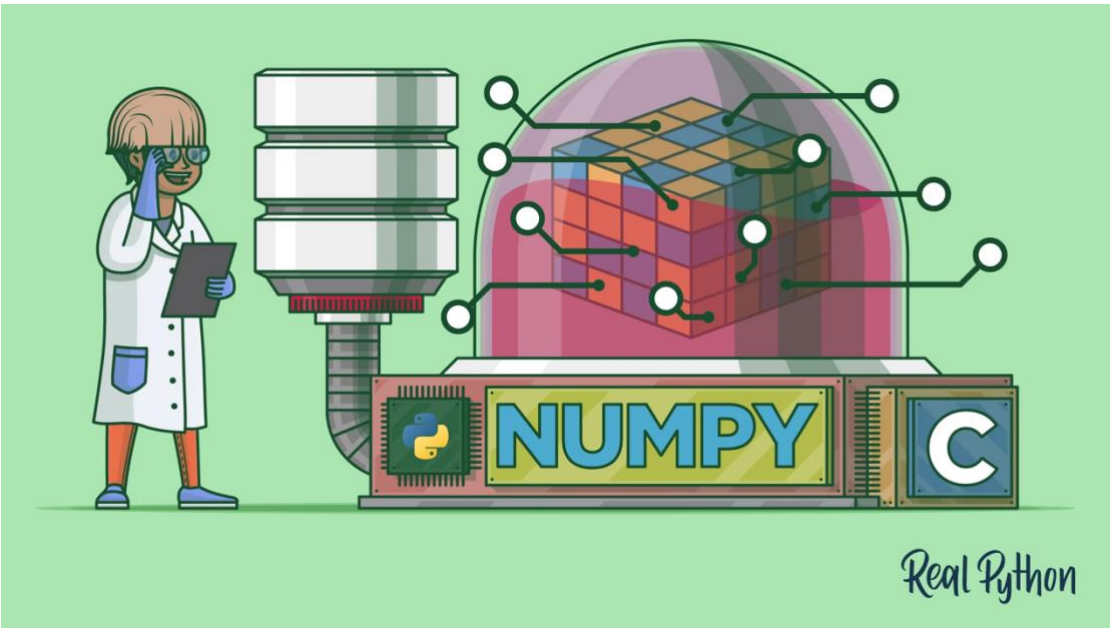
NUMPY

For Machine learning



Sadia Khatun

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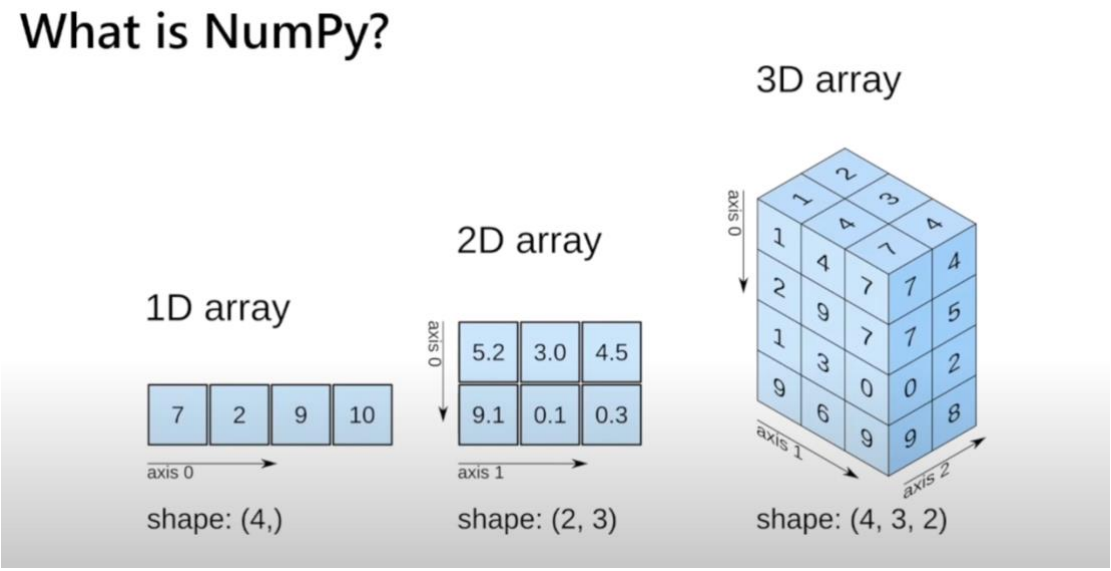
Best Wishes !!

CHAPTER 1: NUMPY FOR BEGINNERS

1.1 Introduction

What is NumPy?
NumPy is a multi-dimensional array library.



Why use NumPy over list?
How are Lists different from NumPy?

Lists	NumPy
Slow Insertion, deletion, appending, concatenation, etc. **a = [1,3,5]** **b = [1,2,3]** **a*b = ERROR**	Fast Insertion, deletion, appending, concatenation, etc. Lots More ..!! **a =np.array([1,3,5])** **b = np.array([1,2,3])** **a*b = np.array([1,6,15])**

Why Is NumPy Faster? –Fixed Type

1. Faster to read less bytes of memory.
2. No type checking when iterating through objects.

3	1	4
5	7	9
3	4	6

3x3 matrix

Let's see how this integer values differ between Numpy and Lists . Let's Just zoom in on that's 5 there in that matrix. Our computer don't see 5 they see binary that represents that's 5.

Int32/int8/int16

Binary NumPy 00000000 00000000 00000000 00000101

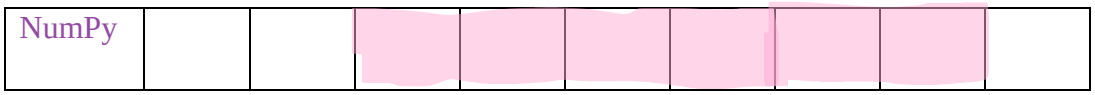
5 → 00000101

List is buit in int type
Consist of

Size -00000000 00000000 00000000 0000010
References – 8 bytes
Object Type -8 bytes.
Object Value –8 bytes

So lists require lots more space than NumPy.

Why Is NumPy Faster? –Contiguous Memory



1.SIMD Vector Processing
2.Effective Cache Utilization

Applications of NumPy?
1. Mathematics (MATLAB Replacement)
2. Plotting (Matplotlib)
3. Backend (Pandas Connect 4, Digital Photography)
4. Machine Learning

1.2 The Basics (creating arrays, shape, size, data type)

```
import numpy as np
```

creating array:

```
[9]   1 a=np.array([1,2,3],dtype='int32')
      2 print(a)

     [1 2 3]
```

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

[[1 2 3]
 [1 3 4]
 [3 4 5]]
```

Basic Operation:

Get dimension	*X.NDIM*
Get shape	*x.shape*
Get data type	*x.dtype*
Get each item size in bytes	*x.itemsize*
Get total size in bytes	*x.nbytes*
Get number of elements in array	*x.size*

```
1 c=np.array([[1,2],[3,4],[5,6]],dtype='int8')
2 print(c)
3 print(c.shape)
4 print(c.dtype)
5 print(c.ndim)
```

```
[[1 2]
 [3 4]
 [5 6]]
(3, 2)
int8
2
```

```
[20] 1 b=np.array([[1,2,3],[1,3,4],[3,4,5]])
     2 print(b)
```

```
[[1 2 3]
 [1 3 4]
 [3 4 5]]
```

```
[18] 1 # size of each elements in byte as we define 64 bit so its give 8 bytes
     2 b.itemsize
```

```
8
```

```
[19] 1 b.dtype
```

```
dtype('int64')
```

```
[17] 1 # total size
     2 b.nbytes # 8bytes * 9 elements
```

```
72
```

```
1 b.size #number of element
```

```
9
```

1.3 Accessing/changing Specific Elements, Row, Columns, etc(slicing)

3. Accessing/changing Specific Elements, Row, Columns, etc(slicing)

index starting from (0) so if we say 1st row means (0) index value

> Indented block

```
[24]  1 a=np.array([[1,2,3,4,5,6,7],[8,9,10,11,12,13,14]])
      2 print(a)
      3 print(a.shape)
```

```
[[ 1  2  3  4  5  6  7]
 [ 8  9 10 11 12 13 14]]
(2, 7)
```

```
[25]  1 #Get a spacific element x[r,c], if we want 5 from this matrix
      2 a[0,4]
      3
```

```
5
```

```
[26]  1 # #Get a spacific element x[r,c], if we want 5 from this matrix
      2 #but using negetive index
      3
      4 a[0,-3]
```

```
5
```

```
      1 #Get a spacific row , we want 2nd row ,a[2nd row, every element of col (:)]
      2
      3 a[1, :]
```

```
array([ 8,  9, 10, 11, 12, 13, 14])
```

```
[28]  1 #Get a spacific column ,we want 3rd column
      2
      3 a[:, 2]
```

```
array([ 3, 10])
```

```
[29]  1 #Geting a little more fancy [startindex:endindex: stepsize]
      2 # we want 2 , 4 , 6 element from 1st row
      3 #endindex  not will be  include
      4
      5 a[0,1:6:2]
```

```
array([2, 4, 6])
```

```
[31]  1 #Geting a little more fancy [startindex:endindex: stepsize]
      2 # we want 2 , 4 , 6 element from 1st row
      3 #endindex  not will be  include
      4 #use negetive index
      5 a[0, 1:-1:2]
```

```
array([2, 4, 6])
```

```
[32]  1 a=np.array([[1,2,3,4,5,6,7],[8,9,10,11,12,13,14]])
      2 print(a)
      3 print(a.shape)
```

```
[[ 1  2  3  4  5  6  7]
 [ 8  9 10 11 12 13 14]]
(2, 7)
```

```
[33]  1 #change element in matrix
      2 # we want to replace 7 value with 20
      3 # its 1st row and 7th col
      4
      5 a[0,6]=20
      6 print(a)
```

```
[[ 1  2  3  4  5  6 20]
 [ 8  9 10 11 12 13 14]]
```

```
[34]  1 #change element in matrix
      2 # we want replace 4th column by 7
      3
      4 a[:,3]=7
      5 print(a)
```

```
[[ 1  2  3  7  5  6 20]
 [ 8  9 10  7 12 13 14]]
```

```
[47]  1 # create 3x3x3 matrix
      2
      3 c=np.array([[[1,2,3],[3,2,3],[9,2,0]],[[1,3,3],[1,8,3],[1,2,3]],[[1,5,3],[1,5,3],[1,0,3]]])
      4 print(c)
```

```
[[[1 2 3]
  [3 2 3]
  [9 2 0]]

 [[1 3 3]
  [1 8 3]
  [1 2 3]]

 [[1 5 3]
  [1 5 3]
  [1 0 3]]]
```

```
[48]  1 # Get [9,2,0]
      2 c[0,2,:]
      3
```

```
array([9, 2, 0])
```

```
[43]  1 #get just 9
      2
      3 c[0,2,0]
```

```
9
```

```
[51]  1 #get last value from each matrix
      2
      3 c[:,2,2]
```

```
array([0, 3, 3])
```

```
[61]  1 #replace
      2 c[:,1,:]
```

```
array([[3, 2, 3],
       [1, 8, 3],
       [1, 5, 3]])
```

```
[35]  1 #change element in matrix
      2 # we want replace 4th column by 7,3
      3 #dimension should be same
      4 a[:,3]=[7,3]
      5 print(a)
```

```
[[ 1  2  3  7  5  6 20]
 [ 8  9 10  3 12 13 14]]
```

3-d Example

```
[36]  1 b=np.array([[[1,2],[3,4]],[[5,6],[7,8]]])
      2 print(b)
```

```
[[[1 2]
  [3 4]]

 [[5 6]
  [7 8]]]
```

```
[37]  1 # Get spacific element (work outside in )
      2 # we want 4
      3 # 1st matrix 2nd row 2nd column
      4 #[matrix,row,column]
      5
      6 b[0,1,1]
```

```
4
```

```
[38]  1 # want 3,4 from 1st matrix and 7,8 from 2nd matrix
      2 b[:,1,:]
```

```
array([[3, 4],
       [7, 8]])
```

```
[61]  1 #replace
      2 c[:,1,:]
```

```
array([[3, 2, 3],
       [1, 8, 3],
       [1, 5, 3]])
```

```
 1 c[:,1,:]=[[2,3,4],[5,6,7],[9,0,8]]
 2 c
```

```
array([[[1, 2, 3],
        [2, 3, 4],
        [9, 2, 0]],

       [[1, 3, 3],
        [5, 6, 7],
        [1, 2, 3]],

       [[1, 5, 3],
        [9, 0, 8],
        [1, 0, 3]]])
```

1.4 Initializing Different Arrays (1s, 0s, full, random, etc)

operation	example
np.zeros()	`np.zeros((2,4))`
np.ones	`np.ones((4,2,2),dtype='int32')`
np.full()	`np.full((3,4),999, dtype='float32')`
np.full_like	`b=np.full_like(a,4)`
np.random.rand	`np.random.rand(3,3)`
np.random.rand_sample	`np.random.random_sample(a.shape)`
np.random.randint()	`np.random.randint(100,size=(3,3))`
np.identity	`np.identity(5)`
np.repeat	`r1=np.repeat(arr,3)`
a.copy	`b=a.copy()`

initializing Different Types of arrays

```
[34]  1 #All 0s mtraix
      2 # 2-D 2x4 matrix  ((r,c))
      3 np.zeros((2,4))
```

```
array([[0., 0., 0., 0.],
       [0., 0., 0., 0.]])
```

```
[35]  1 #All 0s mtraix
      2 # 3-D 2x4x3 matrix
      3 #2 matrix 4 row and 3 column in  each
      4 np.zeros((2,4,3))
```

```
array([[[0., 0., 0.],
        [0., 0., 0.],
        [0., 0., 0.],
        [0., 0., 0.]],

       [[0., 0., 0.],
        [0., 0., 0.],
        [0., 0., 0.],
        [0., 0., 0.]]])
```

```
[72]  1 #All 0s mtraix
      2 # 4-D 3x4x3x3 matrix
      3 #(3x2=6, 3x3 matrix)=(3,4,3,3)
      4
      5 np.zeros((3,2,3,3))
```

```
array([[[[0., 0., 0.],
         [0., 0., 0.],
         [0., 0., 0.]],

        [[0., 0., 0.],
         [0., 0., 0.],
         [0., 0., 0.]]],


       [[[0., 0., 0.],
         [0., 0., 0.],
         [0., 0., 0.]],

        [[0., 0., 0.],
         [0., 0., 0.],
         [0., 0., 0.]]],


       [[[0., 0., 0.],
         [0., 0., 0.],
         [0., 0., 0.]],

        [[0., 0., 0.],
         [0., 0., 0.],
         [0., 0., 0.]]]])
```

```
[40]  1 #all ones matrix
      2 np.ones((4,2,2),dtype='int32')
```

```
array([[[1, 1],
        [1, 1]],

       [[1, 1],
        [1, 1]],

       [[1, 1],
        [1, 1]],

       [[1, 1],
        [1, 1]]], dtype=int32)
```

```
[41]  1 #any other number
      2 # we want 3x4 matrix all value will be 999
      3
      4 np.full((3,4),999, dtype='float32')
```

```
array([[999., 999., 999., 999.],
       [999., 999., 999., 999.],
       [999., 999., 999., 999.]], dtype=float32)
```

```
[43]  1 #like a shape of a pre define matrix
      2 np.full(a.shape,4)
```

```
array([[4, 4, 4, 4, 4, 4, 4],
       [4, 4, 4, 4, 4, 4, 4]])
```

```
[44]  1 # Any other number (full_like)
      2 # like a shape of a pre define matrix
      3 #if we use full_like no need to use a.shape
      4 #just use a ( a is previously de fine matrix which shape was 2x7)
      5 b=np.full_like(a,4)
      6 print(b)
      7 print(b.shape)
```

```
[[4 4 4 4 4 4 4]
 [4 4 4 4 4 4 4]]
(2, 7)
```

```
[46]  1 #Random decimal number
      2
      3 np.random.rand(3,3)
```

```
array([[0.4094865 , 0.84005832, 0.5917549 ],
       [0.87885947, 0.5329299 , 0.00576045],
       [0.25541651, 0.77344551, 0.97978664]])
```

```
[47]  1 #if we want to pass shape we must use rand_sample
      2 np.random.random_sample(a.shape)
```

```
array([[0.07303068, 0.05024743, 0.86696108, 0.44838652, 0.52121979,
        0.80348145, 0.48693642],
       [0.74299627, 0.927289  , 0.01115618, 0.44459581, 0.92134962,
        0.19499349, 0.13181815]])
```

```
[48]  1 # we want Random Integer values
      2 np.random.randint(7)
```

```
3
```

```
[50]  1 # we want Random Integer values
      2 #and 3x3 matrix
      3 #random number between 100
      4 np.random.randint(100,size=(3,3))
```

```
array([[ 9, 81, 26],
       [51, 63,  4],
       [ 6, 54, 41]])
```

```
      1 # we want Random Integer values
      2 #and 3x3 matrix
      3 #random number 10 between 100 exlcude 100
      4 np.random.randint(10,100,size=(5,5))
```

```
array([[29, 47, 30, 48, 83],
       [76, 79, 32, 32, 48],
       [95, 19, 14, 32, 42],
       [68, 67, 93, 34, 56],
       [86, 79, 46, 38, 78]])
```

```
[54]  1 # we want Random Integer values
      2 #and 3x3 matrix
      3 #random number -10 between 100 exlcude 100
      4 np.random.randint(-10,100,size=(5,5))
```

```
array([[74, 33, 22, 54, 89],
       [81, 69, 23,  3,  4],
       [77, -6, 47, 56, 58],
       [76, -7, 84, 86, 23],
       [61, 25, 81, 10, -9]])
```

```
[55]  1 #the idendity matrix
      2 # by default square matrix
      3 # need to pass just 1 parameter
      4
      5 np.identity(5)
```

```
array([[1., 0., 0., 0., 0.],
       [0., 1., 0., 0., 0.],
       [0., 0., 1., 0., 0.],
       [0., 0., 0., 1., 0.],
       [0., 0., 0., 0., 1.]])
```

```
[57]  1 # repeat a array
      2 #repeat arr each value  3 times
      3 arr=np.array([1,2,3,4])
      4 r1=np.repeat(arr,3)
      5 print(r1)
```

```
[1 1 1 2 2 2 3 3 3 4 4 4]
```

```
[59]  1 # repeat a array
      2 #repeat arr matrix each value  3 times
      3 arr=np.array([[1,2,3,4]])
      4 r1=np.repeat(arr,3,axis=0)
      5 print(r1)
```

```
[[1 2 3 4]
 [1 2 3 4]
 [1 2 3 4]]
```

1.5 Problem #1 (how do you initialize the array?)

Problem #1

want to create this matrix

[1 1 1 1 1]

[1 0 0 0 1]

[1 0 9 0 1]

[1 0 0 0 1]

[1 1 1 1 1]

```
[66]  1 #mathod 1
      2 b=np.ones((5,5),dtype='int8')
      3 b[1:4:,1:4:]=np.zeros((3,3))
      4 b[2,2]=9
      5 print(b)
```

```
[[1 1 1 1 1]
 [1 0 0 0 1]
 [1 0 9 0 1]
 [1 0 0 0 1]
 [1 1 1 1 1]]
```

```
[68]  1 #mathod 2
      2 output = np.ones((5,5))
      3 z=np.zeros((3,3))
      4 z[1,1]=9
      5 output[1:4,1:4]=z
      6 print(output)
```

```
[[1. 1. 1. 1. 1.]
 [1. 0. 0. 0. 1.]
 [1. 0. 9. 0. 1.]
 [1. 0. 0. 0. 1.]
 [1. 1. 1. 1. 1.]]
```

```
[69]  1 #mathod 3
      2 #use negetive index
      3 output = np.ones((5,5))
      4 z=np.zeros((3,3))
      5 z[1,1]=9
      6 output[1:-1,1:-1]=z
      7 print(output)
```

```
[[1. 1. 1. 1. 1.]
 [1. 0. 0. 0. 1.]
 [1. 0. 9. 0. 1.]
 [1. 0. 0. 0. 1.]
 [1. 1. 1. 1. 1.]]
```

1.6 Be careful when copying variables!

Be careful when coping arrays!!

```
[70]  1 a=np.array([1,2,3])
      2 # b point to same a
      3 #so if we change b then a also will be change
      4 b=a
      5 b[0]=100
      6 print(b)
      7 print(a)
```

```
[100   2   3]
[100   2   3]
```

```
1 #solution of this we have to tell numpy to  create a copy of a
2 a=np.array([1,2,3])
3 b=a.copy()
4 b[0]=100
5 print(b)
6 print(a)
```

```
[100   2   3]
[1 2 3]
```

1.7 Basic Mathematics (arithmetic, trigonometry, etc)

```
  1 a=np.array([1,2,3,4])
  2 print(a)
```

```
[1 2 3 4]
```

```
[74]  1 # add 2 with every element
      2 a+2
```

```
array([3, 4, 5, 6])
```

```
[75]  1 # sub 2 with every element
      2 a-2
```

```
array([-1,  0,  1,  2])
```

```
[76]  1 a*2
```

```
array([2, 4, 6, 8])
```

```
[77]  1 a /2
```

```
array([0.5, 1. , 1.5, 2. ])
```

```
  1 a**2
```

```
array([ 1,  4,  9, 16])
```

```
[79]  1 b=np.array([1,0,1,0])
      2 a+b
```

```
array([2, 2, 4, 4])
```

```
[80]  1 np.cos(b)
```

```
array([0.54030231, 1.        , 0.54030231, 1.        ])
```

```
[82]  1 np.sin(a)
```

```
array([ 0.84147098,  0.90929743,  0.14112001, -0.7568025 ])
```

We can do lots more cool stuff with mathematics link is below:

https://docs.scipy.org/doc/numpy/reference/routines.math.html

1.8 Linear Algebra

```
[87]  1 a=np.ones((2,3))
      2 print(a)
      3
      4 b=np.full((3,2),2)
      5 print(b)
      6
      7 # not gonna work a*b
      8 # nxm = mxp
      9 np.matmul(a,b)
```

```
[[1. 1. 1.]
 [1. 1. 1.]]
[[2 2]
 [2 2]
 [2 2]]
array([[6., 6.],
       [6., 6.]])
```

```
[90]  1 # Find the determinant
      2 # determinant of identity matrix is one
      3 c=np.identity(3)
      4
      5 np.linalg.det(c)
      6
```

```
1.0
```

For more cool stuff visit this link below:

https://docs.scipy.org/doc/numpy/reference/routines.linalg.html

#Determinant
Trace
Singular Vector Decomposition
Eigenvalues
Matrix Norm
Inverse
Etc

1.9 Statistics

statistics

```
[92]  1 stats = np.array([[1,2,3],[4,5,6]])
      2 stats
```

```
array([[1, 2, 3],
       [4, 5, 6]])
```

```
[93]  1 # minimum value of matrix
      2 np.min(stats)
```

```
1
```

```
      1 # minimum value of matrix
      2 #for each row  use axis=1
      3 np.min(stats , axis=1)
```

```
array([1, 4])
```

```
[95]  1 # minimum value of matrix
      2 #for each column  use axis=0
      3 np.min(stats , axis=0)
```

```
array([1, 2, 3])
```

```
      1 np.max(stats)
```

```
6
```

```
[97]  1 np.sum(stats)
```

```
21
```

```
[98]  1 #sum all value of each row
      2 np.sum(stats,axis=1)
```

```
array([ 6, 15])
```

1.10 Reorganizing Array

Reorganizing Array

```
[103]  1 before=np.array([[1,2,3,4],[5,6,7,8]])
       2
       3 print(before)
       4 #if total number of values in a matrix
       5 # does not same as total number of values of
       6 # in reshape  matrix then gives errros
       7 after=before.reshape((4,2))
       8 print(after)
```

```
[[1 2 3 4]
 [5 6 7 8]]
[[1 2]
 [3 4]
 [5 6]
 [7 8]]
```

```
[104]  1 after=before.reshape((2,2,2))
       2 print(after)
```

```
[[[1 2]
  [3 4]]

 [[5 6]
  [7 8]]]
```

```
       1 #vertically stacking vectores
       2 #dim is important
       3 # simple concate to matrix one top of the other
       4
       5 v1=np.array([1,2,3,4])
       6 v2=np.array([5,6,7,8])
       7 np.vstack([v1,v2])
       8
```

```
array([[1, 2, 3, 4],
       [5, 6, 7, 8]])
```

```
#vertically stacking vectores
#dim is important
# simple concate to matrix one top of the other

v1=np.array([1,2,3,4])
v2=np.array([5,6,7,8])
np.vstack([v1,v1,v2,v2])

```

```
array([[1, 2, 3, 4],
       [1, 2, 3, 4],
       [5, 6, 7, 8],
       [5, 6, 7, 8]])
```

```
#horizontal stack

h1=np.array([1,2,3,4])
h2=np.array([5,6,7,8])
np.hstack((h1,h2))


```

```
array([1, 2, 3, 4, 5, 6, 7, 8])
```

[109]
```
#horizontal stack

h1=np.ones((2,4))
h2=np.zeros((2,2))

np.hstack((h1,h2))

```

```
array([[1., 1., 1., 1., 0., 0.],
       [1., 1., 1., 1., 0., 0.]])
```

1.11 Load data in from a file

Miscellaneous

laod Data from File

```
# we have to use delimiter  properly
# accrodingly which one use in separte data in file
filedata = np.genfromtxt('data.txt',delimiter=',')
#by default its float
filedata
```

```
array([[  1.,  13.,  21.,  11., 196.,  75.,   4.,   3.,  34.,   6.,   7.,
          8.,   0.,   1.,   2.,   3.,   4.,   5.],
       [  3.,  42.,  12.,  33., 766.,  75.,   4.,  55.,   6.,   4.,   3.,
          4.,   5.,   6.,   7.,   0.,  11.,  12.],
       [  1.,  22.,  33.,  11., 999.,  11.,   2.,   1.,  78.,   0.,   1.,
          2.,   9.,   8.,   7.,   1.,  76.,  88.]])
```

```
[116]
# if we want to int then need to type cast

filedata.astype('int32')

filedata
# actually copy change to other file
filedata =filedata.astype('int32')
filedata
```

```
array([[  1,  13,  21,  11, 196,  75,   4,   3,  34,   6,   7,   8,   0,
          1,   2,   3,   4,   5],
       [  3,  42,  12,  33, 766,  75,   4,  55,   6,   4,   3,   4,   5,
          6,   7,   0,  11,  12],
       [  1,  22,  33,  11, 999,  11,   2,   1,  78,   0,   1,   2,   9,
          8,   7,   1,  76,  88]], dtype=int32)
```

Create this data.txt file:

```
1,13,21,11,196,75,4,3,34,6,7,8,0,1,2,3,4,5
3,42,12,33,766,75,4,55,6,4,3,4,5,6,7,0,11,12
1,22,33,11,999,11,2,1,78,0,1,2,9,8,7,1,76,88
```

1.12 Advanced Indexing and Boolean Masking

```
[117]  1 #if value is greater then 50 give true
       2 filedata>50
```

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

```
[118]  1 #give those values which value is greater the 50
       2 filedata[filedata>50]
```

```
array([196,  75, 766,  75,  55, 999,  78,  76,  88], dtype=int32)
```

```
[120]  1 #any value greater the 50
       2 np.any(filedata>50,axis=0)
```

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

```
[121]  1 #any value greater the 50
       2 np.all(filedata>50,axis=0)
```

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

```
[122]  1 ((filedata>50) & (filedata<100))
```

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

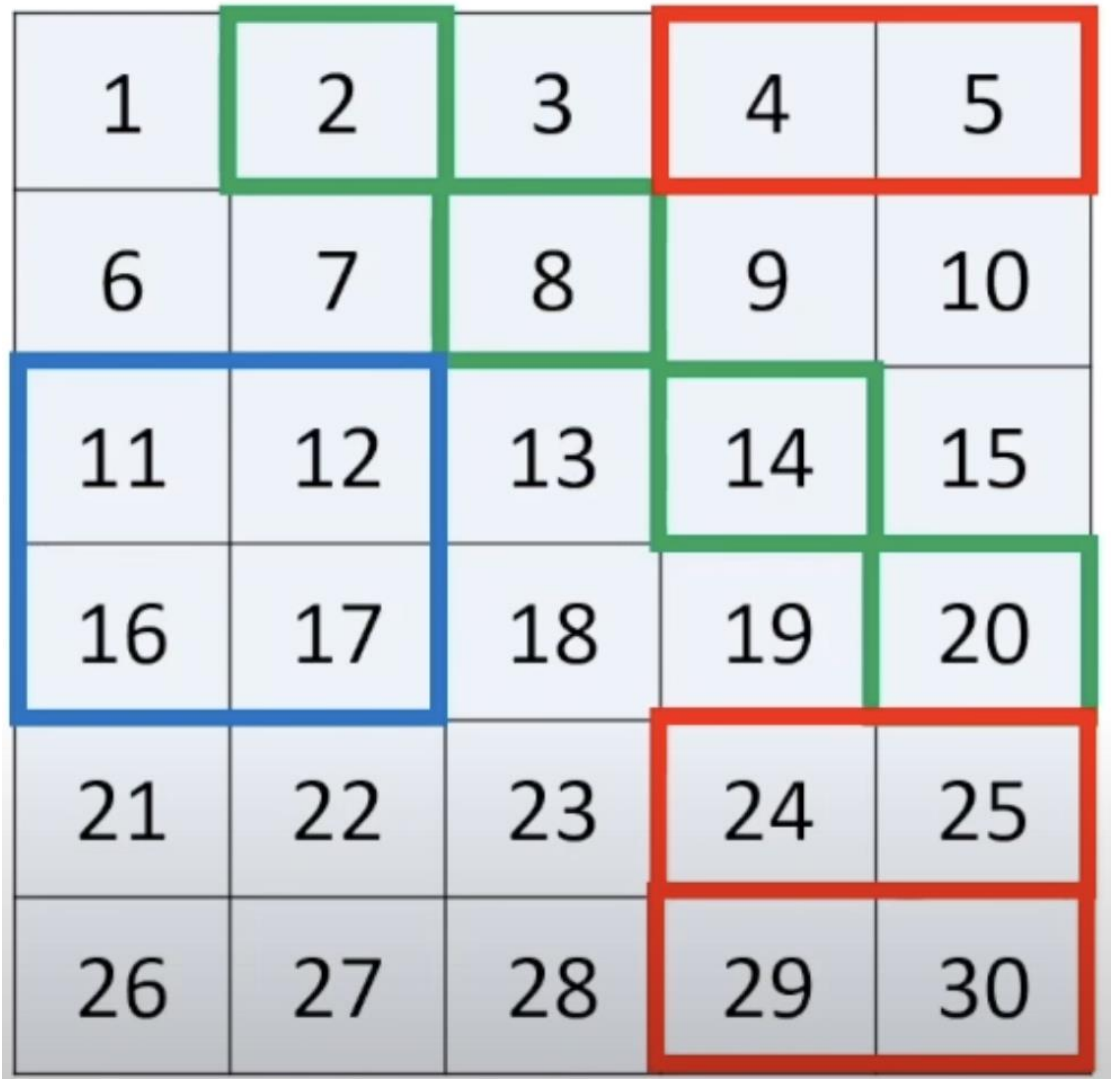
```
[123]  1 (~((filedata>50) & (filedata<100)))
```

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

```
[119]  1 #You can index with a list in Numpy
       2 #we want 2,3,9 value
       3 a=np.array([1,2,3,4,5,6,7,8,9])
       4 a[[1,2,8]]
```

```
array([2, 3, 9])
```

1.13 Problem #2(How do you index these values?)



1.14 Solution:

```
[126]  1 a=np.array([[1,2,3,4,5],[6,7,8,9,10],[11,12,13,14,15],
       2  [16,17,18,19,20],[21,22,23,24,24],[26,27,28,29,30]])
       3 print(a)
```

```
[[ 1  2  3  4  5]
 [ 6  7  8  9 10]
 [11 12 13 14 15]
 [16 17 18 19 20]
 [21 22 23 24 24]
 [26 27 28 29 30]]
```

```
[127]  1 # get the value of 11,12,16,17
       2 # blue area
       3 a[2:4,0:2]
```

```
array([[11, 12],
       [16, 17]])
```

```
       1 # get the 2,8,14,20
       2 #green mark values
       3
       4 #use list as index [row index], [column index]
       5
       6 a[[0,1,2,3],[1,2,3,4]]
```

```
array([ 2,  8, 14, 20])
```

```
[129]  1 #get 4,5,24,25,29,30
       2 #red mark area values
       3 # use list and slicing
       4
       5 a[[0,3,4],3:]
       6
```

```
array([[ 4,  5],
       [19, 20],
       [24, 24]])
```

This Notebook co-lab link:
https://colab.research.google.com/drive/1SjaKmTaHdG_ZKFM0Mjo0DcrGf4GQlToO?usp=sharing

CHAPTER 2: MORE BASIC

2.1 Range

This section covers

np.arange(),
np.linspace()

You can create an array with a range of elements:

```
>>> np.arange(4)
array([0, 1, 2, 3])
```

And even an array that contains a range of evenly spaced intervals. To do this, you will specify the **first number**, **last number**, and the **step size**.

```
>>> np.arange(2, 9, 2)
array([2, 4, 6, 8])
```

You can also use `np.linspace()` to create an array with values that are spaced linearly in a specified interval:

```
>>> np.linspace(0, 10, num=5)
array([ 0. ,  2.5,  5. ,  7.5, 10. ])
```

2.2 Adding, removing, and sorting elements

This section covers `np.sort(), np.concatenate()`

You can quickly sort the numbers in ascending order with:

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

If you start with these arrays:

```
>>> a = np.array([1, 2, 3, 4])
>>> b = np.array([5, 6, 7, 8])
```

You can concatenate them with `np.concatenate()`.

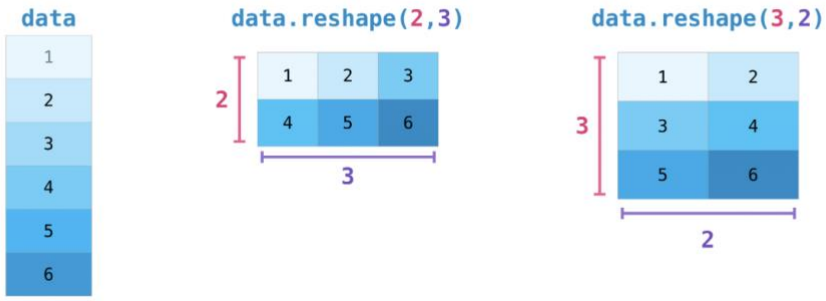
```
>>> np.concatenate((a, b))
array([1, 2, 3, 4, 5, 6, 7, 8])
```

2.3 Transposing and reshaping a matrix

This section covers
arr.reshape(), arr.transpose(), arr.T

You may also need to switch the dimensions of a matrix. This can happen when, for example, you have a model that expects a certain input shape that is different from your dataset. This is where the `reshape` method can be useful. You simply need to pass in the new dimensions that you want for the matrix.

```
>>> data.reshape(2, 3)
array([[1, 2, 3],
       [4, 5, 6]])
>>> data.reshape(3, 2)
array([[1, 2],
       [3, 4],
       [5, 6]])
```



You can also use `.transpose()` to reverse or change the axes of an array according to the values you specify.

If you start with this array:

```
>>> arr = np.arange(6).reshape((2, 3))
>>> arr
array([[0, 1, 2],
       [3, 4, 5]])
```

You can transpose your array with `arr.transpose()`.

```
>>> arr.transpose()
array([[0, 3],
       [1, 4],
       [2, 5]])
```

You can also use `arr.T`:

```
>>> arr.T
array([[0, 3],
       [1, 4],
       [2, 5]])
```

2.4 How to reverse an array

This section covers np.flip()

Reversing a 1D array

If you begin with a 1D array like this one:

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

You can reverse it with:

```
>>> reversed_arr = np.flip(arr)
```

If you want to print your reversed array, you can run:

```
>>> print('Reversed Array: ', reversed_arr)
Reversed Array:  [8 7 6 5 4 3 2 1]
```

2.5 Reshaping and flattening multidimensional array

This section covers

.flatten(), ravel()

If you start with this array:

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

You can use `flatten` to flatten your array into a 1D array.

```
>>> x.flatten()
array([ 1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12])
```

When you use `flatten`, changes to your new array won't change the parent array.

For example:

```
>>> a1 = x.flatten()
>>> a1[0] = 99
>>> print(x)  # Original array
[[ 1  2  3  4]
 [ 5  6  7  8]
 [ 9 10 11 12]]
>>> print(a1)  # New array
[99  2  3  4  5  6  7  8  9 10 11 12]
```

But when you use `ravel`, the changes you make to the new array will affect the parent array.

For example:

```
>>> a2 = x.ravel()
>>> a2[0] = 98
>>> print(x)  # Original array
[[98  2  3  4]
 [ 5  6  7  8]
 [ 9 10 11 12]]
>>> print(a2)  # New array
[98  2  3  4  5  6  7  8  9 10 11 12]
```

2.6 Working with mathematical formulas

$$MeanSquareError = \frac{1}{n}\sum_{i=1}^{n}(Y\_prediction_i - Y_i)^2$$

Implementing this formula is simple and straightforward in NumPy:

```
error = (1/n) * np.sum(np.square(predictions - labels))
```

What makes this work so well is that `predictions` and `labels` can contain one or a thousand values. They only need to be the same size.

You can visualize it this way:

```
                                    predictions  labels
error = (1/3) * np.sum(np.square(      1          1
                                       1     -    2    ))
                                       1          3
```

2.7 How to save and load NumPy Objects

This section covers

np.save, np.savez, np.savetxt, np.load, np.loadtxt

.npy file extension

It's easy to save and load and array with `np.save()`. Just make sure to specify the array you want to save and a file name. For example, if you create this array:

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

You can save it as "filename.npy" with:

```
>>> np.save('filename', a)
```

You can use `np.load()` to reconstruct your array.

```
>>> b = np.load('filename.npy')
```

If you want to check your array, you can run:

```
>>> print(b)
[1 2 3 4 5 6]
```

You can save a NumPy array as a plain text file like a **.csv** or **.txt** file with `np.savetxt`.

For example, if you create this array:

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

You can easily save it as a .csv file with the name "new_file.csv" like this:

```
>>> np.savetxt('new_file.csv', csv_arr)
```

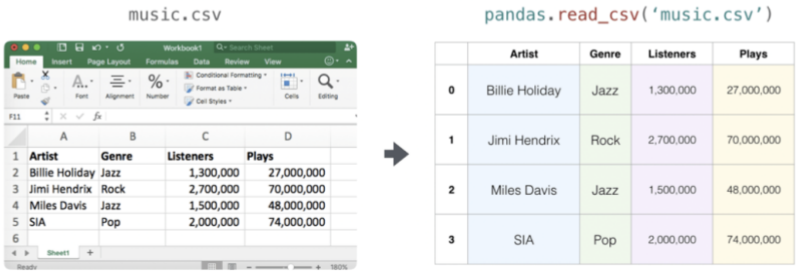
You can quickly and easily load your saved text file using `loadtxt()`:

```
>>> np.loadtxt('new_file.csv')
array([1., 2., 3., 4., 5., 6., 7., 8.])
```

2.8 Importing and exporting a CSV

It's simple to read in a CSV that contains existing information. The best and easiest way to do this is to use Pandas.

```
>>> import pandas as pd

>>> # If all of your columns are the same type:
>>> x = pd.read_csv('music.csv', header=0).values
>>> print(x)
[['Billie Holiday' 'Jazz' 1300000 27000000]
 ['Jimmie Hendrix' 'Rock' 2700000 70000000]
 ['Miles Davis' 'Jazz' 1500000 48000000]
 ['SIA' 'Pop' 2000000 74000000]]

>>> # You can also simply select the columns you need:
>>> x = pd.read_csv('music.csv', usecols=['Artist', 'Plays']).values
>>> print(x)
[['Billie Holiday' 27000000]
 ['Jimmie Hendrix' 70000000]
 ['Miles Davis' 48000000]
 ['SIA' 74000000]]
```



If you created this array “a”

```
>>> a = np.array([[-2.58289208,  0.43014843, -1.24082018, 1.59572603],
...               [ 0.99027828, 1.17150989,  0.94125714, -0.14692469],
...               [ 0.76989341,  0.81299683, -0.95068423, 0.11769564],
...               [ 0.20484034,  0.34784527,  1.96979195, 0.51992837]])
```

You could create a Pandas dataframe

```
>>> df = pd.DataFrame(a)
>>> print(df)
          0         1         2         3
0 -2.582892  0.430148 -1.240820  1.595726
1  0.990278  1.171510  0.941257 -0.146925
2  0.769893  0.812997 -0.950684  0.117696
3  0.204840  0.347845  1.969792  0.519928
```

You can easily save your dataframe with:

```
>>> df.to_csv('pd.csv')
```

And read your CSV with:

```
>>> data = pd.read_csv('pd.csv')
```

	Unnamed: 0	0	1	2	3
0	0	-2.582892	0.430148	-1.240820	1.595726
1	1	0.990278	1.171510	0.941257	-0.146925
2	2	0.769893	0.812997	-0.950684	0.117696
3	3	0.204840	0.347845	1.969792	0.519928

2.9 Plotting arrays with Matplotlib

If you need to generate a plot for your values, it's very simple with Matplotlib.

For example, you may have an array like this one:

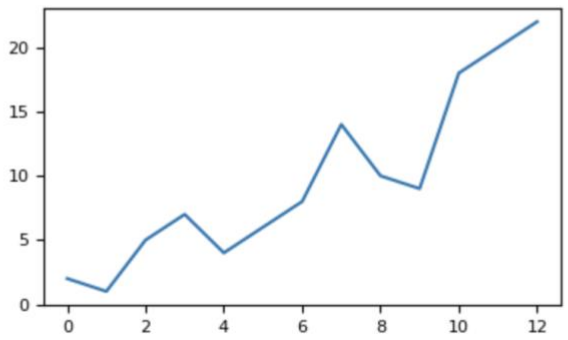
```
>>> a = np.array([2, 1, 5, 7, 4, 6, 8, 14, 10, 9, 18, 20, 22])
```

If you already have Matplotlib installed, you can import it with:

```
>>> import matplotlib.pyplot as plt

# If you're using Jupyter Notebook, you may also want to run the follow
# line of code to display your code in the notebook:

%matplotlib inline
```

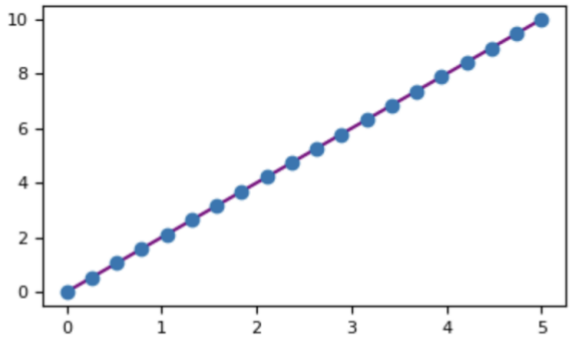
All you need to do to plot your values is run:

```
>>> plt.plot(a)

# If you are running from a command line, you may need to do this:
# >>> plt.show()
```



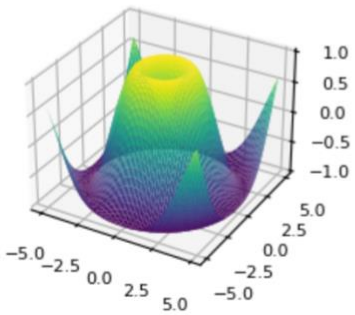
For example, you can plot a 1D array like this:

```
>>> x = np.linspace(0, 5, 20)
>>> y = np.linspace(0, 10, 20)
>>> plt.plot(x, y, 'purple') # line
>>> plt.plot(x, y, 'o')      # dots
```



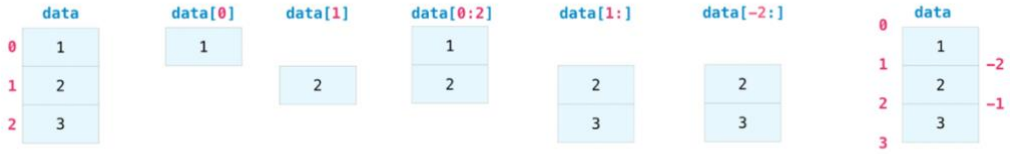
With Matplotlib, you have access to an enormous number of visualization options.

```
>>> fig = plt.figure()
>>> ax = fig.add_subplot(projection='3d')
>>> X = np.arange(-5, 5, 0.15)
>>> Y = np.arange(-5, 5, 0.15)
>>> X, Y = np.meshgrid(X, Y)
>>> R = np.sqrt(X**2 + Y**2)
>>> Z = np.sin(R)

>>> ax.plot_surface(X, Y, Z, rstride=1, cstride=1, cmap='viridis')
```



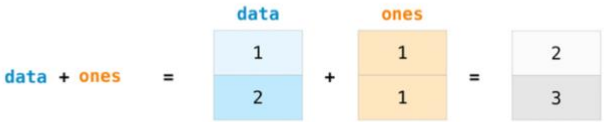
CHAPTER 3: VISUALIZE DIFFERENT TYPE OF OPERATION OF NUMPY

#

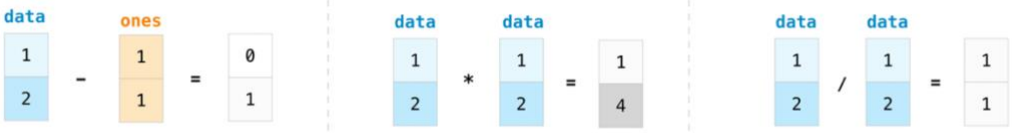


#

#

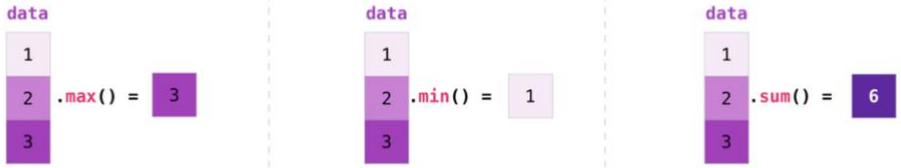


#



#

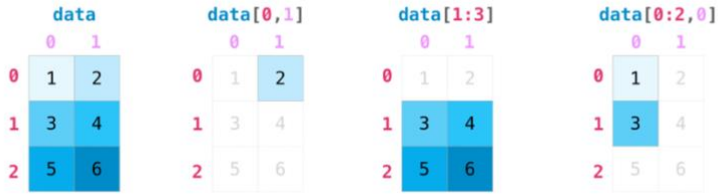

1
2
* 1.6
=
1
2
*
1.6
1.6
=
1.6
3.2


data
1
2
3
.max() = 3
data
1
2
3
.min() = 1
data
1
2
3
.sum() = 6

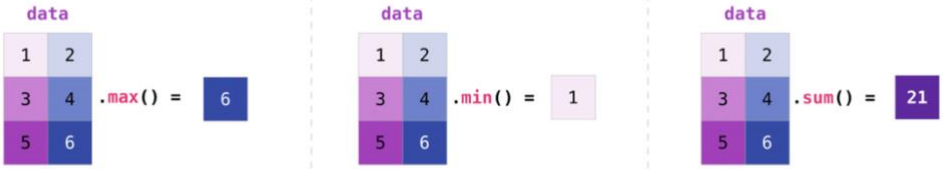
#


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

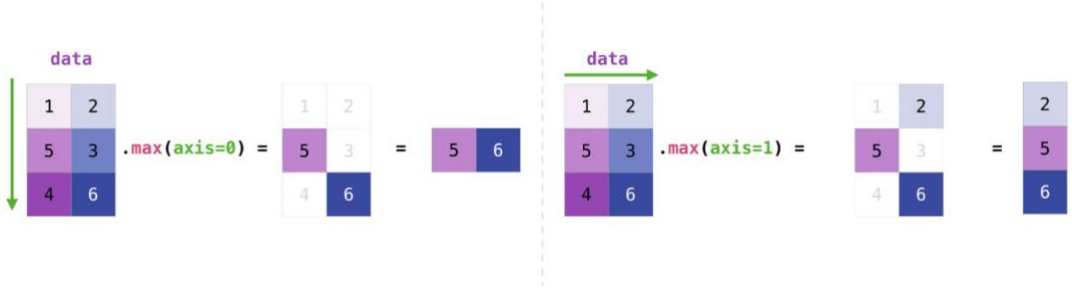
#


data
0 1
0 1 2
1 3 4
2 5 6
data[0,1]
0 1
0 1 2
1 3 4
2 5 6
data[1:3]
0 1
0 1 2
1 3 4
2 5 6
data[0:2,0]
0 1
0 1 2
1 3 4
2 5 6

#


data
1 2
3 4
5 6
.max() = 6
data
1 2
3 4
5 6
.min() = 1
data
1 2
3 4
5 6
.sum() = 21

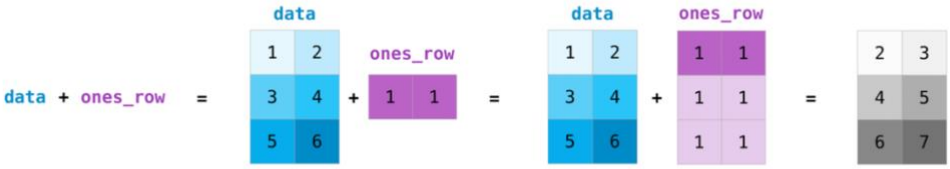
#


data
.max(axis=0) =
data
.max(axis=1) =

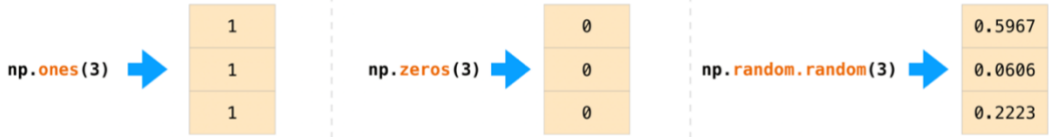
#


data + ones =
data
ones

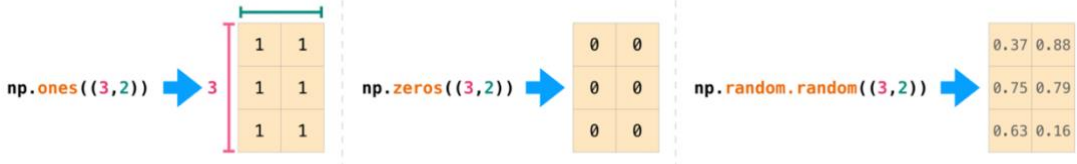
#


data + ones_row =
data
ones_row
data
ones_row

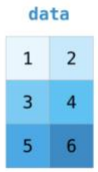
#

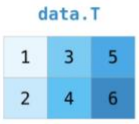

np.ones(3)
np.zeros(3)
np.random.random(3)

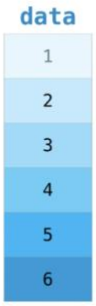
#

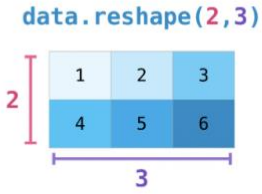

np.ones((3,2))
3
np.zeros((3,2))
np.random.random((3,2))

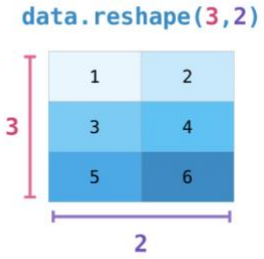
#











#

```
error = (1/3) * np.sum(np.square(    ))
```

0
-1
-2

```
error = (1/3) * np.sum(    )
```

0
1
4

```
error = (1/3) * 5
```

Explore Advance Operation By Yourself!!!!