TSP_GA_son

January 21, 2024

[1]:
```
#pip install pandas numpy tsplib95 matplotlib
```

[2]:
```
import pandas as pd
import numpy as np
import random as rd
from matplotlib import pyplot as plt
import matplotlib.transforms as mtransforms
from math import sqrt
import tsplib95
```

[3]:
```
with open ('turk15.tsp') as f:
    problem = tsplib95.read(f)
```

[4]:
```
print('Problem adı: '+problem.name)
print('Şehir sayısı: '+str(problem.dimension))
```

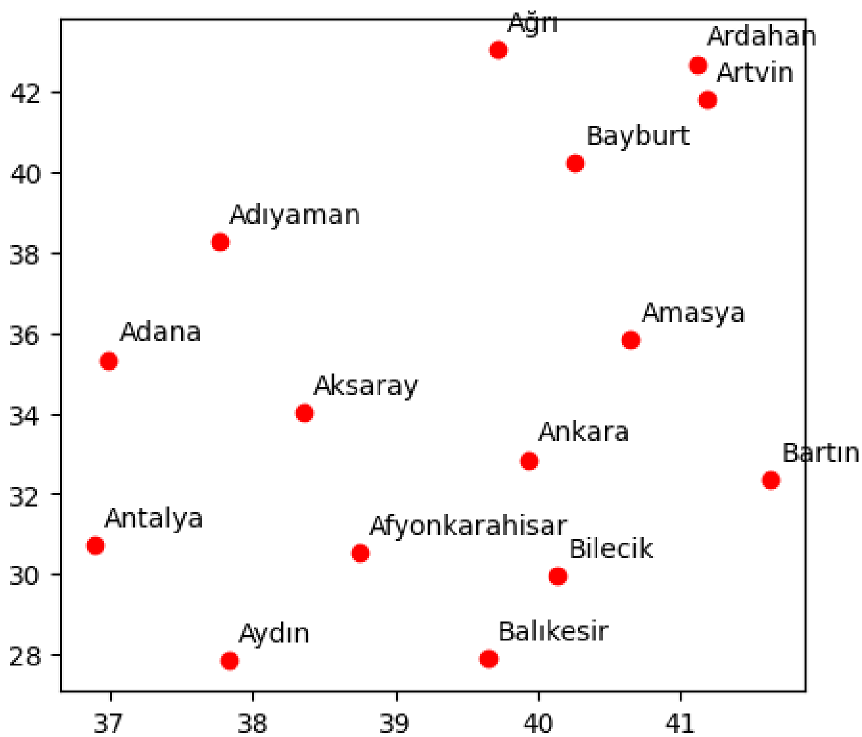
```
Problem adı: turkey15
Şehir sayısı: 15
```

[5]:
```
nodes=list(problem.node_coords.values())

#nodes
```

[6]:
```
#x ve y koordinatlarini diziye ata
node_x=[]
node_y=[]

for i in nodes:
    node_x.append(i[0])
    node_y.append(i[1])

#node_y
```

[7]:
```
cities = ['Adana', 'Adıyaman', 'Afyonkarahisar', 'Ağrı', 'Aksaray', 'Amasya',␣
↪'Ankara', 'Antalya',
          'Ardahan', 'Artvin', 'Aydın', 'Balıkesir', 'Bartın', 'Bayburt',␣
↪'Bilecik']
fig = plt.figure(figsize=(5, 10))
```

```
ax = plt.subplot(2, 1, 1)
trans_offset = mtransforms.offset_copy(ax.transData, fig=fig,
                                       x=0.05, y=0.10, units='inches')
i = 0
for x, y in zip(node_x, node_y):
    plt.plot(x, y, 'ro')
    plt.text(x, y, cities[i], transform=trans_offset)
    i += 1


plt.show()
#atanan x ve y noktalarini cizdir
#plt.scatter(node_x, node_y, marker='s', s=5)
```



[8]:
```
#oklid ile 2 nokta arasi mesafeyi hesaplama
a=[0,0]
b=[5,5]
distance = sqrt(pow(a[0]-b[0], 2) + pow(a[1]-b[1], 2))
distance
```

[8]: 7.0710678118654755

[9]:
```
#oklid ile 2 nokta arasi mesafeyi hesaplama - fonksiyon
def euclidean_dist(a,b):
    ans=sqrt((a[0]-b[0])**2 + (a[1]-b[1])**2)
    return ans
euclidean_dist(a, b)
```

[9]: 7.0710678118654755

[10]:
```
#butun noktalar arasindaki mesafeleri hesapla
temp=[]

for i in nodes:
    temp_row=[]
    for j in nodes:
        temp_row.append(euclidean_dist(i,j))
    temp.append(temp_row)
    #print(temp_row)

#temp
```

[11]:
```
#dataframe e satir sayisi ekle
node_name= []
for i in range(1,16):
    node_name.append(i)

#node_name
```

[12]:
```
#olusturulan mesafeyi dataframe e cevir gorsellestirme vs kolay olmasi icin
Dist=pd.DataFrame(temp, columns=node_name, index=node_name)

#Dist
```

[13]:
```
Dist=pd.DataFrame(temp, columns=node_name, index=node_name)
Dist
```

[13]:

	1	2	3	4	5	6	7 \
1	0.000000	3.039161	5.112494	8.185157	1.895521	3.693995	3.846297
2	3.039161	0.000000	7.803057	5.162451	4.292144	3.782288	5.838262
3	5.112494	7.803057	0.000000	12.556751	3.511723	5.630275	2.602845
4	8.185157	5.162451	12.556751	0.000000	9.130356	7.280934	10.202372
5	1.895521	4.292144	3.511723	9.130356	0.000000	2.918938	1.958009
6	3.693995	3.782288	5.630275	7.280934	2.918938	0.000000	3.065746
7	3.846297	5.838262	2.602845	10.202372	1.958009	3.065746	0.000000
8	4.621082	7.609895	1.868689	12.658120	3.621740	6.352322	3.717687
9	8.443418	5.554044	12.396713	1.443087	9.105213	6.885383	9.920428
10	7.725037	4.929391	11.548550	1.916716	8.294118	6.013402	9.056677
11	7.536956	10.430235	2.842974	15.325746	6.202685	8.473045	5.432320

```
12  7.901215  10.550663   2.789193  15.160119  6.264264  8.002725   4.967897
13  5.525360   7.089464   3.396233  10.890583  3.680897  3.634611   1.777751
14  5.882601   3.170568   9.806947   2.882950  6.484597  4.407289   7.377384
15  6.217081   8.634489   1.498566  13.087066  4.423901  5.882151   2.887646

           8          9         10         11         12         13  \
1    4.621082   8.443418   7.725037   7.536956   7.901215   5.525360
2    7.609895   5.554044   4.929391  10.430235  10.550663   7.089464
3    1.868689  12.396713  11.548550   2.842974   2.789193   3.396233
4   12.658120   1.443087   1.916716  15.325746  15.160119  10.890583
5    3.621740   9.105213   8.294118   6.202685   6.264264   3.680897
6    6.352322   6.885383   6.013402   8.473045   8.002725   3.634611
7    3.717687   9.920428   9.056677   5.432320   4.967897   1.777751
8    0.000000  12.710960  11.909500   3.020017   3.945884   5.009192
9   12.710960   0.000000   0.882780  15.217687  14.881791  10.383029
10  11.909500   0.882780   0.000000  14.375775  14.013772   9.500663
11   3.020017  15.217687  14.375775   0.000000   1.820687   5.882185
12   3.945884  14.881791  14.013772   1.820687   0.000000   4.861481
13   5.009192  10.383029   9.500663   5.882185   4.861481   0.000000
14  10.089450   2.621622   1.845644  12.616232  12.345080   8.008058
15   3.333182  12.766903  11.895550   3.142133   2.136937   2.791003

           14         15
1    5.882601   6.217081
2    3.170568   8.634489
3    9.806947   1.498566
4    2.882950  13.087066
5    6.484597   4.423901
6    4.407289   5.882151
7    7.377384   2.887646
8   10.089450   3.333182
9    2.621622  12.766903
10   1.845644  11.895550
11  12.616232   3.142133
12  12.345080   2.136937
13   8.008058   2.791003
14   0.000000  10.250702
15  10.250702   0.000000
```

[14]:
```python
###### PARAMETRELER

P_size=100  # nufüs büyüklüğü
N_gen=500  # nesil sayısı

p_crossover=0.9  # crossover olasılığı
p_mutation=0.1  # mutation olasılığı
```

```
K=5  # turnuva seçim büyüklüğü
E=10  # elit liste büyüklüğü
```

[15]:
```
rnd_sol = node_name # [1..15] sehir numaralari
def objective(rnd_sol):

    obj=0

    for i in range(len(rnd_sol)):
        Start_node=rnd_sol[i] #rnd_sol[0] = 1

        if i+1==len(rnd_sol):
            End_node=rnd_sol[0] # eger i=15 oldugunda ilk node a git
        else:
            End_node=rnd_sol[i+1] # degilse birer birer devam et

        obj+=Dist[Start_node][End_node]

    return obj

#objective(rnd_sol)
```

[16]:
```
#rasgele 100 tane sonucun uretilmesi. ilk populasyonun tanimlanmasi(100 tane␣
↪gidis guzergahinin tanimlanmasi)
def initialize():

    Loc_Set=list(Dist.columns)

    Pop_list=[]

    for i in range(P_size):
        rnd_sol = rd.sample(Loc_Set, len(Loc_Set))
        Pop_list.append((rnd_sol, objective(rnd_sol)))

    return Pop_list

#initialize()
```

[17]:
```
#cozumleri en iyiye gore siralama. en iyi 10u(E=10 tanimlamistik) alip elit␣
↪liste olusturmak
def elitism(Pop_list):

    Pop_list_ordered=sorted(Pop_list, key=lambda x:x[1])

    Elit_list=[]

    i=0
```

```python
    while len(Elit_list)<E:
        solution=Pop_list_ordered[i][0]
        Elit_add=(solution, objective(solution))
        if Elit_add not in Elit_list:
            Elit_list.append(Elit_add)
        i+=1

    return Elit_list
```

[18]:

```python
#ebeveyn secimi: turnuva ile turnuva secme boyutu kadar (k=5 secmistik). 2␣
↪elemanli ebeveyn listesi hazirlamak
def selection_op():

    parents=[]

    while len(parents)<2:

        tournament_selection_pool=[]

        while len(tournament_selection_pool)<K:

            index=np.random.randint(0, len(Pop_list))


            tournament_selection_pool.append(Pop_list[index])

        tournament_selection_pool_ordered=sorted(tournament_selection_pool,␣
↪key=lambda x: x[1])

        parents.append(tournament_selection_pool_ordered[0])

    return parents
```

[19]:

```python
#crossover ile ebeveynlerden cocuklarin uretilmesi
def crossover_op(parents):
    Childs=[]
    P1=parents[0][0]
    P2=parents[1][0]

    param=len(P1)*0.20
    min_c=param
    max_c=len(P1)-(param-1)

    co_point_1=np.random.randint(min_c,max_c)
    co_point_2=np.random.randint(min_c,max_c)

    P1_seg_1=P1[0:co_point_1]
```

```
    P1_seg_2=P1[co_point_1:len(P1)]

    P2_seg_1=P2[0:co_point_2]
    P2_seg_2=P2[co_point_2:len(P2)]

    temp_1_seg=list(P2)
    temp_2_seg=list(P1)

    ### Birinci çocuk
    op_rand=np.random.rand()
    if op_rand<0.5:
        for i in range(len(P1_seg_1)):
            temp_1_seg.remove(P1_seg_1[i])
        Child_1=P1_seg_1+temp_1_seg
    else:
        for i in range(len(P1_seg_2)):
            temp_1_seg.remove(P1_seg_2[i])
        Child_1=temp_1_seg+P1_seg_2
    Childs.append((Child_1, objective(Child_1)))

    ### İkinci çocuk
    op_rand=np.random.rand()
    if op_rand<0.5:
        for i in range(len(P2_seg_1)):
            temp_2_seg.remove(P2_seg_1[i])
        Child_2=P2_seg_1+temp_2_seg
    else:
        for i in range(len(P2_seg_2)):
            temp_2_seg.remove(P2_seg_2[i])

        Child_2=temp_2_seg+P2_seg_2
    Childs.append((Child_2, objective(Child_2)))
    return Childs
```

[20]:
```
### INSERTION mutasyon yontemi ile mutasyon uygulamak
#mutasyon adayini alarak mutasyona ugratmak

def mutation_op(mutation_cand):

    ran_1=np.random.randint(0,len(mutation_cand))
    ran_2=np.random.randint(0,len(mutation_cand))

    while ran_1==ran_2:
        ran_2=np.random.randint(0,len(mutation_cand))

    x=mutation_cand[ran_1]
    #print(x)
```

```
    mutated=list(mutation_cand)

    mutated.remove(x)

    mutated.insert(ran_2, x)

    return mutated

#print(Pop_list[0][0])
#print(mutation_op(Pop_list[0][0]))
```

[21]:
```
### SWAP
def mutation_op_2(mutation_cand):

    ran_1=np.random.randint(0,len(mutation_cand))
    ran_2=np.random.randint(0,len(mutation_cand))

    while ran_1==ran_2:
        ran_2=np.random.randint(0,len(mutation_cand))
    x=mutation_cand[ran_1]
    y=mutation_cand[ran_2]

    mutated=list(mutation_cand)

    mutated[ran_1]=y
    mutated[ran_2]=x
    return mutated
```

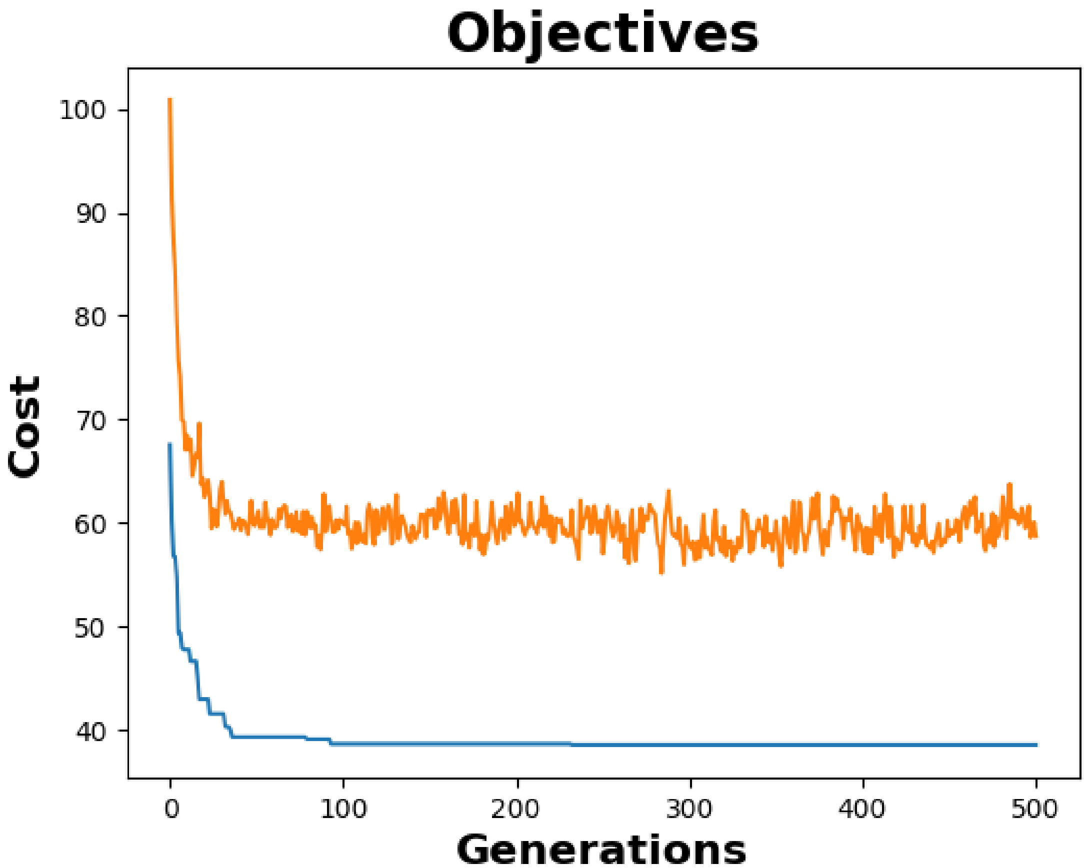
[22]:
```
#gerekli degiskenler
Best_Solutions=[]
Best_Objectives=[]
Best_Ever_Solution=[]
Avg_Objectives=[]
AllSolutions=[]
AllObjectives=[]

#ilk jenerasyonun alinmasi
Pop_list=initialize()
### Jenerasyon-0 için:
Pop_list_ordered=sorted(Pop_list, key=lambda x: x[1]) #siralama

Best_Solutions.append(Pop_list_ordered[0][0])
Best_Objectives.append(Pop_list_ordered[0][1])#en iyi sonucu, onun rotasini,␣
 ↪onun objektif degerini al
#en iyi sonucu jenerasyon bilgisi(0) ile al
Best_Ever_Solution=((Pop_list_ordered[0][0],Pop_list_ordered[0][1],0))
```

```
mean = sum(map(lambda x: x[1], Pop_list))/len(Pop_list)

Avg_Objectives.append(mean)
# 1 den 100.nesile kadar
for i in range(1,N_gen+1):
    New_gen_Pop_list=[]

    for c in range(int((P_size-E)/2)): #ebeveyn secimi (100-10)/2. tamsayi cikmasi icin int yapiyoruz
        Childs=[]
        parents=selection_op()
        rnd=np.random.rand()

        if rnd < p_crossover:
            Childs=crossover_op(parents)
        else:
            Childs=parents
        New_gen_Pop_list=New_gen_Pop_list+Childs

    for p in range(len(New_gen_Pop_list)):  #yeni olusmus cocuklari dolas.
        mutation_cand=New_gen_Pop_list[p][0] #yeni cocuklarin rotasini al
        rnd=np.random.rand()

        if rnd<p_mutation:
            mutated=mutation_op(mutation_cand)
            New_gen_Pop_list[p]=((mutated, objective(mutated)))
        else:
                mutated=mutation_op_2(mutation_cand)
                New_gen_Pop_list[p]=((mutated, objective(mutated)))

    Elit_list=elitism(Pop_list) #bir onceki jenerasyondan en iyileri sec
    New_gen_Pop_list=New_gen_Pop_list+Elit_list  #secilen elitleri yeni jenerasyona ekle
    Pop_list=list(New_gen_Pop_list)#eski jenerasyonu yeni jenerasyon ile degistir
    Pop_list_ordered=sorted(Pop_list, key=lambda x: x[1]) #yeni jenerasyonu en iyiye sirala
    Best_Solutions.append(Pop_list_ordered[0][0]) #en iyi rota ve en iyi cozumu ata
    AllSolutions.append(Pop_list_ordered[0][0])
    AllObjectives.append(Pop_list_ordered[0][1])
    Best_Objectives.append(Pop_list_ordered[0][1])
```

```
    if Pop_list_ordered[0][1] >= Best_Ever_Solution[1]:#olusan en iyi sonucu␣
↪tutmak
        pass
    else: #(en iyi rota, en iyi objektif fonksiyon, jenerasyon bilgisi)
        Best_Ever_Solution=(Pop_list_ordered[0][0], Pop_list_ordered[0][1], i)
    #ortalamayi al
    mean = sum(map(lambda x: x[1], Pop_list))/len(Pop_list)

    Avg_Objectives.append(mean)
```

[23]:
```
Known_Best=38
def printRouteFromSolution(solution):
    cityRoute = ''
    for i in solution:
        cityRoute += cities[i-1] + ', '
    print(cityRoute)
```

[24]:
```
plt.plot(Best_Objectives)
plt.plot(Avg_Objectives)
plt.title('Objectives', fontsize=20, fontweight='bold')
plt.xlabel('Generations', fontsize=16, fontweight='bold')
plt.ylabel('Cost', fontsize=16, fontweight='bold')
plt.show()
```



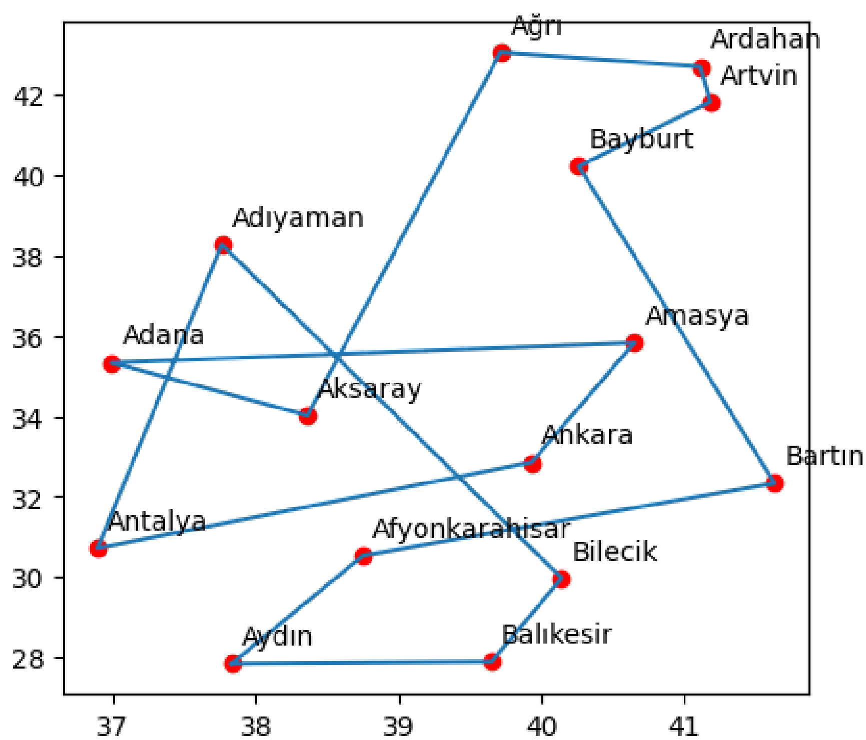

```
[25]: def getNodeXY(solution):
          route_node_x=[]
          route_node_y=[]

          for i in solution:
              route_node_x.append(node_x[i-1])
              route_node_y.append(node_y[i-1])
          route_node_x.append(node_x[solution[0]-1])
          route_node_y.append(node_y[solution[0]-1])
          return route_node_x, route_node_y
```

```
[26]: def plotRoute(route_node_x, route_node_y):
          fig = plt.figure(figsize=(5, 10))
          ax = plt.subplot(2, 1, 1)
          trans_offset = mtransforms.offset_copy(ax.transData, fig=fig, x=0.05, y=0.
       ↪10, units='inches')
          i = 0
          for x, y in zip(node_x, node_y):
              plt.plot(x, y, 'ro')
```

```
        plt.text(x, y, cities[i], transform=trans_offset)
        i += 1
    plt.plot(route_node_x, route_node_y)
    plt.show()
```

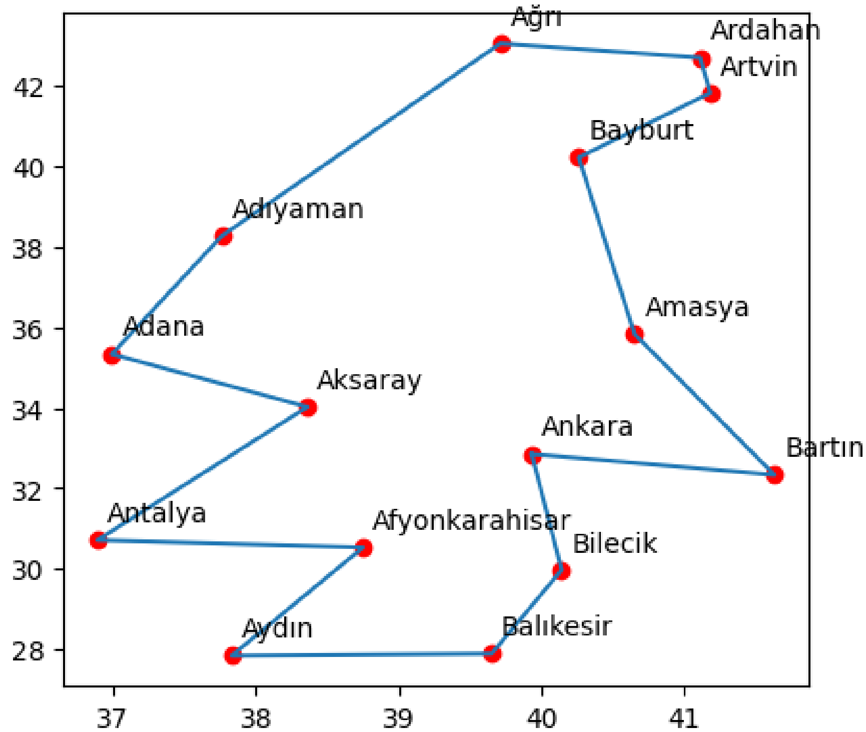
[27]:
```
# 0. nesil
print('Cost                    :', AllObjectives[0])
route_node_x, route_node_y = getNodeXY(AllSolutions[0])
plotRoute(route_node_x, route_node_y)
```

```
Cost                    : 60.124089052641814
```



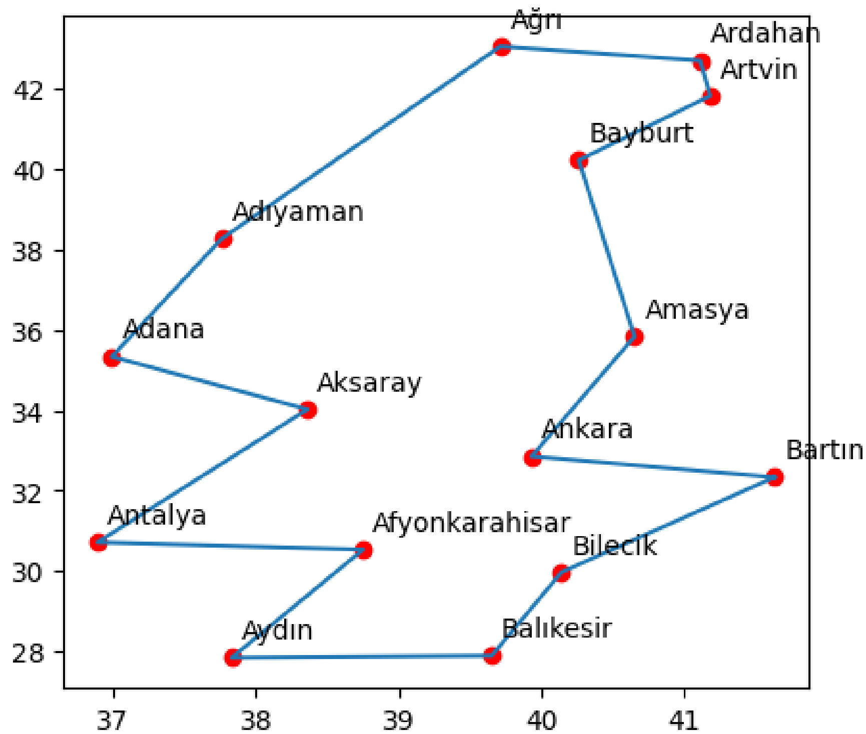
[28]:
```
# 50.nesil
print('Cost                    :', AllObjectives[49])
route_node_x, route_node_y = getNodeXY(AllSolutions[49])
plotRoute(route_node_x, route_node_y)
```

```
Cost                    : 39.266968396326774
```



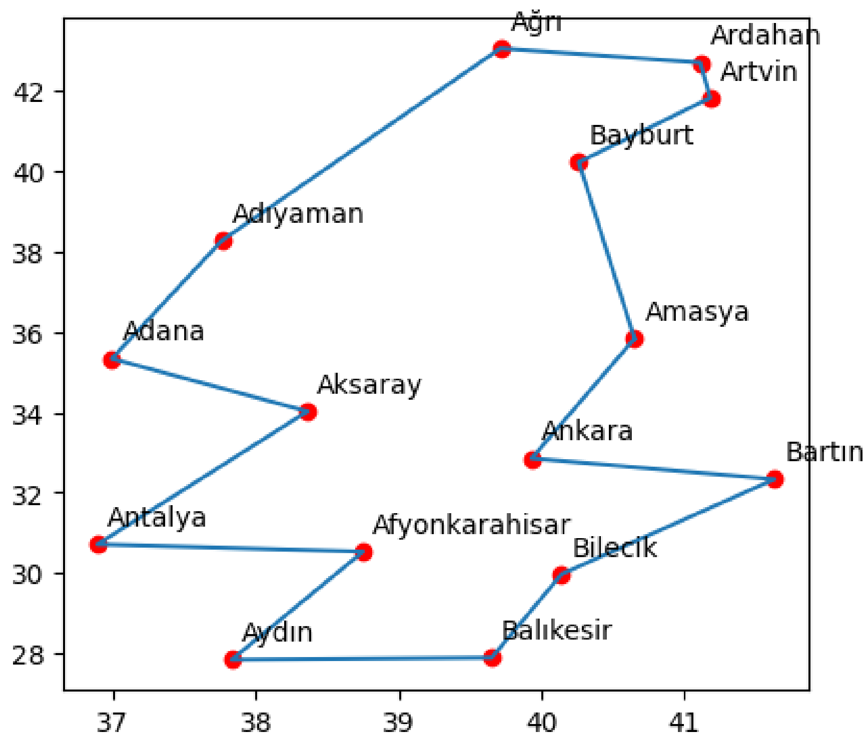
[29]:
```
# 100.nesil
print('Cost                    :', AllObjectives[99])
route_node_x, route_node_y = getNodeXY(AllSolutions[99])
plotRoute(route_node_x, route_node_y)
```

```
Cost                    : 38.60146054259663
```



[30]:
```
# 200. nesil
print('Cost                    :', AllObjectives[199])
route_node_x, route_node_y = getNodeXY(AllSolutions[199])
plotRoute(route_node_x, route_node_y)
```

```
Cost                    : 38.60146054259662
```



[31]:
```
print()
print('####### Solution Output ########')
print('Best Solution       :', Best_Ever_Solution[0])
printRouteFromSolution(Best_Ever_Solution[0])
print()
print('Cost                :', Best_Ever_Solution[1])
print('Found at generation :', Best_Ever_Solution[2])
print('Known Best Solution :', Known_Best)
print('Gap                 : %.2f%%' % ((Best_Ever_Solution[1]-Known_Best)*100/
  ↪Known_Best))
print()
print('####### Parameters ########')
print('Number of generations      : %s' % N_gen)
print('Population size            : %s' % P_size)
print('Probability of crossover   : %.0f%%' % (p_crossover*100))
print('Probability of mutation    : %.0f%%' % (p_mutation*100))
print('Tournament selection       : %s' % K)
print('Elitism selection          : %s' % E)
```

```
####### Solution Output ########
Best Solution       : [6, 14, 10, 9, 4, 2, 1, 5, 7, 3, 8, 11, 12, 15, 13]
Amasya, Bayburt, Artvin, Ardahan, Ağrı, Adıyaman, Adana, Aksaray, Ankara,
```

```
Afyonkarahisar, Antalya, Aydın, Balıkesir, Bilecik, Bartın,

Cost                   : 38.508730949728744
Found at generation : 232
Known Best Solution : 38
Gap                    : 1.34%

####### Parameters ########
Number of generations       : 500
Population size             : 100
Probability of crossover    : 90%
Probability of mutation     : 10%
Tournament selection        : 5
Elitism selection           : 10
```

[32]:

```
# en iyi sonuc
print('Cost                   :', Best_Ever_Solution[1])
route_node_x, route_node_y = getNodeXY(Best_Ever_Solution[0])
plotRoute(route_node_x, route_node_y)
```

```
Cost                   : 38.508730949728744
```