In [1]:

```
pip install pygad
```

```
Requirement already satisfied: pygad in c:\users\teppa\appdata\local\programs\python\py
thon310\lib\site-packages (3.0.1)
Requirement already satisfied: cloudpickle in c:\users\teppa\appdata\local\programs\pyt
hon\python310\lib\site-packages (from pygad) (2.2.1)
Requirement already satisfied: matplotlib in c:\users\teppa\appdata\local\programs\pyth
on\python310\lib\site-packages (from pygad) (3.7.1)
Requirement already satisfied: numpy in c:\users\teppa\appdata\local\programs\python\py
thon310\lib\site-packages (from pygad) (1.24.3)
Requirement already satisfied: contourpy>=1.0.1 in c:\users\teppa\appdata\local\program
s\python\python310\lib\site-packages (from matplotlib->pygad) (1.0.7)
Requirement already satisfied: cycler>=0.10 in c:\users\teppa\appdata\local\programs\py
thon\python310\lib\site-packages (from matplotlib->pygad) (0.11.0)
Requirement already satisfied: fonttools>=4.22.0 in c:\users\teppa\appdata\local\progra
ms\python\python310\lib\site-packages (from matplotlib->pygad) (4.39.4)
Requirement already satisfied: kiwisolver>=1.0.1 in c:\users\teppa\appdata\local\progra
ms\python\python310\lib\site-packages (from matplotlib->pygad) (1.4.4)
Requirement already satisfied: packaging>=20.0 in c:\users\teppa\appdata\local\programs
\python\python310\lib\site-packages (from matplotlib->pygad) (23.1)
Requirement already satisfied: pillow>=6.2.0 in c:\users\teppa\appdata\local\programs\p
ython\python310\lib\site-packages (from matplotlib->pygad) (9.5.0)
Requirement already satisfied: pyparsing>=2.3.1 in c:\users\teppa\appdata\local\program
s\python\python310\lib\site-packages (from matplotlib->pygad) (3.0.9)
Requirement already satisfied: python-dateutil>=2.7 in c:\users\teppa\appdata\local\pro
grams\python\python310\lib\site-packages (from matplotlib->pygad) (2.8.2)
Requirement already satisfied: six>=1.5 in c:\users\teppa\appdata\local\programs\python
\python310\lib\site-packages (from python-dateutil>=2.7->matplotlib->pygad) (1.16.0)
Note: you may need to restart the kernel to use updated packages.
```

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_star
cluster1_x2 = numpy.random.random(size=(cluster1_num_samples))
cluster1_x2 = cluster1_x2 * (cluster1_x2_end - cluster1_x2_start) + cluster1_x2_star
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_star
cluster2_x2 = numpy.random.random(size=(cluster2_num_samples))
cluster2_x2 = cluster2_x2 * (cluster2_x2_end - cluster2_x2_start) + cluster2_x2_star
```

In [4]:

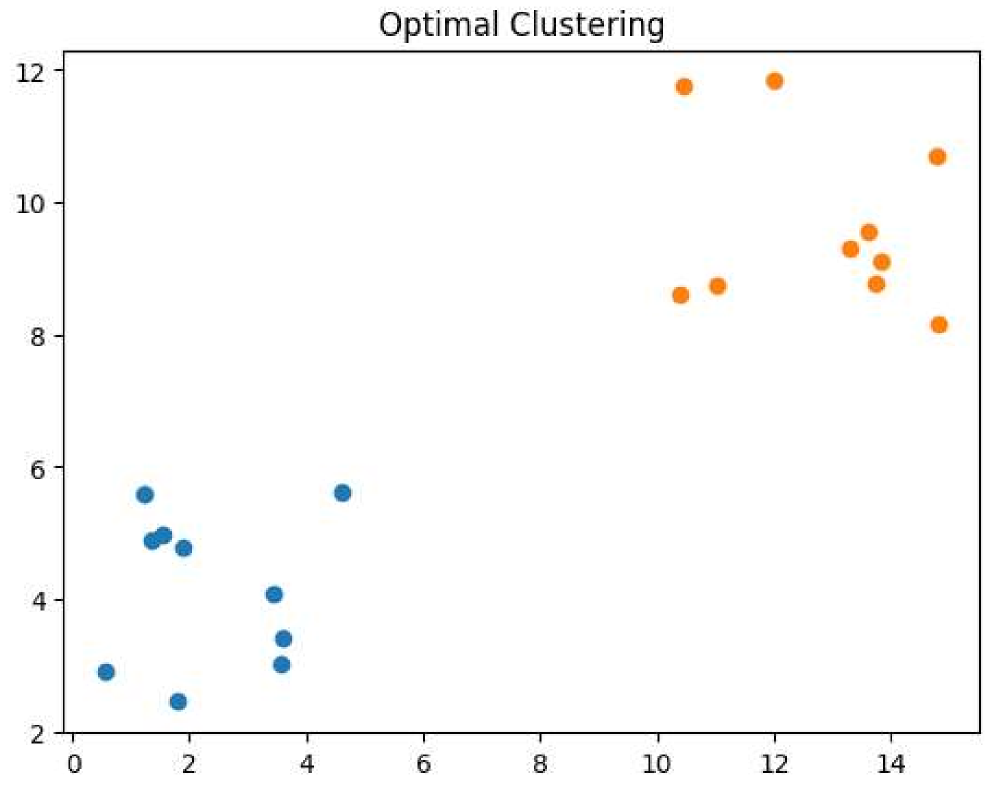
```
c1 = numpy.array([cluster1_x1, cluster1_x2]).T
c2 = numpy.array([cluster2_x1, cluster2_x2]).T
data = numpy.concatenate((c1, c2), axis=0)
data
```

Out[4]:

```
array([[ 1.55331119,  4.99041417],
       [ 3.60682044,  3.4220136 ],
       [ 1.8131347 ,  2.452977  ],
       [ 1.23792428,  5.6012753 ],
       [ 4.60907514,  5.60703768],
       [ 1.36104336,  4.90751325],
       [ 3.56504051,  3.01751409],
       [ 1.88641462,  4.78928166],
       [ 3.45109161,  4.07611465],
       [ 0.56367652,  2.92290524],
       [11.03399448,  8.7449499 ],
       [12.01150988, 11.83227685],
       [10.46568335, 11.76228294],
       [14.80604998,  8.16315304],
       [10.38047679,  8.6041612 ],
       [13.62016714,  9.54872787],
       [13.82516803,  9.11690802],
       [13.75399664,  8.7771184 ],
       [13.30806194,  9.29591619],
       [14.76505165, 10.70519255]])
```

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 [15]:

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

In [19]:

```
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_vect
        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, cluster
    clusters_sum_dist = numpy.array(clusters_sum_dist)
    return cluster_centers, all_clusters_dists, cluster_indices, clusters, clusters_

```

In [20]:

```
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 [21]:

```
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 [22]:

```
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_solu
```

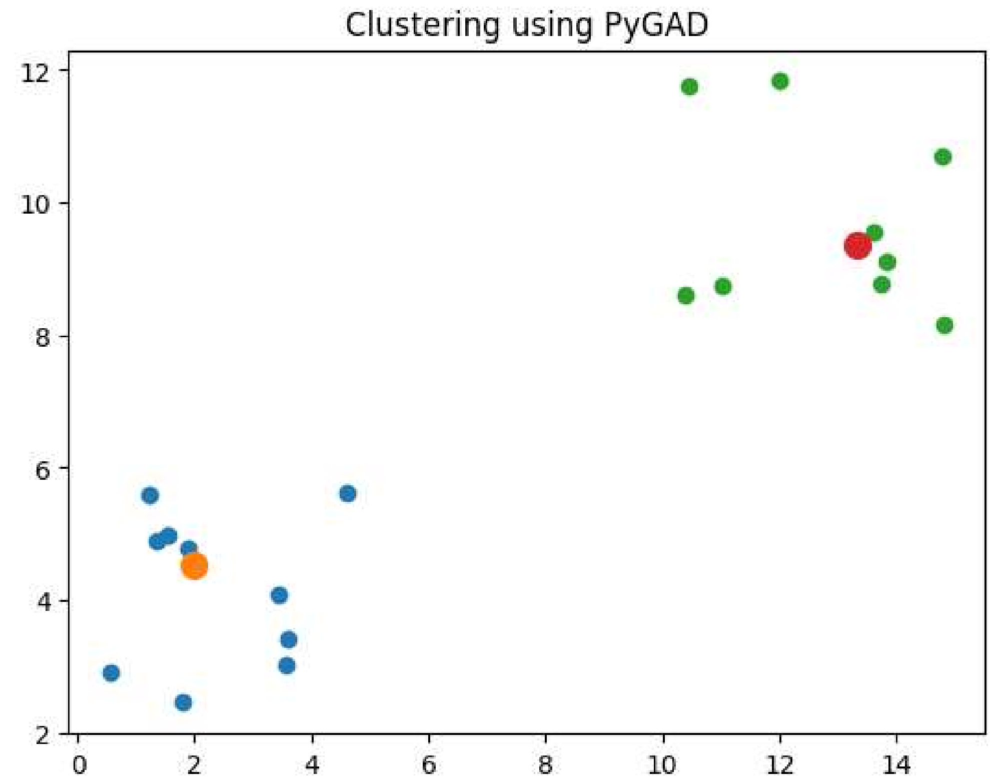
```
Best solution is [ 2.00025129  4.53557572 13.33064791  9.34925505]
Fitness of the best solution is 0.030117799659938056
Best solution found after 55 generations
```

In [28]:

```
cluster_centers, all_clusters_dists, cluster_indices, clusters, clusters_sum_dist= c
```

In [29]:

```
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[cluste
matplotlib.pyplot.title("Clustering using PyGAD")
matplotlib.pyplot.show()
```



In [ ]:

```

```