In [1]:

```
pip install pygad
```

```
Collecting pygadNote: you may need to restart the kernel to use updated packages.

  Downloading pygad-3.0.1-py3-none-any.whl (67 kB)
                                              0.0/68.0 kB ? eta -:--:--
                                              0.0/68.0 kB ? eta -:--:--
     ------------------                       30.7/68.0 kB 1.4 MB/s eta 0:00:01
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     ----------------------------------     61.4/68.0 kB 365.7 kB/s eta 0:00:01
     ----------------------------------     61.4/68.0 kB 365.7 kB/s eta 0:00:01
     -------------------------------------- 68.0/68.0 kB 284.3 kB/s eta 0:00:00
Collecting cloudpickle (from pygad)
  Downloading cloudpickle-2.2.1-py3-none-any.whl (25 kB)
Requirement already satisfied: matplotlib in c:\users\91628\appdata\local\programs\python\python311\lib
\site-packages (from pygad) (3.7.1)
Requirement already satisfied: numpy in c:\users\91628\appdata\local\programs\python\python311\lib\site
-packages (from pygad) (1.24.3)
Requirement already satisfied: contourpy>=1.0.1 in c:\users\91628\appdata\local\programs\python\python3
11\lib\site-packages (from matplotlib->pygad) (1.0.7)
Requirement already satisfied: cycler>=0.10 in c:\users\91628\appdata\local\programs\python\python311\l
ib\site-packages (from matplotlib->pygad) (0.11.0)
Requirement already satisfied: fonttools>=4.22.0 in c:\users\91628\appdata\local\programs\python\python
311\lib\site-packages (from matplotlib->pygad) (4.39.4)
Requirement already satisfied: kiwisolver>=1.0.1 in c:\users\91628\appdata\local\programs\python\python
311\lib\site-packages (from matplotlib->pygad) (1.4.4)
Requirement already satisfied: packaging>=20.0 in c:\users\91628\appdata\local\programs\python\python31
1\lib\site-packages (from matplotlib->pygad) (23.1)
Requirement already satisfied: pillow>=6.2.0 in c:\users\91628\appdata\local\programs\python\python311
\lib\site-packages (from matplotlib->pygad) (9.5.0)
Requirement already satisfied: pyparsing>=2.3.1 in c:\users\91628\appdata\local\programs\python\python3
11\lib\site-packages (from matplotlib->pygad) (3.0.9)
Requirement already satisfied: python-dateutil>=2.7 in c:\users\91628\appdata\local\programs\python\pyt
hon311\lib\site-packages (from matplotlib->pygad) (2.8.2)
Requirement already satisfied: six>=1.5 in c:\users\91628\appdata\local\programs\python\python311\lib\s
ite-packages (from python-dateutil>=2.7->matplotlib->pygad) (1.16.0)
Installing collected packages: cloudpickle, pygad
Successfully installed cloudpickle-2.2.1 pygad-3.0.1
```

In [2]:

```python
import numpy
import matplotlib.pyplot
import pygad
```

In [3]:

```python
cluster1_num_samples = 10
cluster1_x1_start = 0
cluster1_x1_end = 5
cluster1_x2_start = 2
cluster1_x2_end = 6
cluster1_x1 = numpy.random.random(size=(cluster1_num_samples))
cluster1_x1 = cluster1_x1 * (cluster1_x1_end - cluster1_x1_start) + cluster1_x1_start
cluster1_x2 = numpy.random.random(size=(cluster1_num_samples))
cluster1_x2 = cluster1_x2 * (cluster1_x2_end - cluster1_x2_start) + cluster1_x2_start
cluster2_num_samples = 10
cluster2_x1_start = 10
cluster2_x1_end = 15
cluster2_x2_start = 8
cluster2_x2_end = 12
cluster2_x1 = numpy.random.random(size=(cluster2_num_samples))
cluster2_x1 = cluster2_x1 * (cluster2_x1_end - cluster2_x1_start) + cluster2_x1_start
cluster2_x2 = numpy.random.random(size=(cluster2_num_samples))
cluster2_x2 = cluster2_x2 * (cluster2_x2_end - cluster2_x2_start) + cluster2_x2_start
```

In [4]:

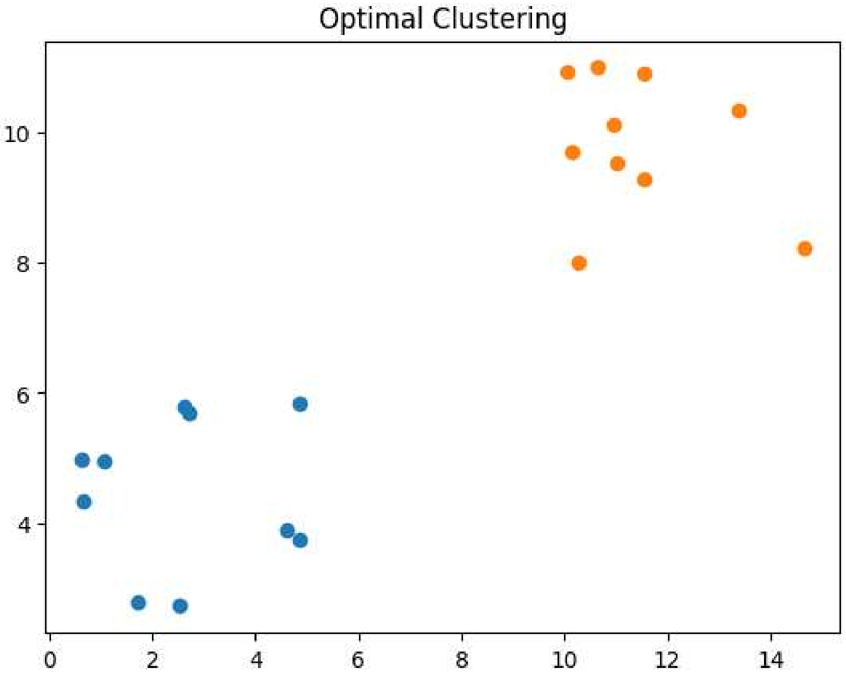
```
c1 = numpy.array([cluster1_x1, cluster1_x2]).T
c2 = numpy.array([cluster2_x1, cluster2_x2]).T
data = numpy.concatenate((c1, c2), axis=0)
data
```

Out[4]:

```
array([[ 1.72288999,  2.78970057],
       [ 0.65357543,  4.3381189 ],
       [ 4.87316912,  5.84203925],
       [ 0.62667858,  4.96530086],
       [ 1.05550037,  4.95532715],
       [ 2.518657  ,  2.71856085],
       [ 2.62407056,  5.78136767],
       [ 4.59644412,  3.88572269],
       [ 2.71063387,  5.69575225],
       [ 4.86343189,  3.74550299],
       [10.05922719, 10.93212316],
       [11.54391504, 10.90589019],
       [13.39747724, 10.35457682],
       [14.65098069,  8.21776617],
       [11.02939397,  9.54262327],
       [10.1517708 ,  9.70583737],
       [10.95065601, 10.12572446],
       [11.551258  ,  9.30203194],
       [10.2802861 ,  8.01532188],
       [10.64584854, 11.00438192]])
```

In [5]:

```
matplotlib.pyplot.scatter(cluster1_x1, cluster1_x2)
matplotlib.pyplot.scatter(cluster2_x1, cluster2_x2)
matplotlib.pyplot.title("Optimal Clustering")
matplotlib.pyplot.show()
```



In [6]:

```
def euclidean_distance(X, Y):
 return numpy.sqrt(numpy.sum(numpy.power(X - Y, 2), axis=1))
```

In [10]:

```
def cluster_data(solution, solution_idx):
 global num_cluster, data
 feature_vector_length = data.shape[1]
 cluster_centers = []
 all_clusters_dists = []
 clusters = []
 clusters_sum_dist = []
 for clust_idx in range(num_clusters):
     cluster_centers.append(solution[feature_vector_length*clust_idx:feature_vector_length*(clust_id
     cluster_center_dists = euclidean_distance(data, cluster_centers[clust_idx])
     all_clusters_dists.append(numpy.array(cluster_center_dists))
 cluster_centers = numpy.array(cluster_centers)
 all_clusters_dists = numpy.array(all_clusters_dists)
 cluster_indices = numpy.argmin(all_clusters_dists, axis=0)
 for clust_idx in range(num_clusters):
     clusters.append(numpy.where(cluster_indices == clust_idx)[0])

 if len(clusters[clust_idx]) == 0:
     clusters_sum_dist.append(0)
 else:
     clusters_sum_dist.append(numpy.sum(all_clusters_dists[clust_idx, clusters[clust_idx]]))
     clusters_sum_dist = numpy.array(clusters_sum_dist)
 return cluster_centers, all_clusters_dists, cluster_indices, clusters, clusters_sum_dist
```

In [11]:

```
def fitness_func(ga_instance,solution, solution_idx):
 _, _, _, _, clusters_sum_dist = cluster_data(solution, solution_idx)
 fitness = 1.0 / (numpy.sum(clusters_sum_dist) + 0.00000001)
 return fitness
```

In [12]:

```
num_clusters = 2
num_genes = num_clusters * data.shape[1]
ga_instance = pygad.GA(num_generations=100,
     sol_per_pop=10,
        num_parents_mating=5,
        init_range_low=-6,
        init_range_high=20,
        keep_parents=2,
        num_genes=num_genes,
        fitness_func=fitness_func,
      suppress_warnings=True)
ga_instance.run()
```

In [13]:

```
best_solution, best_solution_fitness, best_solution_idx = ga_instance.best_solution()
print("Best solution is {bs}".format(bs=best_solution))
print("Fitness of the best solution is {bsf}".format(bsf=best_solution_fitness))
print("Best solution found after {gen} generations".format(gen=ga_instance.best_solution_generation)
```

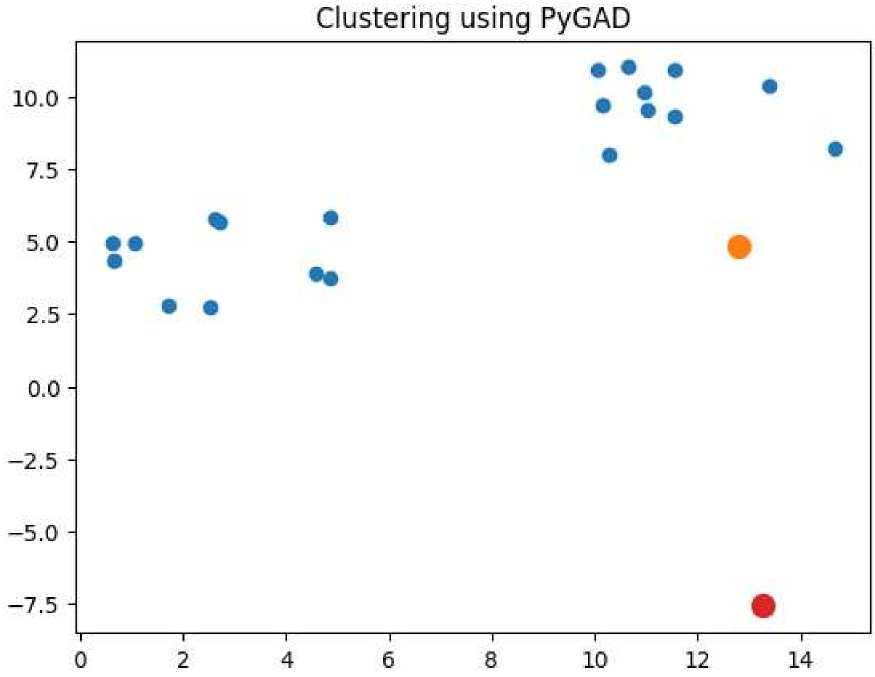
```
Best solution is [12.79744381  4.84048842 13.24723204 -7.57102919]
Fitness of the best solution is 100000000.0
Best solution found after 0 generations
```

In [20]:

```
cluster_centers, all_clusters_dists, cluster_indices, clusters, clusters_sum_dist=cluster_data(best_solu
```

In [21]:

```
for cluster_idx in range(num_clusters):
    cluster_x = data[clusters[cluster_idx], 0]
    cluster_y = data[clusters[cluster_idx], 1]
    matplotlib.pyplot.scatter(cluster_x, cluster_y)
    matplotlib.pyplot.scatter(cluster_centers[cluster_idx, 0], cluster_centers[cluster_idx, 1], lin
matplotlib.pyplot.title("Clustering using PyGAD")
matplotlib.pyplot.show()
```



Clustering using PyGAD

In [ ]: