SNP

March 8, 2021

[1]:
```
import numpy as np
import numpy.linalg as alg
import pandas as pd
import random
import math
import matplotlib.pyplot as plt
import seaborn as sns
```

0.0.1 Import Data

[2]:
```
df = pd.read_csv('ceph_hgdp_minor_code_XNA.betterAnnotated.csv')
df.head(6)
```

[2]:

	snp	chr	pos	HGDP00448	HGDP00479	HGDP00985	HGDP01094	\
0	rs10000929	4	131516474	1	0	0	1	
1	rs10002472	4	159087423	2	1	2	2	
2	rs10005550	4	128697858	2	2	2	2	
3	rs10007576	4	59063992	2	0	2	1	
4	rs10007998	4	35988597	0	0	0	0	
5	rs10010285	4	35687757	0	1	0	0	

	HGDP00982	HGDP00911	HGDP01202	…	HGDP01342	HGDP00824	HGDP01319	\
0	1	0	1	…	1	0	1	
1	0	2	2	…	2	2	2	
2	1	0	1	…	2	2	2	
3	2	2	2	…	2	1	2	
4	0	0	0	…	2	1	2	
5	0	1	1	…	0	1	0	

	HGDP01357	HGDP00549	HGDP00953	HGDP01070	HGDP01376	HGDP00671	HGDP01024
0	0	0	2	0	0	0	2
1	1	2	1	1	2	0	2
2	1	2	2	2	2	1	2
3	1	2	2	1	1	1	0
4	0	2	0	1	2	2	1
5	1	2	0	1	0	2	0

[6 rows x 1046 columns]

[3]:
```
snp = df.drop(columns=['snp', 'chr', 'pos'])

snp.head(6)
```

[3]:

	HGDP00448	HGDP00479	HGDP00985	HGDP01094	HGDP00982	HGDP00911	\
0	1	0	0	1	1	0	
1	2	1	2	2	0	2	
2	2	2	2	2	1	0	
3	2	0	2	1	2	2	
4	0	0	0	0	0	0	
5	0	1	0	0	0	1	

	HGDP01202	HGDP00927	HGDP00461	HGDP00451	…	HGDP01342	HGDP00824	\
0	1	1	1	1	…	1	0	
1	2	1	2	2	…	2	2	
2	1	1	2	2	…	2	2	
3	2	1	1	2	…	2	1	
4	0	0	0	1	…	2	1	
5	1	1	0	2	…	0	1	

	HGDP01319	HGDP01357	HGDP00549	HGDP00953	HGDP01070	HGDP01376	\
0	1	0	0	2	0	0	
1	2	1	2	1	1	2	
2	2	1	2	2	2	2	
3	2	1	2	2	1	1	
4	2	0	2	0	1	2	
5	0	1	2	0	1	0	

	HGDP00671	HGDP01024
0	0	2
1	0	2
2	1	2
3	1	0
4	2	1
5	2	0

[6 rows x 1043 columns]

[4]:
```
(P, N) = snp.shape
print('The shape pf origianl dataset is {} * {}'.format(P, N))
```

```
The shape pf origianl dataset is 488919 * 1043
```

[5]:
```
info = pd.read_csv('ceph_hgdp_minor_code_XNA.sampleInformation.csv')
```

```
info.head(6)
```

[5]:
```
           ID Gender     Population             Geographic.origin  \
0  HGDP00448      M  Biaka Pygmies      Central African Republic
1  HGDP00479      M  Biaka Pygmies      Central African Republic
2  HGDP00985      M  Biaka Pygmies      Central African Republic
3  HGDP01094      M  Biaka Pygmies      Central African Republic
4  HGDP00982      M  Mbuti Pygmies  Democratic Republic of Congo
5  HGDP00911      M       Mandenka                       Senegal

  Geographic.area  region     distance  latitude  longtitude
0  Central Africa  Africa  2384.859098       4.0        17.0
1  Central Africa  Africa  2384.859098       4.0        17.0
2  Central Africa  Africa  2384.859098       4.0        17.0
3  Central Africa  Africa  2384.859098       4.0        17.0
4  Central Africa  Africa  1335.495772       1.0        29.0
5  Central Africa  Africa  5469.912857      12.0       -12.0
```

0.0.2 MDS Algorithm

[6]:
```
k1=500
k2=1000

R1 = np.zeros((k1, P), dtype=float)
R2 = np.zeros((k2, P), dtype=float)

for i in range(k1):
    t = random.sample(range(0, P), k1)
    R1[i, t] = 1/k1
for i in range(k2):
    t = random.sample(range(0, P), k2)
    R2[i, t] = 1/k2
```

[7]:
```
H = - np.ones((N, N))/N
H += np.eye(N)

X = np.array(snp)

X1 = np.dot(R1, X)
X1_centered = np.dot(X1, H)
K1 = np.dot(X1_centered.T, X1_centered)

X2 = np.dot(R2, X)
X2_centered = np.dot(X2, H)
K2 = np.dot(X2_centered.T, X2_centered)
```

[8]:
```
eigen_values_k1, eigen_vectors_k1 = alg.eig(K1)
eigen_pairs_k1 = [ (eigen_values_k1[i], eigen_vectors_k1[:, i]) for i in␣
 ↪range(len(eigen_values_k1))]

eigen_values_k2, eigen_vectors_k2 = alg.eig(K2)
eigen_pairs_k2 = [ (eigen_values_k2[i], eigen_vectors_k2[:, i]) for i in␣
 ↪range(len(eigen_values_k2))]
```

[9]:
```
eigen_pairs_k1.sort(key=lambda eigen_pairs_k1: eigen_pairs_k1[0], reverse=True)
eigen_pairs_k2.sort(key=lambda eigen_pairs_k2: eigen_pairs_k2[0], reverse=True)
```

[10]:
```
lambda1_k1, pca1_k1 = eigen_pairs_k1[0]
pca1_k1 = pca1_k1.astype(np.float64)
cord1_k1 = math.sqrt(lambda1_k1) * pca1_k1
lambda2_k1, pca2_k1 = eigen_pairs_k1[1]
pca2_k1 = pca2_k1.astype(np.float64)
cord2_k1 = math.sqrt(lambda2_k1)* pca2_k1

lambda1_k2, pca1_k2 = eigen_pairs_k2[0]
pca1_k2 = pca1_k2.astype(np.float64)
cord1_k2 = math.sqrt(lambda1_k2) * pca1_k2
lambda2_k2, pca2_k2 = eigen_pairs_k2[1]
pca2_k2 = pca2_k2.astype(np.float64)
cord2_k2 = math.sqrt(lambda2_k2) * pca2_k2
```

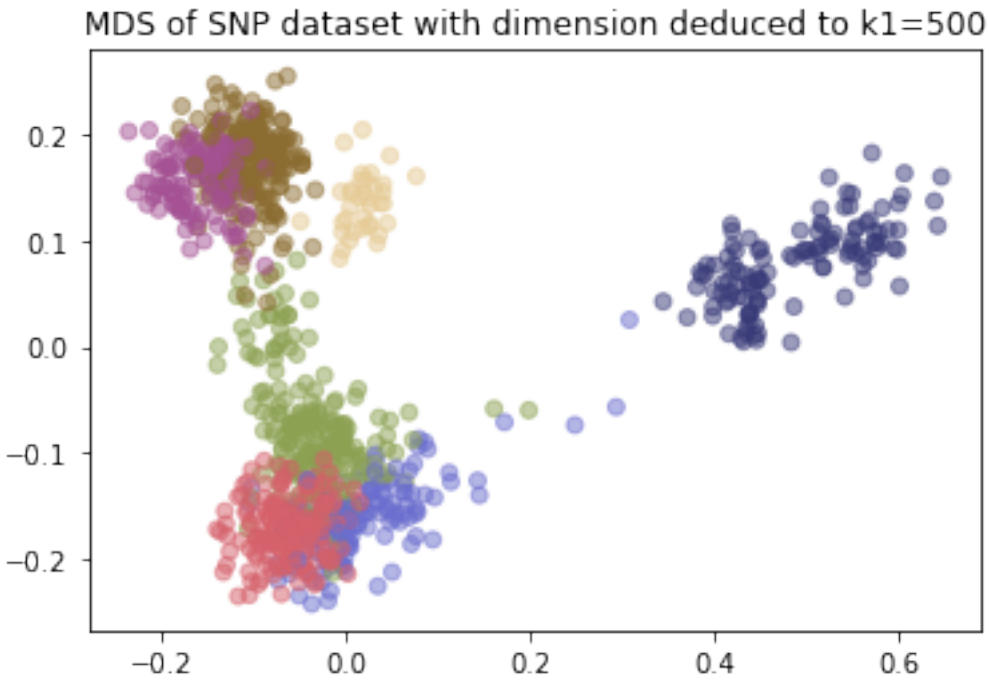
```
/opt/anaconda3/envs/MATH5473/lib/python3.7/site-
packages/ipykernel_launcher.py:2: ComplexWarning: Casting complex values to real
discards the imaginary part

/opt/anaconda3/envs/MATH5473/lib/python3.7/site-
packages/ipykernel_launcher.py:3: ComplexWarning: Casting complex values to real
discards the imaginary part
  This is separate from the ipykernel package so we can avoid doing imports
until
/opt/anaconda3/envs/MATH5473/lib/python3.7/site-
packages/ipykernel_launcher.py:5: ComplexWarning: Casting complex values to real
discards the imaginary part
  """
/opt/anaconda3/envs/MATH5473/lib/python3.7/site-
packages/ipykernel_launcher.py:6: ComplexWarning: Casting complex values to real
discards the imaginary part

/opt/anaconda3/envs/MATH5473/lib/python3.7/site-
packages/ipykernel_launcher.py:9: ComplexWarning: Casting complex values to real
discards the imaginary part
  if __name__ == '__main__':
/opt/anaconda3/envs/MATH5473/lib/python3.7/site-
```

```
packages/ipykernel_launcher.py:10: ComplexWarning: Casting complex values to
real discards the imaginary part
  # Remove the CWD from sys.path while we load stuff.
/opt/anaconda3/envs/MATH5473/lib/python3.7/site-
packages/ipykernel_launcher.py:12: ComplexWarning: Casting complex values to
real discards the imaginary part
  if sys.path[0] == '':
/opt/anaconda3/envs/MATH5473/lib/python3.7/site-
packages/ipykernel_launcher.py:13: ComplexWarning: Casting complex values to
real discards the imaginary part
  del sys.path[0]
```

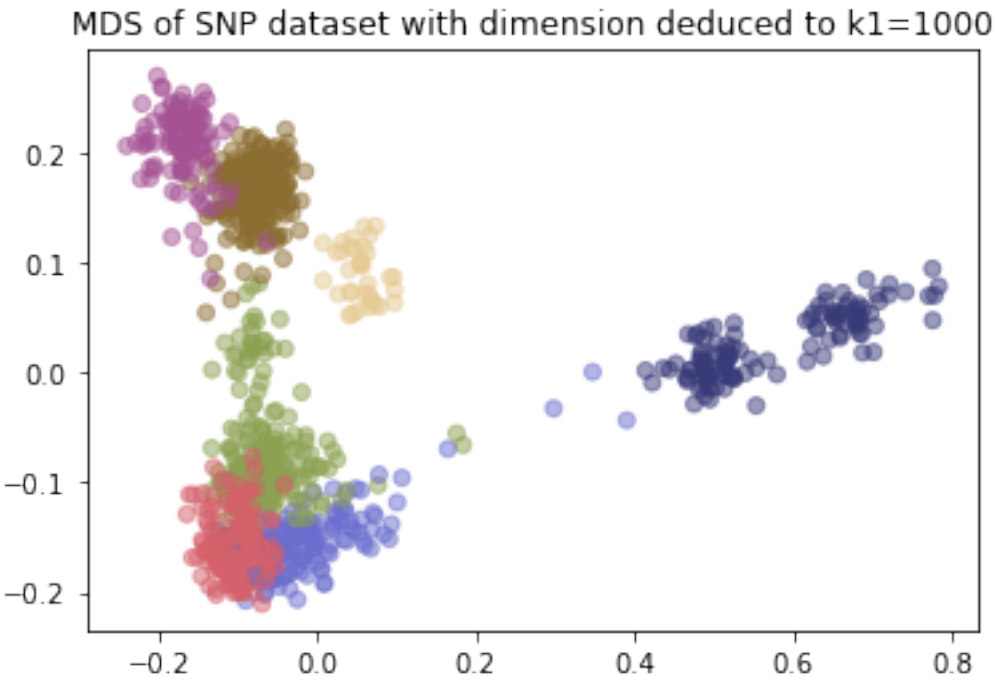
0.0.3 Visualization

[11]:
```
region = info['region']
keys = list(region.unique())
color_range = list(np.linspace(0, 1, len(keys), endpoint=False))
colors = [plt.cm.tab20b(x) for x in color_range]
color_dict = dict(zip(keys, colors))
color_dict['No data'] = 'lightgray'
```

[12]:
```
df1 = pd.DataFrame(dict(pca1=cord1_k1, pca2=cord2_k1, region=region))
fig1, ax1 = plt.subplots()
ax1.scatter(df1['pca1'], df1['pca2'], c=df1['region'].map(color_dict), alpha=0.
↪5)
plt.title('MDS of SNP dataset with dimension deduced to k1=500')
plt.show()
```



[13]:
```
df2 = pd.DataFrame(dict(pca1=cord1_k2, pca2=cord2_k2, region=region))
fig2, ax2 = plt.subplots()
ax2.scatter(df2['pca1'], df2['pca2'], c=df2['region'].map(color_dict), alpha=0.
 ↪5)
plt.title('MDS of SNP dataset with dimension deduced to k1=1000')
plt.show()
```



0.0.4 Conclusion

According to the two graphs above, we can reach the same concluison as introduced in class about the SNP dataset. In this exercise, I have to constrain k to a small number because my computer cannot handle large matrix and give the result. Thus, only k = 500 and k = 1000 are tried.

[ ]:
```
```