APSC 1001

Introduction to Matrices with Python

```
import numpy as np
```

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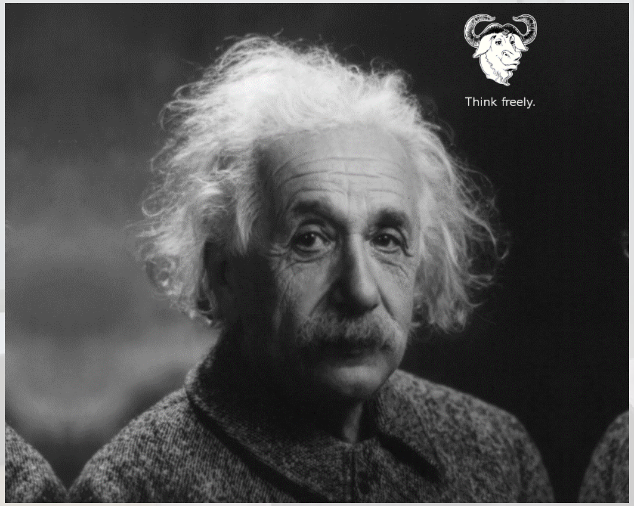
Photo: Kartik Bulusu

What patterns do you notice ?

Digital image is a matrix

These images contain elements of “uint8” data type

$$\begin{bmatrix} 49 & 49 & \cdots & 34 & 35 & 35 \\ \vdots & \vdots & \cdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \cdots & \vdots & \vdots & \vdots \\ 40 & 34 & \cdots & 51 & 49 & 46 \end{bmatrix}$$



Python:

```
>>> import matplotlib.pyplot as plt
>>> img = plt.imread('name')
>>> plt.imshow(img, cmap=plt.cm.hot)
>>> plt.show()
```

python™

Fingerprint image source: https://commons.wikimedia.org/wiki/File:Fingerprint_picture.svg
Einstein image source: http://mytree.tv/think/einstein-gnu-think-freely/
Feynman image source: https://commons.wikimedia.org/wiki/File:Richard_feynman_-_fermilab1.jpg

What is a Matrix ?

DATA

- Arranged in ROWS and COLUMNS
- Typically carries a MEANING

DATA

- Rectangular ARRAY of numbers

ARRAYS

- Two-dimensional arrays
- *m* rows and *n* columns

Source: http://giphy.com/search/matrix-gif

$$\begin{bmatrix} 1 & -4 \\ 9 & 6 \end{bmatrix}$$

$$\begin{bmatrix} 15 & 3 & 9 \\ 2 & 5 & 4 \end{bmatrix}$$

$$\begin{bmatrix} 11 & 7 \\ 4 & 2 \\ 6 & 9 \\ 3 & 1 \end{bmatrix}$$

Photo: Kartik Bulusu

Bookkeeping in a Matrix

$a_{i,j}$

n columns → j changes

m rows ↓ i changes

$$\begin{bmatrix} a_{0,0} & a_{0,1} & a_{0,2} & \cdots \\ a_{1,0} & a_{1,1} & a_{1,2} & \cdots \\ a_{2,0} & a_{2,1} & a_{2,2} & \cdots \\ \vdots & \vdots & \vdots & \ddots \end{bmatrix}$$

The ORDER of a matrix

- $A_{m\times n}$ *is* $m \times n$
- *Read as "m-by-n"*

a_{ij} *is called an ELEMENT*

- *at the i^{th} row and j^{th} column of A*

```
import numpy as np
A = np.matrix([[-1, 2],[3, 4]])
A[0,0]
A[0,:]
A[:,0]
A[1,0]
```

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Matrix scalar operations

$$A = \begin{bmatrix} -1 & 2 \\ 3 & 4 \end{bmatrix} \;\&\; s = 6$$

- Matrix, *A* has *m rows* and *m columns*
- *The ORDER of matrix, A ??*
- *The ORDER of the scalar, s ??*

$$\begin{bmatrix} -1 & 2 \\ 3 & 4 \end{bmatrix} * 6 = \begin{bmatrix} -6 & 12 \\ 18 & 24 \end{bmatrix}$$

Scalar Multiplication and Division

$$\begin{cases} \underset{(m\times m)}{A} * \underset{(1\times 1)}{s} = \underset{(m\times m)}{D} \\ \underset{(m\times m)}{A} * \underset{(1\times 1)}{s^{-1}} = \underset{(m\times m)}{F} \end{cases}$$

- **Each element a_{ij}**
- *Is either* ***multiplied*** *with or* ***divided*** *by* ***s***

$$\begin{bmatrix} -1 & 2 \\ 3 & 4 \end{bmatrix} * \left(\frac{1}{6}\right) = \begin{bmatrix} -\frac{1}{6} & \frac{1}{3} \\ \frac{1}{2} & \frac{2}{3} \end{bmatrix}$$

Python:

```
>>> import numpy as np
>>> A = np.matrix([[-1, 2],[3, 4]])
>>> B1 = A * 6
>>> B2 = A * (1/6)
>>> len(B1)
>>> np.shape(B2)
```

python™

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Python Commands:

```
>>> import numpy as np
>>> A = np.matrix([[-1, 2],[3, 4]])
>>> np.matrix('1 2; 3 4') # use Matlab-style syntax
>>> np.arange(25).reshape((5, 5)) # create a 1-d range and reshape
>>> np.array(range(25)).reshape((5, 5)) # pass a Python range and reshape
>>> np.array([5] * 25).reshape((5, 5)) # pass a Python list and reshape
>>> np.empty((5, 5)) # allocate, but don't initialize
>>> np.ones((5, 5)) # initialize with ones
>>> np.zeros([5, 5])
>>> np.ndarray((5, 5)) # use the low-level constructor
```