libraries

```
import h5py
import numpy as np
import matplotlib.pyplot as plt
```

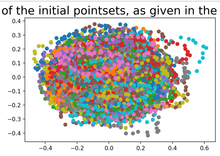
```
C:\ProgramData\Anaconda3\lib\site-packages\h5py\__init__.py:36:
FutureWarning: Conversion of the second argument of issubdtype from
`float` to `np.floating` is deprecated. In future, it will be treated
as `np.float64 == np.dtype(float).type`.
  from ._conv import register_converters as _register_converters
```

%matplotlib auto

```
n = 2
f = h5py.File('../data/ellipses2D.mat','r')
numOfPoints = f.get('numOfPoints')
numOfPoints = np.array(numOfPoints) # For converting to numpy array
numOfPointSets = f.get('numOfPointSets')
numOfPointSets = np.array(numOfPointSets)
pointSets = f.get('pointSets')
pointSets = np.array(pointSets)
plt.figure()
for i in range(300):
    plt.scatter(pointSets[i, :, 0], pointSets[i, :, 1])
plt.title('Plot of the initial pointsets, as given in the dataset', fontdict = {'fontsize' : 20})
```

```
Text(0.5,1,'Plot of the initial pointsets, as given in the
dataset')
```

Plot of the initial pointsets, as given in the dataset

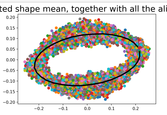


mean shape computation

```
mean = np.mean(pointSets, axis=1)
mean = np.reshape(mean,(300,1,2))
pointSetsCen = pointSets - mean

for i in range(300):
    norm = np.linalg.norm(pointSetsCen[i, :, :])
    pointSetsCen[i, :, :] = pointSetsCen[i, :, :]/norm

#rotated = np.zeros((300,32,2))
mean_shape = np.copy(pointSetsCen[0, :, :])
thresh = 1.e-7
error = 1
while thresh < error:
#for j in range(2):
    for i in range(300):
        a1 = np.matmul(pointSetsCen[i, :, :].T  , mean_shape)
        u, s, vh = np.linalg.svd(a1, full_matrices=True)
    #    d = np.linalg.det(np.matmul(vh, u.T))
        eye = np.identity(n)
        eye[n-1,n-1] = -1
        R1 = vh @ u
        if np.linalg.det(R1)==-1:
            R1 = vh @ eye @ u
        pointSetsCen[i, :, :] =  (R1 @ pointSetsCen[i, :, :].T).T

    best_mean_shape = np.mean(pointSetsCen, axis=0)
    best_mean_shape = best_mean_shape/np.linalg.norm(best_mean_shape)
    error = np.linalg.norm(best_mean_shape - mean_shape)
    mean_shape = best_mean_shape

plt.figure()
for i in range(300):
    plt.scatter(pointSetsCen[i, :, 0], pointSetsCen[i, :, 1])

plt.plot(best_mean_shape[:,0], best_mean_shape[:,1],c='black',linewidth=3, markersize=12)
plt.title('Plot of computed shape mean, together with all the aligned pointsets.', fontdict = {'fontsize' : 20})
```

```
Text(0.5,1,'Plot of computed shape mean, together with all the
aligned pointsets.')
```

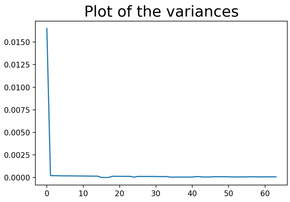
Plot of computed shape mean, together with all the aligned pointsets.



Variance

```
pointSetsCenNew = pointSetsCen - mean_shape
pointSetsCenNew = np.reshape(pointSetsCenNew, (300, 64))
covariance = np.cov(pointSetsCenNew.T)
W, V = np.linalg.eig(covariance)
W, V = np.real(W), np.real(V)


plt.figure()
plt.plot(W)
plt.title('Plot of the variances',fontdict = {'fontsize' : 20})
#Principal Modes of shape Variation
s1 = np.sqrt(W[0])
s2 = np.sqrt(W[1])

a1 = mean_shape + 2*s1*np.reshape(V[:, 0],(32,2))
a2 = mean_shape - 2*s1*np.reshape(V[:, 0],(32,2))

b1 = mean_shape + 2*s2*np.reshape(V[:, 1],(32,2))
b2 = mean_shape - 2*s2*np.reshape(V[:, 1],(32,2))
```

Plot of the variances

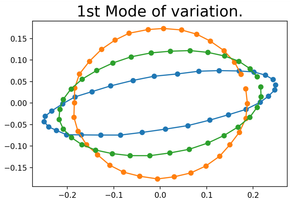


1st mode of variation

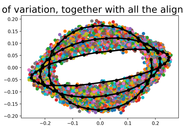
```
plt.figure()
plt.plot(a1[:,0],a1[:,1], '-o')
plt.plot(a2[:,0],a2[:,1], '-o')
plt.plot(mean_shape[:,0], mean_shape[:,1], '-o')
plt.title('1st Mode of variation.',fontdict = {'fontsize' : 20})

plt.figure()
for i in range(300):
    plt.scatter(pointSetsCen[i, :, 0], pointSetsCen[i, :, 1])
plt.plot(a1[:,0],a1[:,1], '-o',c='black',linewidth=3)
plt.plot(a2[:,0],a2[:,1], '-o',c='black',linewidth=3)
plt.plot(mean_shape[:,0], mean_shape[:,1], '-o',c='black',linewidth=3)
plt.title('1st Mode of variation, together with all the aligned pointsets.',fontdict = {'fontsize' : 20})
```

```
Text(0.5,1,'1st Mode of variation, together with all the aligned
pointsets.')
```

1st Mode of variation.



1st Mode of variation, together with all the aligned pointsets.

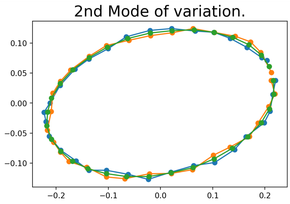


2nd mode of variation

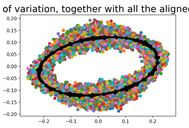
```
plt.figure()
plt.plot(b1[:,0],b1[:,1],'-o')
plt.plot(b2[:,0],b2[:,1], '-o')
plt.plot(mean_shape[:,0], mean_shape[:,1], '-o')
plt.title('2nd Mode of variation.',fontdict = {'fontsize' : 20})


plt.figure()
for i in range(300):
    plt.scatter(pointSetsCen[i, :, 0], pointSetsCen[i, :, 1])
plt.plot(b1[:,0],b1[:,1], '-o',c='black',linewidth=3)
plt.plot(b2[:,0],b2[:,1], '-o',c='black',linewidth=3)
plt.plot(mean_shape[:,0], mean_shape[:,1], '-o',c='black',linewidth=3)
plt.title('2nd Mode of variation, together with all the aligned pointsets.',fontdict = {'fontsize' : 20})
```

```
Text(0.5,1,'2nd Mode of variation, together with all the aligned
pointsets.')
```

2nd Mode of variation.



2nd Mode of variation, together with all the aligned pointsets.



Published from ellipses2D.py using Pweave 0.30.3 on 21-01-2019.