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 -:--:--
     ------------------                       30.7/68.0 kB 1.4 MB/s eta 0:00:01
     ---------------------------------------- 68.0/68.0 kB 930.9 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\rubin\appdata\local\programs
\python\python310\lib\site-packages (from pygad) (3.7.1)
Requirement already satisfied: numpy in c:\users\rubin\appdata\local\programs\pytho
n\python310\lib\site-packages (from pygad) (1.24.3)
Requirement already satisfied: contourpy>=1.0.1 in c:\users\rubin\appdata\local\pro
grams\python\python310\lib\site-packages (from matplotlib->pygad) (1.0.7)
Requirement already satisfied: cycler>=0.10 in c:\users\rubin\appdata\local\program
s\python\python310\lib\site-packages (from matplotlib->pygad) (0.11.0)
Requirement already satisfied: fonttools>=4.22.0 in c:\users\rubin\appdata\local\pr
ograms\python\python310\lib\site-packages (from matplotlib->pygad) (4.39.4)
Requirement already satisfied: kiwisolver>=1.0.1 in c:\users\rubin\appdata\local\pr
ograms\python\python310\lib\site-packages (from matplotlib->pygad) (1.4.4)
Requirement already satisfied: packaging>=20.0 in c:\users\rubin\appdata\local\prog
rams\python\python310\lib\site-packages (from matplotlib->pygad) (23.1)
Requirement already satisfied: pillow>=6.2.0 in c:\users\rubin\appdata\local\progra
ms\python\python310\lib\site-packages (from matplotlib->pygad) (9.5.0)
Requirement already satisfied: pyparsing>=2.3.1 in c:\users\rubin\appdata\local\pro
grams\python\python310\lib\site-packages (from matplotlib->pygad) (3.0.9)
Requirement already satisfied: python-dateutil>=2.7 in c:\users\rubin\appdata\local
\programs\python\python310\lib\site-packages (from matplotlib->pygad) (2.8.2)
Requirement already satisfied: six>=1.5 in c:\users\rubin\appdata\local\programs\py
thon\python310\lib\site-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]:
```
import numpy
import matplotlib.pyplot
import pygad
```

In [3]:
```
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([[ 2.50314767,  3.5818487 ],
       [ 2.295851  ,  2.81092938],
       [ 1.55567081,  3.42888606],
       [ 1.98683   ,  3.3219831 ],
       [ 1.40946219,  2.83481948],
       [ 4.9073541 ,  2.72400835],
       [ 0.6001436 ,  2.03778139],
       [ 4.02500744,  4.99864003],
       [ 1.35692141,  5.31930467],
       [ 0.68330986,  3.79459406],
       [10.13838048,  8.85205877],
       [13.17419134,  9.35686094],
       [10.45355121,  9.0613304 ],
       [10.87989468,  8.58734682],
       [13.9607056 , 11.70446911],
       [11.4882087 , 10.51976967],
       [14.87479307, 11.78462663],
       [12.81377454,  8.82037644],
       [12.32597703, 10.6938435 ],
       [10.61583297, 11.29975922]])
```

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 [7]:
```
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_vecto
        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 [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
```

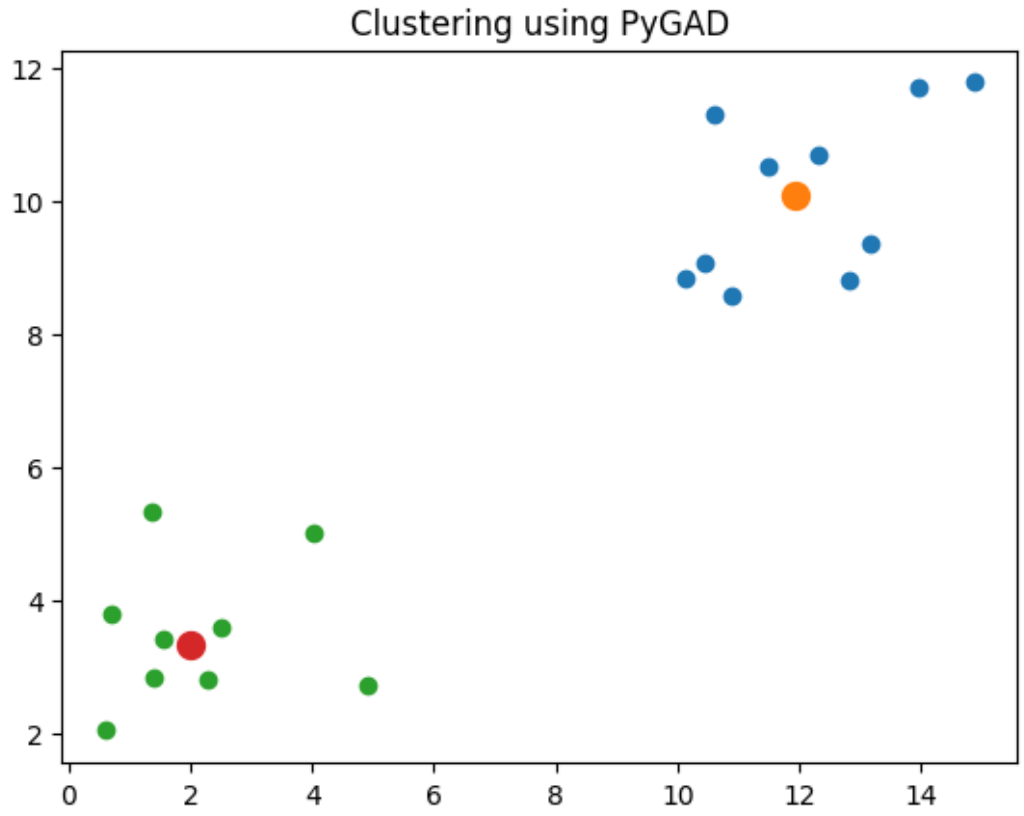
In [12]:
```
num_clusters = 2
num_genes = num_clusters * data.shape[1]
ga_instance = pygad.GA(num_generations=100,
                       sol_per_pop=10,
                       num_parents_mating=5,
                       init_range_low=-6,
                       init_range_high=20,
                       keep_parents=2,
                       num_genes=num_genes,
                       fitness_func=fitness_func,
                       suppress_warnings=True)

ga_instance.run()
```

In [16]:
```
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 [11.9267912  10.09443422  1.99152314  3.33225208]
Fitness of the best solution is 0.03195347860185624
Best solution found after 91 generations
```

In [19]:
```
cluster_centers, all_clusters_dists, cluster_indices, clusters, clusters_sum= cluste
```

In [20]:
```
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[clust
matplotlib.pyplot.title("Clustering using PyGAD")
matplotlib.pyplot.show()
```



In [ ]:
```

```