

## Lab#2

This session aims at learning Python programming. The focus is on using Python libraries: *numpy* and *matplotlib* and writing Python programs to do some particular tasks.

### Problem 1.1: *Python numpy and matplotlib libraries*

(0 points)

1. Installing numpy and matplotlib libraries

```
$pip install numpy
$pip install matplotlib
```

2. Using numpy and matplotlib libraries from command lines:

```
>>> import numpy as np
>>> import matplotlib.pyplot as plt
>>> plt.plot(np.random.rand(10))
>>> plt.show()
```

### Problem 1.2: *Working with numpy*

(0 points)

\* Array shapes and axes

```
>>> import numpy as np
>>> a = np.array([1,2,3,4,5,6,7,8,9,10,11,12]).reshape(4,3)
>>> a.shape
(4, 3)
>>> a
array([[ 1,  2,  3],
       [ 4,  5,  6],
       [ 7,  8,  9],
       [10, 11, 12]])
>>> np.swapaxes(a,0,1)
array([[ 1,  4,  7, 10],
       [ 2,  5,  8, 11],
       [ 3,  6,  9, 12]])
```

\* Array transposing, sorting, and concatenating

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

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

Further reading from: <https://numpy.org/doc/stable/user/quickstart.html>

**Problem 1.3:** *Working with matplotlib*

(10 points)

\* Draw a line graph

```
>>> import matplotlib.pyplot as plt
>>> years = list(range(1950, 2011, 10))
>>> gdp = [300.2, 543.3, 1075.9, 2862.5, 5979.6, 10289.7, 14958.3]

# create a line chart, years on x-axis, gdp on y-axis
>>> plt.plot(years, gdp, color='green', marker='o', linestyle='solid')

# add a title
>>> plt.title("Nominal GDP")

# add a label to the y-axis
>>> plt.ylabel("Billions of $")

# add a label to the x-axis
>>> plt.xlabel("Year")
>>> plt.show()
```

**Exercise 1:** Use matplotlib to draw a line chart for 3 countries from 1960 to 2021 (10 years step)

```
Country X's gdp = [400.2, 643.3, 1175.9, 3062.5, 6079.6, 11289.7, 16058.3]
Country Y's gdp = [336.0, 472.0, 1028.0, 2092.0, 5131.0, 7689.0, 14147.0]
Country Z's gdp = [1307.0, 1158.0, 1191.0, 3140.0, 9023.0, 15502.0, 22218.0]
```

\* Draw a bar graph

```
>>> movies = ["Annie Hall", "Ben-Hur", "Casablanca", "Gandhi", "West Side Story"]
>>> num_oscars = [5, 11, 3, 8, 10]
>>> xs = range(len(movies)) # xs is range(5)

# plot bars with left x-coordinates [xs], heights [num_oscars]
>>> plt.bar(xs, num_oscars)

# label x-axis with movie names at bar centers
>>> plt.xticks(xs, movies)

>>> plt.ylabel("# of Academy Awards")
>>> plt.title("My Favorite Movies")
>>> plt.show()
```

**Exercise 2:** Use matplotlib to draw a bar chart for 3 countries from 1960 to 2021 (10 years step) for the data of three countries above.

**Exercise 3:** Use matplotlib to draw a pie chart for 4 countries

```
countries = ['X', 'Y', 'Z', 'W']
export_rate = [50%, 24%, 18%, 8%]
```

**Problem 1.4:** *Manipulating image with linear algebra*

(0 points)

\* Load and show an existing image

```
>>> from scipy import misc
>>> from numpy import linalg
>>> import matplotlib.pyplot as plt
>>> img = misc.face()
>>> plt.imshow(img)
>>> plt.show()
```

\* Get shape, axis and array properties

```
>>> img.shape # the shape property of image
>>> img.ndim   # the dimension number of image
>>> img[:, :, 0] # the pixel matrix of image
```

\* Manipulate on array

```
>>> img_array = img / 255
>>> img_array.max(), img_array.min()
# multiplication operator @ to convert gray scale
>>> img_gray = img_array @ [0.2126, 0.7152, 0.0722]
>>> plt.imshow(img_gray, cmap="gray")
>>> plt.show()
```

\* Apply linear algebra on array (*svd* can be intensive computation)

```
>>> U, s, Vt = linalg.svd(img_gray) # take time
>>> U.shape, s.shape, Vt.shape
```

**Exercise 4 (bonus):** Analyze your own image using *numpy* with several matrix processing operations.

The programs must handle error situations (including wrong input) in a meaningful way. The solution (only one .txt file) is formatted in *name\_id\_l2.txt* and submitted to the Blackboard system before 2021-03-21. Note that students are responsible for missing/duplicated files due to wrong formats. Copying the whole source code from various sources such as the Internet is disallowed.