Lab Instructions - session 1

Introduction to numpy and matplotlib

A review of numpy arrays and matrices + matplotlib

Open an interactive python environment (python shell, ipython shell, or jupyter notebook), and run the following commands and see the output. Do not close the environment

Creating numpy arrays

```
>>> l = [1,2,3]
>>> l
>>> import numpy
>>> a = numpy.array(l)
>>> a
>>> a[2] = 300
>>> a

>>> type(l)
>>> type(a)

>>> import numpy as np
>>> a = np.array(l)
>>> a

>>> a = np.zeros(10)
>>> a
>>> a.dtype
>>> a[2] = 4
>>> a

>>> a = np.zeros(10, dtype=np.int64)
>>> a
>>> a.dtype
    a = np.ones(10)
>>> a
>>> a = np.ones(10) * -20
>>> a
>>>
    np.full(10, 222)
>>> a = np.arange(10)
>>> a
>>> 2**a
```

Numpy array basic properties and methods

```
>>> a = np.array([1,2,3])
>>> len(a)
>>> a.shape
>>> type(a)
>>> a.size
>>> a.ndim
>>> a.dtype
```

Lists vs numpy array

```
>>> l1 = [1,2,3]
>>> l2 = [4,5,6]
>>> a1 = np.array(l1)
>>> a2 = np.array(l2)
>>> l1+l2
>>> a1+a2
```

Basic operations

```
>>> a = np.array([1,2,3])
>>> b = np.array([4,5,6])
>>> a+b
>>> a-b
>>> a*b
>>> b**a
>>> a + 4
>>> a * 2
>>> a.dtype
>>> a/b

>>> a = np.array([1.0,2,3])
>>> a
>>> a.dtype
>>> a / b

>>> a = np.array([1,2,3], dtype=np.float64)
>>> a
>>> a.dtype
```

Slicing

```
>>> a = np.array([0,10,20,30,40, 50, 60, 70, 80, 90, 100])
>>> a
>>> a[2]
>>> a[2:8]
>>> a[2:-1]
>>> a[2:]
>>> a[:8]
>>> a[2:8:2]
>>> a[8:2:-1]
>>> a[::-1]

>>> a[[1,3,3,4,5]]
```

2D Arrays

```
>>>  A = np.zeros((4,6))
>>>  A
>>>  A = np.zeros((4,6), dtype=np.int32)
>>>  A
>>>  A = np.ones((3,7))
>>>  A
>>>  A = np.ones((3,8), dtype=np.uint8)
>>>  A
>>>  np.full((4,3), 50.0)
>>>
>>>  A = np.array([[1,2,3,4], [5,6,7,8], [9,10,11,12]])
>>>  A[1,2]
>>>  A[0,-1]
>>>  A[1,2]
>>>  A.shape
>>>  A.shape[0]
>>>  A.shape[1]
>>>  A.shape[::-1]
>>>  A.size
>>>  A.ndim
>>>
>>>  A[0,:]
>>>  A[0,:].shape
>>>  A[[0],:]
>>>  A[[0],:].shape
>>>  A[:,2]
>>>  A[:,[2]]
```

```
>>>  A[:,2].shape
>>>  A[:,[2]].shape
>>>
>>>  A[1:3]
>>>  A[1:3, :]
>>>  A[:,:3]
>>>  A[:,::2]
>>>  A[:,::-1]
>>>
>>>  r = np.array([0, 1, 0, 2, 2])
>>>  A
>>>  r
>>>  A[r,:]
>>>
>>>
>>>  A
>>>  A[:,0] = 1
>>>  A
>>>  A[:,0] = [20,30,40]
>>>  A
>>>
>>>  A
>>>  A.T
>>>
>>>  B = np.array([[1,1,1,1], [2,2,2,2], [3,3,3,3]])
>>>  A
>>>  B
>>>  A + B
>>>  A * B
>>>
>>>  A.dot(B)
>>>  A.dot(B.T)
>>>
>>>  I = np.eye(3)
>>>  I
>>>
>>>  np.random.random((2,3))
>>>  np.random.random((2,3))
>>>  np.random.random((2,3))
>>>
>>>  np.random.rand(2,3)
>>>  np.random.rand(2,3)
>>>
>>>  np.random.randn(2,3)
>>>  np.random.randn(2,3)
```

Numpy slices are references (not copies)

```
>>> A = np.array([[1,2,3,4], [5,6,7,8], [9,10,11,12]])
>>> b = A[:,1]
>>> b
>>> A
>>> b[1] = 10000
>>> b
>>> A

>>> b = A[:,0].copy()
>>> b
>>> b[1] = -20000
>>> b
>>> A
```

Masks

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

Operations on arrays

```
>>> A = np.array([[1,2,3,4], [5,6,7,8], [9,10,11,12]])
>>> A.sum()
>>> A.sum(axis=0)
>>> A.sum(axis=1)
>>> A.min()
>>> A.min(axis=0)
>>> A.max(axis=0,keepdims=True)
>>>
>>> A.max(axis=1)
>>> A.max(axis=1,keepdims=True)
>>> A.mean(axis=1)
>>>
>>> A.prod(axis=0)
```

Concatenation

```
>>> X = np.array([[1,2],[3,4]])
>>> Y = np.array([[10,20,30],[40,50,60]])
>>> Z = np.array([[7,7],[8,8],[9,9]])
>>> X
>>> Z
>>> np.concatenate((X,Z))
>>> np.concatenate((X,Z), axis=0)
>>> X
>>> Y
>>> np.concatenate((X,Y), axis=1)
>>> np.vstack((X,Z))
>>> np.r_[X,Z]
>>> np.hstack(X,Y)
>>> np.hstack((X,Y))
>>> np.c_[X,Y]
>>> Y
>>> np.tile(Y,(4,3))
```

Reshaping

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


>>> b = A.ravel()
>>> b
>>> b.shape
>>> b.reshape((2,6))

>>> b
>>> b.shape = (2,6)
>>> b
```

Row-wise and column-wise math operations

```
>>> A = np.array([[1,2,3,4], [5,6,7,8], [9,10,11,12]])
>>> b = np.array([1, 0, 2,-2])
>>> A
>>> b
>>> A-b
>>>
>>> c = np.array([1,2,3])
>>> A-c
>>> c
>>> c.shape = (3,1)
>>> c
>>> A
>>> A-c
```

Numpy arrays vs numpy matrices

```
>>> A = np.array([[1,2,3], [1,1,1], [-1,-2,-3]])
>>> A
>>> A*A
>>> A.dot(A)
>>>
>>> M = np.matrix([[1,2,3], [1,1,1], [-1,-2,-1]])
>>> M*M
>>> np.multiply(M,M)

>>> M=mat(A)
>>> M
>>> M=matrix(A)
>>> M
>>> M.T
>>> M.I
>>> M.I * M
>>> M * M.I
>>> M.A
>>> type(M)
>>> type(M.A)

>>> C = np.matrix("1 2; 3 4; 5 6")
>>> C
>>> M*C
```

N-dimensional arrays

```
>>> A = np.zeros((2,4,3))
>>> A
>>> A.shape

>>> A[:,:,0].shape
>>> A[:,:,0] = [[1,2,3,4],[5,6,7,8]]
>>> A[:,:,1] = [[2,2,2,2],[4,4,4,4]]
>>> A[:,:,2] = [[10,20,30,40],[11,21,31,41]]
>>>
>>> A[:,:,2]
>>> A[:,2:,2]
>>> A.ravel()
```

Plotting with Matplotlib

```
>>> from matplotlib import pyplot as plt
>>>
>>> x = np.arange(0, 2 * np.pi, 0.1)
>>> x
>>> y = np.cos(x)
>>> y
>>> plt.plot(x,y)
>>> plt.show()

>>> plt.plot(x,np.sin(x))
>>> plt.plot(x,np.cos(x))
>>> plt.show()
```

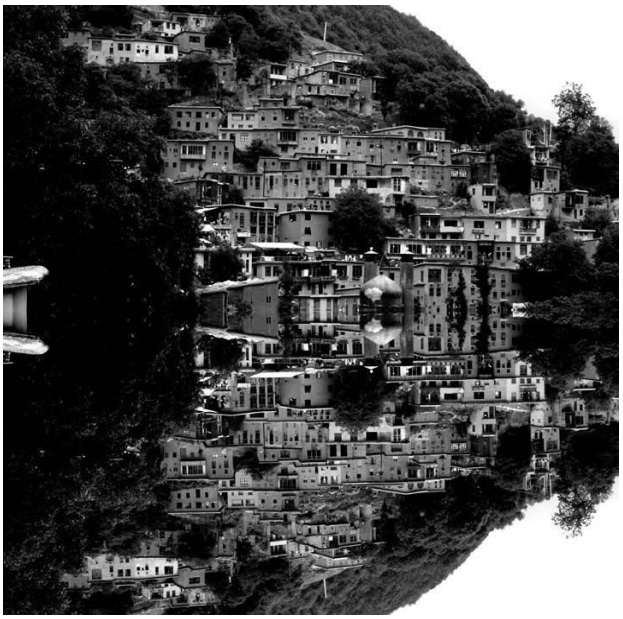
Reading and displaying images

```
>>> from scipy.misc import imread

>>> I = imread('masoleh_gray.jpg')
>>> I.shape
>>> I.dtype
>>> plt.imshow(I)
>>> plt.show()
>>> plt.imshow(I,cmap='gray')
>>> plt.show()
>>>
>>> plt.imshow(I[100:200,50:250],cmap='gray')
>>> plt.show()
```

Today's task:

Read the image 'masoleh_gray.jpg' and create a new image by vertically concatenating it with its vertically inverted image (like below). Display the new image.



References

1. https://docs.scipy.org/doc/numpy-dev/user/numpy-for-matlab-users.html
2. https://docs.scipy.org/doc/numpy-dev/user/quickstart.html
3. http://cs231n.github.io/python-numpy-tutorial