4, 5, 6, 7])

print(arr[::2])
```

Slicing 2-D Arrays

Example

From the second element, slice elements from index 1 to index 4 (not included):

```
import numpy as np

arr = np.array([[1, 2, 3, 4, 5], [6, 7, 8, 9, 10]])

print(arr[1, 1:4])
```

Note: Remember that *second element* has index 1.

Example

From both elements, return index 2:

```
import numpy as np

arr = np.array([[1, 2, 3, 4, 5], [6, 7, 8, 9, 10]])

print(arr[0:2, 2])
```

Example

From both elements, slice index 1 to index 4 (not included), this will return a 2-D array:

```
import numpy as np
```

```
arr = np.array([[1, 2, 3, 4, 5], [6, 7, 8, 9, 10]])  
  
print(arr[0:2, 1:4])
```

NumPy Array Shape

Shape of an Array

The shape of an array is the number of elements in each dimension.

Get the Shape of an Array

NumPy arrays have an attribute called `shape` that returns a tuple with each index having the number of corresponding elements.

Example

Print the shape of a 2-D array:

```
import numpy as np  
  
arr = np.array([[1, 2, 3, 4], [5, 6, 7, 8]])  
  
print(arr.shape)
```

The example above returns `(2, 4)`, which means that the array has 2 dimensions, where the first dimension has 2 elements and the second has 4.

Example

Create an array with 5 dimensions using `ndmin` using a vector with values 1,2,3,4 and verify that last dimension has value 4:

```
import numpy as np  
  
arr = np.array([1, 2, 3, 4], ndmin=5)
```

```
print(arr)
print('shape of array :', arr.shape)
```

What does the shape tuple represent?

Integers at every index tells about the number of elements the corresponding dimension has.

In the example above at index-4 we have value 4, so we can say that 5th (4 + 1 th) dimension has 4 elements.

NumPy Array Reshaping

Reshaping arrays

Reshaping means changing the shape of an array.

The shape of an array is the number of elements in each dimension.

By reshaping we can add or remove dimensions or change number of elements in each dimension.

Reshape From 1-D to 2-D

Example

Convert the following 1-D array with 12 elements into a 2-D array.

The outermost dimension will have 4 arrays, each with 3 elements:

```
import numpy as np

arr = np.array([1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12])

newarr = arr.reshape(4, 3)

print(newarr)
```

Reshape From 1-D to 3-D

Example

Convert the following 1-D array with 12 elements into a 3-D array.

The outermost dimension will have 2 arrays that contains 3 arrays, each with 2 elements:

```
import numpy as np

arr = np.array([1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12])

newarr = arr.reshape(2, 3, 2)

print(newarr)
```

Can We Reshape Into any Shape?

Yes, as long as the elements required for reshaping are equal in both shapes.

We can reshape an 8 elements 1D array into 4 elements in 2 rows 2D array but we cannot reshape it into a 3 elements 3 rows 2D array as that would require $3 \times 3 = 9$ elements.

Example

Try converting 1D array with 8 elements to a 2D array with 3 elements in each dimension (will raise an error):

```
import numpy as np

arr = np.array([1, 2, 3, 4, 5, 6, 7, 8])

newarr = arr.reshape(3, 3)

print(newarr)
```

Returns Copy or View?

Example

Check if the returned array is a copy or a view:

```
import numpy as np

arr = np.array([1, 2, 3, 4, 5, 6, 7, 8])

print(arr.reshape(2, 4).base)
```

The example above returns the original array, so it is a view.

Unknown Dimension

You are allowed to have one "unknown" dimension.

Meaning that you do not have to specify an exact number for one of the dimensions in the reshape method.

Pass `-1` as the value, and NumPy will calculate this number for you.

Example

Convert 1D array with 8 elements to 3D array with 2x2 elements:

```
import numpy as np

arr = np.array([1, 2, 3, 4, 5, 6, 7, 8])

newarr = arr.reshape(2, 2, -1)

print(newarr)
```

Note: We can not pass `-1` to more than one dimension.

Flattening the arrays

Flattening array means converting a multidimensional array into a 1D array.

We can use `reshape(-1)` to do this.

Example

Convert the array into a 1D array:

```
import numpy as np

arr = np.array([[1, 2, 3], [4, 5, 6]])

newarr = arr.reshape(-1)

print(newarr)
```

Note: There are a lot of functions for changing the shapes of arrays in numpy `flatten`, `ravel` and also for rearranging the elements `rot90`, `flip`, `fliplr`, `flipud` etc. These fall under Intermediate to Advanced section of numpy.

NumPy Array Iterating

Iterating Arrays

Iterating means going through elements one by one.

As we deal with multi-dimensional arrays in numpy, we can do this using basic `for` loop of python.

If we iterate on a 1-D array it will go through each element one by one.

Example

Iterate on the elements of the following 1-D array:

```
import numpy as np

arr = np.array([1, 2, 3])

for x in arr:
    print(x)
```


Iterating 2-D Arrays

In a 2-D array it will go through all the rows.

Example

Iterate on the elements of the following 2-D array:

```
import numpy as np

arr = np.array([[1, 2, 3], [4, 5, 6]])

for x in arr:
    print(x)
```

If we iterate on a n -D array it will go through $n-1$ th dimension one by one.

To return the actual values, the scalars, we have to iterate the arrays in each dimension.

Example

Iterate on each scalar element of the 2-D array:

```
import numpy as np

arr = np.array([[1, 2, 3], [4, 5, 6]])

for x in arr:
    for y in x:
        print(y)
```

Iterating 3-D Arrays

In a 3-D array it will go through all the 2-D arrays.

Example

Iterate on the elements of the following 3-D array:

```
import numpy as np

arr = np.array([[[1, 2, 3], [4, 5, 6]], [[7, 8, 9], [10, 11, 12]]])

for x in arr:
    print(x)
```

To return the actual values, the scalars, we have to iterate the arrays in each dimension.

Example

Iterate down to the scalars:

```
import numpy as np

arr = np.array([[[1, 2, 3], [4, 5, 6]], [[7, 8, 9], [10, 11, 12]]])

for x in arr:
    for y in x:
        for z in y:
            print(z)
```

Iterating Arrays Using nditer()

The function `nditer()` is a helping function that can be used from very basic to very advanced iterations. It solves some basic issues which we face in iteration, let's go through it with examples.

Iterating on Each Scalar Element

In basic `for` loops, iterating through each scalar of an array we need to use n `for` loops which can be difficult to write for arrays with very high dimensionality.

Example

Iterate through the following 3-D array:

```
import numpy as np

arr = np.array([[[1, 2], [3, 4]], [[5, 6], [7, 8]]])

for x in np.nditer(arr):
    print(x)
```

Iterating Array With Different Data Types

We can use `op_dtypes` argument and pass it the expected datatype to change the datatype of elements while iterating.

NumPy does not change the data type of the element in-place (where the element is in array) so it needs some other space to perform this action, that extra space is called buffer, and in order to enable it in `nditer()` we pass `flags=['buffered']`.

Example

Iterate through the array as a string:

```
import numpy as np

arr = np.array([1, 2, 3])

for x in np.nditer(arr, flags=['buffered'], op_dtypes=['S']):
    print(x)
```

Iterating With Different Step Size

We can use filtering and followed by iteration.

Example

Iterate through every scalar element of the 2D array skipping 1 element:

```
import numpy as np

arr = np.array([[1, 2, 3, 4], [5, 6, 7, 8]])

for x in np.nditer(arr[:, ::2]):
    print(x)
```

Enumerated Iteration Using ndenumerate()

Enumeration means mentioning sequence number of somethings one by one.

Sometimes we require corresponding index of the element while iterating, the `ndenumerate()` method can be used for those usecases.

Example

Enumerate on following 1D arrays elements:

```
import numpy as np

arr = np.array([1, 2, 3])

for idx, x in np.ndenumerate(arr):
    print(idx, x)
```

Example

Enumerate on following 2D array's elements:

```
import numpy as np

arr = np.array([[1, 2, 3, 4], [5, 6, 7, 8]])

for idx, x in np.ndenumerate(arr):
    print(idx, x)
```

NumPy Joining Array

Joining NumPy Arrays

Joining means putting contents of two or more arrays in a single array.

In SQL we join tables based on a key, whereas in NumPy we join arrays by axes.

We pass a sequence of arrays that we want to join to the `concatenate()` function, along with the axis. If axis is not explicitly passed, it is taken as 0.

Example

Join two arrays

```
import numpy as np

arr1 = np.array([1, 2, 3])
arr2 = np.array([4, 5, 6])

arr = np.concatenate((arr1, arr2))

print(arr)
```

Example

Join two 2-D arrays along rows (axis=1):

```
import numpy as np

arr1 = np.array([[1, 2], [3, 4]])
arr2 = np.array([[5, 6], [7, 8]])

arr = np.concatenate((arr1, arr2), axis=1)

print(arr)
```

Joining Arrays Using Stack Functions

Stacking is same as concatenation, the only difference is that stacking is done along a new axis.

We can concatenate two 1-D arrays along the second axis which would result in putting them one over the other, ie. stacking.

We pass a sequence of arrays that we want to join to the `stack()` method along with the axis. If axis is not explicitly passed it is taken as 0.

Example

```
import numpy as np

arr1 = np.array([1, 2, 3])

arr2 = np.array([4, 5, 6])

arr = np.stack((arr1, arr2), axis=1)

print(arr)
```

Stacking Along Rows

NumPy provides a helper function: `hstack()` to stack along rows.

Example

```
import numpy as np

arr1 = np.array([1, 2, 3])

arr2 = np.array([4, 5, 6])

arr = np.hstack((arr1, arr2))

print(arr)
```

Stacking Along Columns

NumPy provides a helper function: `vstack()` to stack along columns.

Example

```
import numpy as np

arr1 = np.array([1, 2, 3])
arr2 = np.array([4, 5, 6])
arr = np.vstack((arr1, arr2))

print(arr)
```

Stacking Along Height (depth)

NumPy provides a helper function: `dstack()` to stack along height, which is the same as depth.

Example

```
import numpy as np

arr1 = np.array([1, 2, 3])
arr2 = np.array([4, 5, 6])
arr = np.dstack((arr1, arr2))

print(arr)
```

NumPy Splitting Array

Splitting NumPy Arrays

Splitting is reverse operation of Joining.

Joining merges multiple arrays into one and Splitting breaks one array into multiple.

We use `array_split()` for splitting arrays, we pass it the array we want to split and the number of splits.

Example

Split the array in 3 parts:

```
import numpy as np

arr = np.array([1, 2, 3, 4, 5, 6])

newarr = np.array_split(arr, 3)

print(newarr)
```

Note: The return value is a list containing three arrays.

If the array has less elements than required, it will adjust from the end accordingly.

Example

Split the array in 4 parts:

```
import numpy as np

arr = np.array([1, 2, 3, 4, 5, 6])

newarr = np.array_split(arr, 4)

print(newarr)
```


Note: We also have the method `split()` available but it will not adjust the elements when elements are less in source array for splitting like in example above, `array_split()` worked properly but `split()` would fail.

Split Into Arrays

The return value of the `array_split()` method is an array containing each of the split as an array.

If you split an array into 3 arrays, you can access them from the result just like any array element:

Example

Access the splitted arrays:

```
import numpy as np

arr = np.array([1, 2, 3, 4, 5, 6])

newarr = np.array_split(arr, 3)

print(newarr[0])
print(newarr[1])
print(newarr[2])
```

Splitting 2-D Arrays

Use the same syntax when splitting 2-D arrays.

Use the `array_split()` method, pass in the array you want to split and the number of splits you want to do.

Example

Split the 2-D array into three 2-D arrays.

```
import numpy as np

arr = np.array([[1, 2], [3, 4], [5, 6], [7, 8], [9, 10], [11, 12]])

newarr = np.array_split(arr, 3)

print(newarr)
```

The example above returns three 2-D arrays.

Let's look at another example, this time each element in the 2-D arrays contains 3 elements.

Example

Split the 2-D array into three 2-D arrays.

```
import numpy as np

arr = np.array([[1, 2, 3], [4, 5, 6], [7, 8, 9], [10, 11, 12],
               [13, 14, 15], [16, 17, 18]])

newarr = np.array_split(arr, 3)

print(newarr)
```

The example above returns three 2-D arrays.

In addition, you can specify which axis you want to do the split around.

The example below also returns three 2-D arrays, but they are split along the row (axis=1).

Example

Split the 2-D array into three 2-D arrays along rows.

```
import numpy as np

arr = np.array([[1, 2, 3], [4, 5, 6], [7, 8, 9], [10, 11, 12],
               [13, 14, 15], [16, 17, 18]])

newarr = np.array_split(arr, 3, axis=1)
```

```
print(newarr)
```

An alternate solution is using `hsplit()` opposite of `hstack()`

Example

Use the `hsplit()` method to split the 2-D array into three 2-D arrays along rows.

```
import numpy as np

arr = np.array([[1, 2, 3], [4, 5, 6], [7, 8, 9], [10, 11, 12],
               [13, 14, 15], [16, 17, 18]])

newarr = np.hsplit(arr, 3)

print(newarr)
```

Note: Similar alternates to `vstack()` and `dstack()` are available as `vsplit()` and `dsplit()`.

NumPy Searching Arrays

Searching Arrays

You can search an array for a certain value, and return the indexes that get a match.

To search an array, use the `where()` method.

Example

Find the indexes where the value is 4:

```
import numpy as np

arr = np.array([1, 2, 3, 4, 5, 4, 4])

x = np.where(arr == 4)
```

```
print(x)
```

The example above will return a tuple: `(array([3, 5, 6]),)`

Which means that the value 4 is present at index 3, 5, and 6.

Example

Find the indexes where the values are even:

```
import numpy as np

arr = np.array([1, 2, 3, 4, 5, 6, 7, 8])

x = np.where(arr%2 == 0)

print(x)
```

Example

Find the indexes where the values are odd:

```
import numpy as np

arr = np.array([1, 2, 3, 4, 5, 6, 7, 8])

x = np.where(arr%2 == 1)

print(x)
```

Search Sorted

There is a method called `searchsorted()` which performs a binary search in the array, and returns the index where the specified value would be inserted to maintain the search order.

The `searchsorted()` method is assumed to be used on sorted arrays.

Example

Find the indexes where the value 7 should be inserted:

```
import numpy as np

arr = np.array([6, 7, 8, 9])

x = np.searchsorted(arr, 7)

print(x)
```

Example explained: The number 7 should be inserted on index 1 to remain the sort order.

The method starts the search from the left and returns the first index where the number 7 is no longer larger than the next value.

Search From the Right Side

By default the left most index is returned, but we can give `side='right'` to return the right most index instead.

Example

Find the indexes where the value 7 should be inserted, starting from the right:

```
import numpy as np

arr = np.array([6, 7, 8, 9])

x = np.searchsorted(arr, 7, side='right')

print(x)
```

Example explained: The number 7 should be inserted on index 2 to remain the sort order.

The method starts the search from the right and returns the first index where the number 7 is no longer less than the next value.

Multiple Values

To search for more than one value, use an array with the specified values.

Example

Find the indexes where the values 2, 4, and 6 should be inserted:

```
import numpy as np

arr = np.array([1, 3, 5, 7])

x = np.searchsorted(arr, [2, 4, 6])

print(x)
```

The return value is an array: `[1 2 3]` containing the three indexes where 2, 4, 6 would be inserted in the original array to maintain the order.

NumPy Sorting Arrays

Sorting Arrays

Sorting means putting elements in an *ordered sequence*.

Ordered sequence is any sequence that has an order corresponding to elements, like numeric or alphabetical, ascending or descending.

The NumPy ndarray object has a function called `sort()`, that will sort a specified array.

Example

Sort the array:

```
import numpy as np

arr = np.array([3, 2, 0, 1])

print(np.sort(arr))
```

Note: This method returns a copy of the array, leaving the original array unchanged.

You can also sort arrays of strings, or any other data type:

Example

Sort the array alphabetically:

```
import numpy as np

arr = np.array(['banana', 'cherry', 'apple'])

print(np.sort(arr))
```

Example

Sort a boolean array:

```
import numpy as np

arr = np.array([True, False, True])

print(np.sort(arr))
```

Sorting a 2-D Array

If you use the `sort()` method on a 2-D array, both arrays will be sorted:

Example

Sort a 2-D array:

```
import numpy as np

arr = np.array([[3, 2, 4], [5, 0, 1]])

print(np.sort(arr))
```

NumPy Filter Array

Filtering Arrays

Getting some elements out of an existing array and creating a new array out of them is called *filtering*.

In NumPy, you filter an array using a *boolean index list*.

A *boolean index list* is a list of booleans corresponding to indexes in the array.

If the value at an index is `True` that element is contained in the filtered array, if the value at that index is `False` that element is excluded from the filtered array.

Example

Create an array from the elements on index 0 and 2:

```
import numpy as np

arr = np.array([41, 42, 43, 44])

x = [True, False, True, False]

newarr = arr[x]

print(newarr)
```

The example above will return `[41, 43]`, why?

Because the new array contains only the values where the filter array had the value `True`, in this case, index 0 and 2.

Creating the Filter Array

In the example above we hard-coded the `True` and `False` values, but the common use is to create a filter array based on conditions.

Example

Create a filter array that will return only values higher than 42:

```
import numpy as np

arr = np.array([41, 42, 43, 44])

# Create an empty list
filter_arr = []

# go through each element in arr
for element in arr:
    # if the element is higher than 42, set the value to True, otherwise
    False:
    if element > 42:
        filter_arr.append(True)
    else:
        filter_arr.append(False)

newarr = arr[filter_arr]

print(filter_arr)
print(newarr)
```

Example

Create a filter array that will return only even elements from the original array:

```
import numpy as np

arr = np.array([1, 2, 3, 4, 5, 6, 7])

# Create an empty list
filter_arr = []

# go through each element in arr
for element in arr:
    # if the element is completely divisible by 2, set the value to True,
    otherwise False
```

```
if element % 2 == 0:
    filter_arr.append(True)
else:
    filter_arr.append(False)

newarr = arr[filter_arr]

print(filter_arr)
print(newarr)
```

Creating Filter Directly From Array

The above example is quite a common task in NumPy and NumPy provides a nice way to tackle it.

We can directly substitute the array instead of the iterable variable in our condition and it will work just as we expect it to.

Example

Create a filter array that will return only values higher than 42:

```
import numpy as np

arr = np.array([41, 42, 43, 44])

filter_arr = arr > 42

newarr = arr[filter_arr]

print(filter_arr)
print(newarr)
```

Example

Create a filter array that will return only even elements from the original array:

```
import numpy as np

arr = np.array([1, 2, 3, 4, 5, 6, 7])

filter_arr = arr % 2 == 0
```

```
newarr = arr[filter_arr]
```

```
print(filter_arr)
```

```
print(newarr)
```

