In [1]:
```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt

from sklearn.decomposition import PCA

```

In [2]:
```
np.set_printoptions(suppress=True, linewidth=150, precision=2)
np.random.seed(123456)
```

Clusters Specification

In [67]:
```
N = 1000 # Number of Entities
K = 7 # Number of Clusters
V = 5  # Number of Features
minimum = 50  # Minimum Number of Entities in each cluster

remaining = N - K * minimum
remaining
```

Out[67]: 650

In [68]:
```
ur = [np.random.uniform() for k in range(K-1)]
ur.sort()
```

In [69]:
```
structures = []
tmp = []
for k in range(K-1):
    if k == 0:
        tmp.append(ur[k]-0)
    elif k == K-2:
        tmp.append(1-ur[k])
    else:
        tmp.append(ur[k+1]-ur[k])

```

In [70]:
```
structures = [int(remaining*i+ minimum) for i in tmp]
structures += [N - sum(structures)]
print(structures, sum(structures))
```

```
[195, 173, 145, 79, 268, 79, 61] 1000
```

In [71]:
```
d1, d2 = 1, -1
a = 1.0
```

In [72]:
```
mu_1 = np.multiply(np.random.uniform(low=d2, high=d1, size=K), 1.0)
mu_2 = np.multiply(np.random.uniform(low=d2, high=d1, size=K), 0.75
mu_3 = np.multiply(np.random.uniform(low=d2, high=d1, size=K), 0.5)
mu_4 = np.multiply(np.random.uniform(low=d2, high=d1, size=K), 0.25
mu_1
```

Out[72]:
```
array([-0.48,  0.36, -0.27, -0.8 ,  0.64,  0.59, -0.11])
```

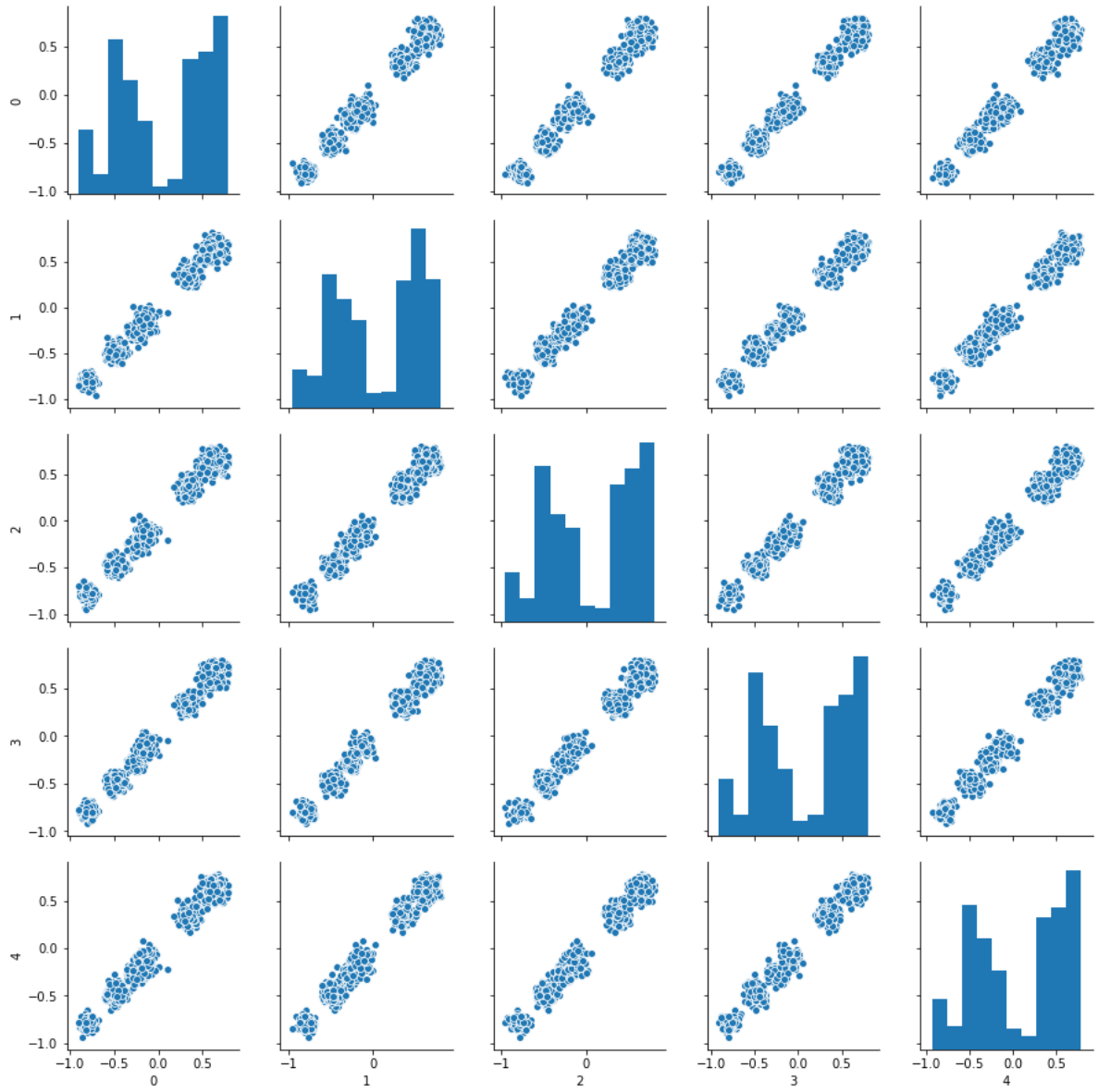
In [73]:
```
d1_ = 0.05*2
d2_ = 0.025*2

cov = np.diag(np.random.uniform(low=d2_, high=d1_, size=(K, K)))
cov
```

Out[73]:
```
array([0.06, 0.06, 0.05, 0.05, 0.06, 0.06, 0.07])
```

Create Y matrix with a=1 (few or no intermix)

In [74]:
```
Y1 = np.zeros([N, V])
interval = 0
for k in range(K):
    for i in range(interval, structures[k]+interval):
        Y1[i, :] = np.random.normal(loc=mu_1[k], scale=cov[k], size
    interval += structures[k]
```

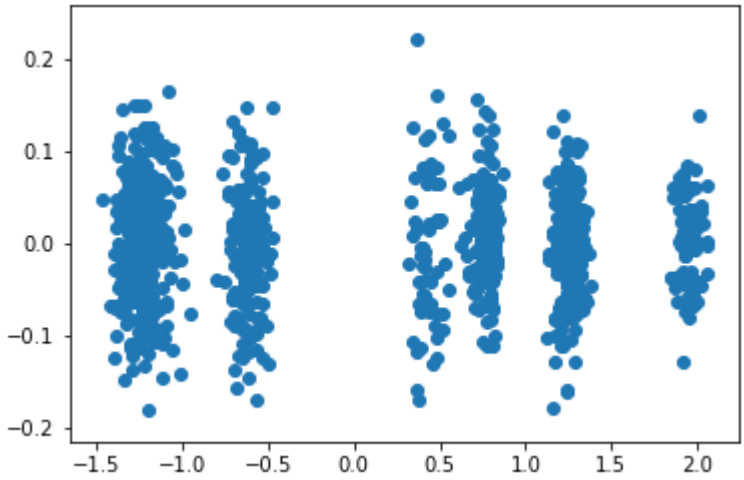
In [75]:
```
t1 = pd.DataFrame(Y1)  # Create a Pandas DataFrame to plot scatter
sns.pairplot(t1)
plt.show()
```



Compute PCA as it is mentioned in the paper

In [76]:
```
pca = PCA(n_components=2)
Y_r1 = pca.fit(Y1).transform(Y1)
```

In [77]:
```
plt.figure()
colors = ['navy', 'turquoise', 'darkorange']
lw = 2
target_names = list(range(V))

plt.scatter(Y_r1[:, 0], Y_r1[:,1])
plt.show()
```

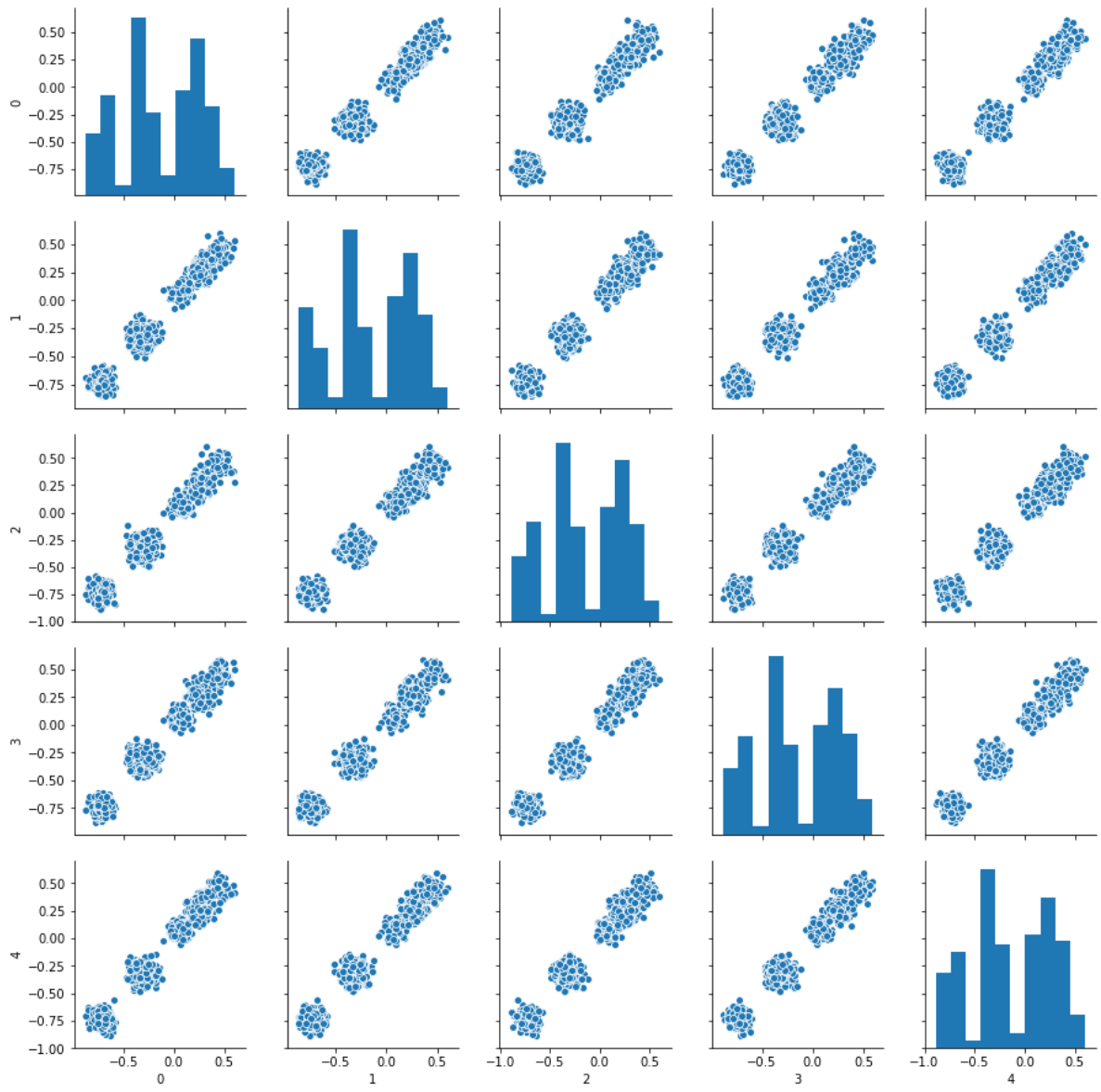


The Problem is' in this scatter plot shows just 5 clusters instead of 7 clusters.

Now let us repeat the procedure with a=0.75

In [78]:
```
Y2 = np.zeros([N, V])
interval = 0
for k in range(K):
    for i in range(interval, structures[k]+interval):
        Y2[i, :] = np.random.normal(loc=mu_2[k], scale=cov[k], size=
    interval += structures[k]
```

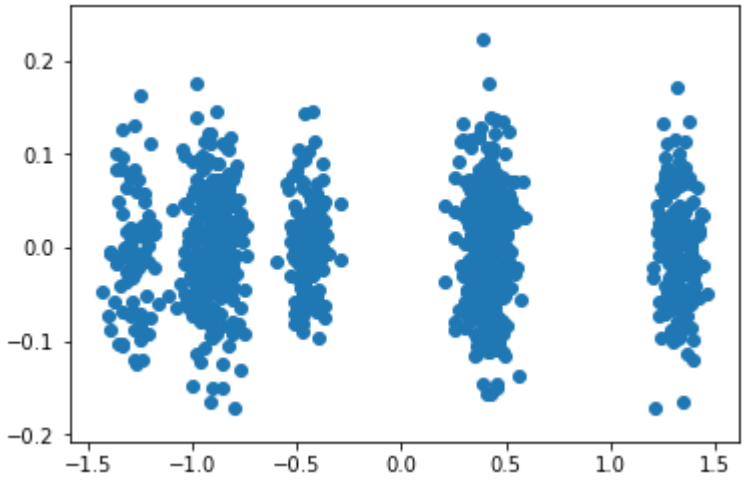
In [79]:
```
t2 = pd.DataFrame(Y2)  # Create a Pandas DataFrame to plot scatter
sns.pairplot(t2)
plt.show()
```



Compute PCA as it is used in the paper

In [80]:
```
pca = PCA(n_components=2)
Y_r2 = pca.fit(Y2).transform(Y2)
```

In [81]:
```
plt.figure()
colors = ['navy', 'turquoise', 'darkorange']
lw = 2
target_names = list(range(V))

plt.scatter(Y_r2[:, 0], Y_r2[:,1])
plt.show()
```

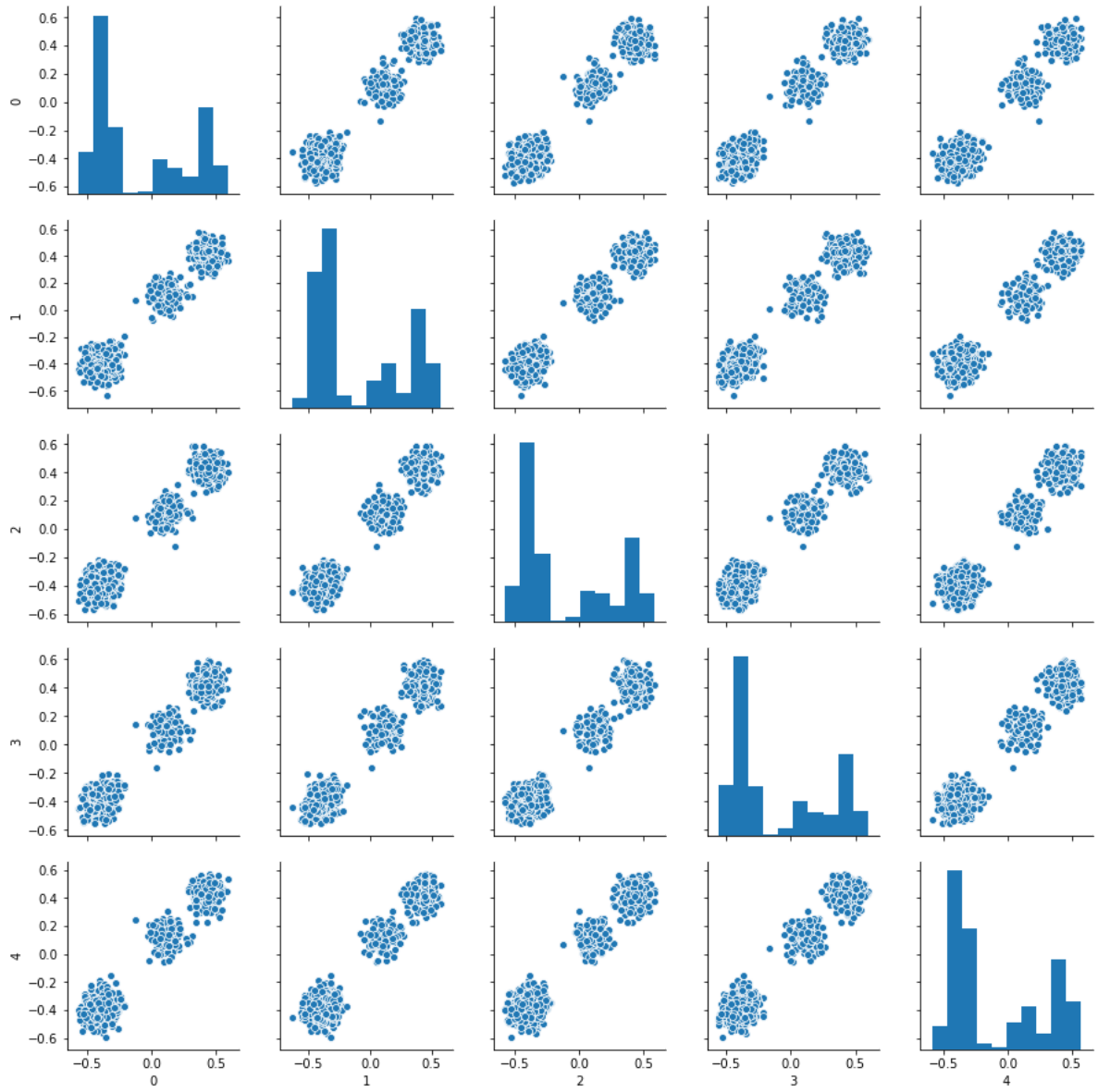


Now the Five clusters are intermixed as we expected!

Now let us repeat the procedure with a=0.5

In [82]:
```
Y3 = np.zeros([N, V])
interval = 0
for k in range(K):
    for i in range(interval, structures[k]+interval):
        Y3[i, :] = np.random.normal(loc=mu_3[k], scale=cov[k], size=
    interval += structures[k]
```

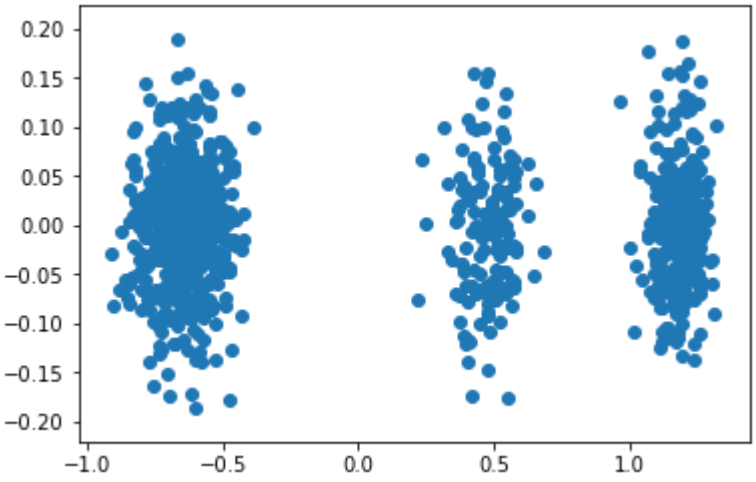
In [83]:
```
t3 = pd.DataFrame(Y3)  # Create a Pandas DataFrame to plot scatter
sns.pairplot(t3)
plt.show()
```



Compute PCA as it is used in the paper

In [84]:
```
pca = PCA(n_components=2)
Y_r3 = pca.fit(Y3).transform(Y3)
```

In [85]:
```
plt.figure()
colors = ['navy', 'turquoise', 'darkorange']
lw = 2
target_names = list(range(V))

plt.scatter(Y_r3[:, 0], Y_r3[:,1])
plt.show()
```



Now the clusters are more intermixed as it is expected!

In [ ]:
```

```