GA_rosenbrock

May 24, 2021

[1]:

```
from numpy.random import randint
from numpy.random import rand
from numpy.random import normal
from random import uniform
```

[2]:

```
def objective(x):
    '''
    rosenbrock function

    :param
     x : coordinates(x,y)

    :returns
     value of rosenbrock function at X(x,y)
    '''
    a = 1
    b = 15
    return ((a - x[0]**2)+b*((x[1]-x[0]**2)**2))
```

[3]:

```
def crossover(p1, p2, r_cross):
    '''
    Crossover function

    :params
     p1 : parent 1
     p2 : parent 2
     r_cross : rate of crossover

    :returns
     c1 : child 1
     c2 : child 2
    '''
    c1, c2 = p1.copy(), p2.copy()
    r = uniform(0, 1.1)
    while(r > 1):
        r = uniform(0, 1.1)
    if r < r_cross:
        c1[0],c1[1] = p1[0], p2[1]
        c2[0],c2[1] = p2[0], p1[1]
    return c1,c2
```

[4]:

```
def mutation(c, r_mut):
    '''
    mutates the child

    :params
     c     : offspring to mutate
     r_mut: rate of mutation

    :returns
     p : offspring
     truth value if mutation was successful or not
    '''
    p = c.copy()
    r = uniform(0, 1.1)
    while(r > 1):
        r = uniform(0, 1.1)
    if r < r_mut:
        idx = randint(0,2)
        p[idx] = float(normal(5,1,1))
        return p, True
    return p, False
```

[5]:

```
def tournament(pop):
    '''
    The crossover function requires two parents to be selected from the␣
 ↪population pool.
    The Tournament is used to do this. Two individuals are selected from the␣
 ↪population
    pool and a random number in [0, 1] is chosen. If this number is less than␣
 ↪the
    'selection rate' (e.g. 0.85), then the fitter individual is selected;␣
 ↪otherwise, the
    weaker one is selected.

    :params
     pop : population

    :returns
     individual who won the tournament
    '''
    c1 = pop[randint(0,len(pop)-1)]
    c2 = pop[randint(0,len(pop)-1)]
    f1 = objective(c1)
    f2 = objective(c2)

    if f1>f2:
        fittest = c1
        weakest = c2
    else:
        fittest = c2
        weakest = c1

    selection_rate = 0.85
    r = uniform(0,1.1)
    while r>1:
        r = uniform(0,1.1)
    if r < selection_rate:
        return fittest
    else:
        return weakest
```

```
[9]: def genetic_algorithm(objective, bounds, n_iter, n_pop, r_cross, r_mut):
    '''
    GA to optimize objective function

    :params
     objective : objective function
     n_iter    : number of generation/number of iterations
     n_pop     : size of population
     r_cross   : rate of crossover
     r_mut     : rate of mutation

    :returns
     best      : best individual
     best_eval : score of best individual
    '''

    pop = []

    # initialize population
    for i in range(n_pop):
        individual = []
        for i in range(2):
            num = float(normal(10,2,1))
            while num < bounds[i][0] and num > bounds[i][1]:
                num = float(normal(10,2,1))
            individual.append(num)
        pop.append(individual)
    Nm = 0                                     # number of mutations
    phi = 0
    sigma = 1
    best = pop[0]
    best_eval = objective(pop[0])

    for gen in range(n_iter):
        scores = [objective(p) for p in pop]   # get scores of all individuals in the population
        for i in range(n_pop):
            if scores[i] < best_eval:
                best, best_eval = pop[i], scores[i]
        print("\n>Generation %d, new best f(%s) = %f" % (gen, best, best_eval))

        next_pop = []
        for i in range(0,n_pop,2):
            # conduct tournament to get 2 parents for crossover
            p1 = tournament(pop)
            p2 = tournament(pop)

            # perform crossover
            c1,c2 = crossover(p1,p2,1.0)

            # mutate child 1
            old_val = objective(c1)
            c1,success = mutation(c1,r_mut)
            if success:
                Nm += 1
                if objective(c1) < old_val:
                    phi = phi + 1

            # mutate child 2
            old_val = objective(c2)
            c2,success = mutation(c2,r_mut)
            if success:
                Nm += 1
                if objective(c2) < old_val:
                    phi = phi + 1

            # add children to next generation population
            next_pop.append(c1)
            next_pop.append(c2)

        print('Total Number of mutations:', Nm)
        if(Nm == 0):
            phi = 0
        else:
            phi = phi / Nm
        if(phi < 0.2):
            sigma = sigma/0.998
        elif(phi > 0.2):
            sigma = sigma*0.998

        # Calculate new adaptive mutation rate to stop too much mutation..
        r_mut = abs(normal(loc=0.0, scale=sigma, size=None))
        while r_mut > 0.2:
            r_mut = abs(normal(loc=0.0, scale=sigma, size=None))
        print('New r_mut:',r_mut)
        Nm = 0
        phi = 0

        # checks if population is stale
        if next_pop == pop:
            print('Stale')

        pop = next_pop
    return best, best_eval
```

[10]:

```
bounds = [(-20,20),(-20,20)]
# total iterations or generations
n_iter = 100
# define the population size
n_pop = 100
# crossover rate
r_cross = 0.9
# mutation rate
r_mut = 0.06

# perform the genetic algorithm search
best, score = genetic_algorithm(objective, bounds, n_iter, n_pop, r_cross,␣
 ↪r_mut)
print('Done!')

print('f(%s) = %f' % (best, score))
```

```
>Generation 0, new best f([5.965200402594902, 8.398873948056824]) = 11050.569263
Total Number of mutations: 5
New r_mut: 0.18631361491797904

>Generation 1, new best f([4.203630407260952, 11.67589385471392]) = 522.360581
Total Number of mutations: 12
New r_mut: 0.10309126680081959
```

```
>Generation 2, new best f([3.7581114286086574, 10.188089245996549]) = 219.176838
Total Number of mutations: 13
New r_mut: 0.043723836767971536

>Generation 3, new best f([3.466455316582394, 10.037822983383014]) = 47.699997
Total Number of mutations: 3
New r_mut: 0.10684580270532879

>Generation 4, new best f([3.466455316582394, 10.037822983383014]) = 47.699997
Total Number of mutations: 14
New r_mut: 0.039286967440486

>Generation 5, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 2
New r_mut: 0.03223922177647788

>Generation 6, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 2
New r_mut: 0.18257642392113071

>Generation 7, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 19
New r_mut: 0.12281579626242248

>Generation 8, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 12
New r_mut: 0.11311113368533103

>Generation 9, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 11
New r_mut: 0.18569164923501036

>Generation 10, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 16
New r_mut: 0.10872354171077002

>Generation 11, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 14
New r_mut: 0.08078657235773659

>Generation 12, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 8
New r_mut: 0.04027742548500188

>Generation 13, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 3
New r_mut: 0.0629254962793096
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>Generation 14, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 5
New r_mut: 0.10212611857134152

>Generation 15, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 13
New r_mut: 0.0776222813634536

>Generation 16, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 11
New r_mut: 0.09620883502652587

>Generation 17, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 12
New r_mut: 0.08633318323870637

>Generation 18, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 6
New r_mut: 0.08381338251954837

>Generation 19, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 10
New r_mut: 0.13935559535157402

>Generation 20, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 11
New r_mut: 0.0460765049915544

>Generation 21, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 2
New r_mut: 0.017093827644218712

>Generation 22, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 2
New r_mut: 0.07894338076027681

>Generation 23, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 3
New r_mut: 0.062255279822668604

>Generation 24, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 4
New r_mut: 0.1254565622058753

>Generation 25, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 10
New r_mut: 0.14310267619209266
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>Generation 26, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 17
New r_mut: 0.114057247768266

>Generation 27, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 18
New r_mut: 0.06213991701643782

>Generation 28, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 3
New r_mut: 0.06669657241842275

>Generation 29, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 8
New r_mut: 0.16550167181642478

>Generation 30, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 18
New r_mut: 0.01533677296211348

>Generation 31, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 1
New r_mut: 0.1877070324049414

>Generation 32, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 20
New r_mut: 0.010667539779933668

>Generation 33, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 0
New r_mut: 0.1816733695449659

>Generation 34, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 14
New r_mut: 0.03916566086809287

>Generation 35, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 3
New r_mut: 0.17431235252384308

>Generation 36, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 17
New r_mut: 0.151795260303818

>Generation 37, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 18
New r_mut: 0.11691166269282377
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>Generation 38, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 18
New r_mut: 0.10454951462488812

>Generation 39, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 14
New r_mut: 0.09033321346174879

>Generation 40, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 8
New r_mut: 0.08760815366173035

>Generation 41, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 8
New r_mut: 0.064916468254598

>Generation 42, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 7
New r_mut: 0.09521118697863167

>Generation 43, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 10
New r_mut: 0.13986351421262155

>Generation 44, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 13
New r_mut: 0.041630868074023455

>Generation 45, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 5
New r_mut: 0.04693826804987859

>Generation 46, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 3
New r_mut: 0.029790200030220423

>Generation 47, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 2
New r_mut: 0.09982406723011736

>Generation 48, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 6
New r_mut: 0.02053410103880698

>Generation 49, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 4
New r_mut: 0.1734758318425255
```

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>Generation 50, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 21
New r_mut: 0.017339006044592348

>Generation 51, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 4
New r_mut: 0.024675410928160495

>Generation 52, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 4
New r_mut: 0.10350854488362983

>Generation 53, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 11
New r_mut: 0.136253375904109

>Generation 54, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 13
New r_mut: 0.012120162270928436

>Generation 55, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 0
New r_mut: 0.07638047643382495

>Generation 56, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 3
New r_mut: 0.1515217805954714

>Generation 57, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 15
New r_mut: 0.057841710907268015

>Generation 58, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 4
New r_mut: 0.12306958749970756

>Generation 59, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 16
New r_mut: 0.043709928304265656

>Generation 60, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 7
New r_mut: 0.1644158916715977

>Generation 61, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 19
New r_mut: 0.002118299002901746
```

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>Generation 62, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 0
New r_mut: 0.09176739691533836

>Generation 63, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 8
New r_mut: 0.12327948433435304

>Generation 64, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 13
New r_mut: 0.023541540355781057

>Generation 65, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 0
New r_mut: 0.04072481609608002

>Generation 66, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 5
New r_mut: 0.1907705502100992

>Generation 67, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 25
New r_mut: 0.17252015549567218

>Generation 68, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 19
New r_mut: 0.18664454828209057

>Generation 69, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 21
New r_mut: 0.17574465889454233

>Generation 70, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 14
New r_mut: 0.18412151117776163

>Generation 71, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 11
New r_mut: 0.07982466272642641

>Generation 72, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 11
New r_mut: 0.16152993881433303

>Generation 73, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 11
New r_mut: 0.10125806940464857
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>Generation 74, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 8
New r_mut: 0.1373638454853567

>Generation 75, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 9
New r_mut: 0.13145716197377605

>Generation 76, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 10
New r_mut: 0.11848698194889859

>Generation 77, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 11
New r_mut: 0.02492406874098456

>Generation 78, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 4
New r_mut: 0.027004632097150944

>Generation 79, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 3
New r_mut: 0.050685535082025154

>Generation 80, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 1
New r_mut: 0.1770284782452878

>Generation 81, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 10
New r_mut: 0.18531362700973333

>Generation 82, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 17
New r_mut: 0.01832377447511275

>Generation 83, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 0
New r_mut: 0.08064172652354118

>Generation 84, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 7
New r_mut: 0.17682581940431813

>Generation 85, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 19
New r_mut: 0.19541794560024012
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>Generation 86, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 17
New r_mut: 0.09198093352019167

>Generation 87, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 6
New r_mut: 0.18811427471015335

>Generation 88, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 18
New r_mut: 0.06964777310972442

>Generation 89, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 6
New r_mut: 0.19341431056771785

>Generation 90, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 19
New r_mut: 0.0031577465887751037

>Generation 91, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 3
New r_mut: 0.016103325359970944

>Generation 92, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 0
New r_mut: 0.10409709873575305

>Generation 93, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 12
New r_mut: 0.04396386984506962

>Generation 94, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 3
New r_mut: 0.18091611990071374

>Generation 95, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 21
New r_mut: 0.09159319186715241

>Generation 96, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 12
New r_mut: 0.013418669396513035

>Generation 97, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 1
New r_mut: 0.03840117835310288
```

```
>Generation 98, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 4
New r_mut: 0.13105716919152874

>Generation 99, new best f([3.306131431744111, 10.9613513578875]) = -9.916233
Total Number of mutations: 9
New r_mut: 0.1251585823537558
Done!
f([3.306131431744111, 10.9613513578875]) = -9.916233
```

```
[ ]:
```