Practical 11

Develop A Genetic Algorithm For Optimization Of Hyper Parameters In Machine Learning.

In [1]:

```
import random
import numpy as np
DATA = [[3, 7],# Benefit, Weight
        [8, 8],
        [3, 4],
        [2, 10],
        [7, 4],
        [9, 6],
        [4, 4]]
INDIVIDUAL_NAMES = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H']
```

In [2]:

```
class Individual:
    def __init__(self, name, encoding):
        self.name = name
        self.encoding = encoding
        self.weight = self.getWeight()
        self.fitness = self.getFitness()
        self.probability = 0
        self.cumProb = 0

    def getWeight(self):
        weightTemp = 0
        for i in range(len(self.encoding)):
            if self.encoding[i] == 1:
                weightTemp += DATA[i][1]
        return weightTemp

    def getFitness(self):
        fitnessTemp = 0
        for i in range(len(self.encoding)):
            if self.encoding[i] == 1:
                fitnessTemp += DATA[i][0]
        if self.weight <= 22:
            return fitnessTemp
        else:
            return 0

    def getEncoding(self):
        return self.encoding

    def setProbability(self, fitness, fitnessCumulative):
        self.probability = fitness/fitnessCumulative

    def setCumProb(self, cumProb):
        self.cumProb = cumProb
```

In [3]:

```
MAX_LOOP = 10
initialPop = True
totalFitnesses = []
```

In [4]:

```
for gen in range(MAX_LOOP):

    print('#################### GENERATION NO', gen, '####################')
    print()
```

```
    print('### New individuals gen', gen, '###')
    INDIVIDUALS = [None for _ in range(len(INDIVIDUAL_NAMES))]
    if initialPop == True:
        random.seed(13)
        for i in range(len(INDIVIDUALS)):
            INDIVIDUALS[i] = Individual(INDIVIDUAL_NAMES[i], [random.randrange(2) for _ in range(len
(DATA))])
            print(INDIVIDUALS[i].name, INDIVIDUALS[i].encoding,
                INDIVIDUALS[i].weight, INDIVIDUALS[i].fitness)
        print()
        initialPop = False

    else:
        INDIVIDUALS = [None for _ in range(len(INDIVIDUAL_NAMES))]
        for i in range(len(INDIVIDUALS)):
            INDIVIDUALS[i] = Individual(INDIVIDUAL_NAMES[i], ENCODINGS[i])
            print(INDIVIDUALS[i].name, INDIVIDUALS[i].encoding,
                INDIVIDUALS[i].weight, INDIVIDUALS[i].fitness)
        print()

    print('### Sorted individuals gen', gen, '###')
    INDIVIDUALS.sort(key=lambda x: x.fitness, reverse=True)

    for i in range(len(INDIVIDUALS)):
        print(INDIVIDUALS[i].name, INDIVIDUALS[i].encoding,
            INDIVIDUALS[i].weight, INDIVIDUALS[i].fitness)

    print()

    print('### Probability of individuals gen', gen, '###')
    fitnessCumulative = 0
    for i in range(len(INDIVIDUALS)):
        fitnessCumulative += INDIVIDUALS[i].fitness

    for i in range(len(INDIVIDUALS)):
        INDIVIDUALS[i].setProbability(INDIVIDUALS[i].fitness, fitnessCumulative)
    for i in range(len(INDIVIDUALS)):
        print(INDIVIDUALS[i].name, INDIVIDUALS[i].encoding,
            INDIVIDUALS[i].weight, INDIVIDUALS[i].fitness, INDIVIDUALS[i].probability)
    totalFitnesses.append(fitnessCumulative)
    print()

    print('### Cumulative probability of individuals gen', gen, '###')
    cumProb = 0
    for i in range(len(INDIVIDUALS)):
        cumProb += INDIVIDUALS[i].probability
        INDIVIDUALS[i].setCumProb(cumProb)
    for i in range(len(INDIVIDUALS)):
        print(INDIVIDUALS[i].name, INDIVIDUALS[i].cumProb)
    print()

    random.seed(13)
    randomRWS = []
    for i in range(len(INDIVIDUALS)):
        randomRWS.append(random.random())

    print('### Generated random values to perform RWS selection gen', gen, '###')
    for i in range(len(randomRWS)):
        print(randomRWS[i])

    print()

    resultRWS = []
    for i in range(len(randomRWS)):
        for j in range(len(INDIVIDUALS)):
            if randomRWS[i] < INDIVIDUALS[j].cumProb:
                resultRWS.append(INDIVIDUALS[j])
                break
            else:
                continue

    print('### Selected individuals gen', gen, '###')
    for i in range(len(resultRWS)):
        print(resultRWS[i].name, resultRWS[i].fitness, resultRWS[i].encoding)

    print()
```

```
    resultRWS.sort(key=lambda x: x.fitness, reverse=True)

    print('### Sorted selected individuals based on fitness gen', gen, '(the two best individuals
will not be crossovered)###')
    for i in range(len(resultRWS)):
        print(resultRWS[i].name, resultRWS[i].fitness, resultRWS[i].encoding)

    print()

    resultRWScopy = resultRWS[2:]
    random.shuffle(resultRWScopy)
    resultRWS[2:] = resultRWScopy

    print('### Multipoint crossover (index 0, 2, 4, 6) gen', gen, '###')
    ENCODINGS = [resultRWS[i].encoding for i in range(2)]

    CROSSOVER = [resultRWS[i].encoding for i in range(2,len(resultRWS[0].encoding)+1)]
    CROSSOVER = np.array(CROSSOVER)
    CROSSOVER = CROSSOVER.tolist()


    print("Before crossover")
    for i in range(len(CROSSOVER)):
        print(CROSSOVER[i])
    print()

    for i in range(0,len(CROSSOVER),2):
        for j in range(0,len(CROSSOVER[0]),2):
            temp = CROSSOVER[i][j]
            CROSSOVER[i][j] = CROSSOVER[i+1][j]
            CROSSOVER[i+1][j] = temp

    print("After crossover")
    for i in range(len(CROSSOVER)):
        print(CROSSOVER[i])
    print()

    ENCODINGS += CROSSOVER
    print('### Elitism individuals + crossovered individuals gen', gen, '###')
    for i in range(len(ENCODINGS)):
        print(ENCODINGS[i])
    print()
```

```
#################### GENERATION NO 0 ####################

### New individuals gen 0 ###
A [1, 1, 0, 0, 0, 0, 0] 15 11
B [0, 0, 0, 1, 0, 1, 0] 16 11
C [0, 1, 0, 0, 1, 1, 1] 22 28
D [0, 1, 1, 0, 1, 1, 1] 26 0
E [1, 1, 0, 1, 1, 1, 0] 35 0
F [1, 1, 0, 1, 0, 0, 1] 29 0
G [1, 1, 1, 1, 1, 1, 0] 39 0
H [1, 0, 0, 0, 1, 0, 0] 11 10

### Sorted individuals gen 0 ###
C [0, 1, 0, 0, 1, 1, 1] 22 28
A [1, 1, 0, 0, 0, 0, 0] 15 11
B [0, 0, 0, 1, 0, 1, 0] 16 11
H [1, 0, 0, 0, 1, 0, 0] 11 10
D [0, 1, 1, 0, 1, 1, 1] 26 0
E [1, 1, 0, 1, 1, 1, 0] 35 0
F [1, 1, 0, 1, 0, 0, 1] 29 0
G [1, 1, 1, 1, 1, 1, 0] 39 0

### Probability of individuals gen 0 ###
C [0, 1, 0, 0, 1, 1, 1] 22 28 0.4666666666666667
A [1, 1, 0, 0, 0, 0, 0] 15 11 0.18333333333333332
B [0, 0, 0, 1, 0, 1, 0] 16 11 0.18333333333333332
H [1, 0, 0, 0, 1, 0, 0] 11 10 0.16666666666666666
D [0, 1, 1, 0, 1, 1, 1] 26 0 0.0
E [1, 1, 0, 1, 1, 1, 0] 35 0 0.0
F [1, 1, 0, 1, 0, 0, 1] 29 0 0.0
G [1, 1, 1, 1, 1, 1, 0] 39 0 0.0

### Cumulative probability of individuals gen 0 ###
```

```
C 0.4666666666666667
A 0.65
B 0.8333333333333334
H 1.0
D 1.0
E 1.0
F 1.0
G 1.0

### Generated random values to perform RWS selection gen 0 ###
0.2590084917154736
0.6852579929645369
0.6840819180161107
0.8493361613899302
0.1857241738737354
0.2305586089654681
0.14715991816841778
0.22516293556211264

### Selected individuals gen 0 ###
C 28 [0, 1, 0, 0, 1, 1, 1]
B 11 [0, 0, 0, 1, 0, 1, 0]
B 11 [0, 0, 0, 1, 0, 1, 0]
H 10 [1, 0, 0, 0, 1, 0, 0]
C 28 [0, 1, 0, 0, 1, 1, 1]
C 28 [0, 1, 0, 0, 1, 1, 1]
C 28 [0, 1, 0, 0, 1, 1, 1]
C 28 [0, 1, 0, 0, 1, 1, 1]

### Sorted selected individuals based on fitness gen 0 (the two best individuals will not be cross
overed)###
C 28 [0, 1, 0, 0, 1, 1, 1]
C 28 [0, 1, 0, 0, 1, 1, 1]
C 28 [0, 1, 0, 0, 1, 1, 1]
C 28 [0, 1, 0, 0, 1, 1, 1]
C 28 [0, 1, 0, 0, 1, 1, 1]
B 11 [0, 0, 0, 1, 0, 1, 0]
B 11 [0, 0, 0, 1, 0, 1, 0]
H 10 [1, 0, 0, 0, 1, 0, 0]

### Multipoint crossover (index 0, 2, 4, 6) gen 0 ###
Before crossover
[0, 0, 0, 1, 0, 1, 0]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 0, 0, 1, 0, 1, 0]
[0, 1, 0, 0, 1, 1, 1]
[1, 0, 0, 0, 1, 0, 0]

After crossover
[0, 0, 0, 1, 1, 1, 1]
[0, 1, 0, 0, 0, 1, 0]
[0, 1, 0, 0, 0, 1, 0]
[0, 0, 0, 1, 1, 1, 1]
[1, 1, 0, 0, 1, 1, 0]
[0, 0, 0, 0, 1, 0, 1]

### Elitism individuals + crossovered individuals gen 0 ###
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 0, 0, 1, 1, 1, 1]
[0, 1, 0, 0, 0, 1, 0]
[0, 1, 0, 0, 0, 1, 0]
[0, 0, 0, 1, 1, 1, 1]
[1, 1, 0, 0, 1, 1, 0]
[0, 0, 0, 0, 1, 0, 1]

#################### GENERATION NO 1 ####################

### New individuals gen 1 ###
A [0, 1, 0, 0, 1, 1, 1] 22 28
B [0, 1, 0, 0, 1, 1, 1] 22 28
C [0, 0, 0, 1, 1, 1, 1] 24 0
D [0, 1, 0, 0, 0, 1, 0] 14 17
E [0, 1, 0, 0, 0, 1, 0] 14 17
F [0, 0, 0, 1, 1, 1, 1] 24 0
G [1, 1, 0, 0, 1, 1, 0] 25 0
```

```
H [0, 0, 0, 0, 1, 0, 1] 8 11

### Sorted individuals gen 1 ###
A [0, 1, 0, 0, 1, 1, 1] 22 28
B [0, 1, 0, 0, 1, 1, 1] 22 28
D [0, 1, 0, 0, 0, 1, 0] 14 17
E [0, 1, 0, 0, 0, 1, 0] 14 17
H [0, 0, 0, 0, 1, 0, 1] 8 11
C [0, 0, 0, 1, 1, 1, 1] 24 0
F [0, 0, 0, 1, 1, 1, 1] 24 0
G [1, 1, 0, 0, 1, 1, 0] 25 0

### Probability of individuals gen 1 ###
A [0, 1, 0, 0, 1, 1, 1] 22 28 0.27722772277227725
B [0, 1, 0, 0, 1, 1, 1] 22 28 0.27722772277227725
D [0, 1, 0, 0, 0, 1, 0] 14 17 0.16831683168316833
E [0, 1, 0, 0, 0, 1, 0] 14 17 0.16831683168316833
H [0, 0, 0, 0, 1, 0, 1] 8 11 0.10891089108910891
C [0, 0, 0, 1, 1, 1, 1] 24 0 0.0
F [0, 0, 0, 1, 1, 1, 1] 24 0 0.0
G [1, 1, 0, 0, 1, 1, 0] 25 0 0.0

### Cumulative probability of individuals gen 1 ###
A 0.27722772277227725
B 0.5544554455445545
D 0.7227722772277229
E 0.8910891089108912
H 1.0000000000000002
C 1.0000000000000002
F 1.0000000000000002
G 1.0000000000000002

### Generated random values to perform RWS selection gen 1 ###
0.2590084917154736
0.6852579929645369
0.6840819180161107
0.8493361613899302
0.1857241738737354
0.2305586089654681
0.14715991816841778
0.22516293556211264

### Selected individuals gen 1 ###
A 28 [0, 1, 0, 0, 1, 1, 1]
D 17 [0, 1, 0, 0, 0, 1, 0]
D 17 [0, 1, 0, 0, 0, 1, 0]
E 17 [0, 1, 0, 0, 0, 1, 0]
A 28 [0, 1, 0, 0, 1, 1, 1]
A 28 [0, 1, 0, 0, 1, 1, 1]
A 28 [0, 1, 0, 0, 1, 1, 1]
A 28 [0, 1, 0, 0, 1, 1, 1]

### Sorted selected individuals based on fitness gen 1 (the two best individuals will not be cross
overed)###
A 28 [0, 1, 0, 0, 1, 1, 1]
A 28 [0, 1, 0, 0, 1, 1, 1]
A 28 [0, 1, 0, 0, 1, 1, 1]
A 28 [0, 1, 0, 0, 1, 1, 1]
A 28 [0, 1, 0, 0, 1, 1, 1]
D 17 [0, 1, 0, 0, 0, 1, 0]
D 17 [0, 1, 0, 0, 0, 1, 0]
E 17 [0, 1, 0, 0, 0, 1, 0]

### Multipoint crossover (index 0, 2, 4, 6) gen 1 ###
Before crossover
[0, 1, 0, 0, 0, 1, 0]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 0, 1, 0]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 0, 1, 0]

After crossover
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 0, 1, 0]
[0, 1, 0, 0, 0, 1, 0]
[0, 1, 0, 0, 1, 1, 1]
```

```
[0, 1, 0, 0, 0, 1, 0]
[0, 1, 0, 0, 1, 1, 1]

### Elitism individuals + crossovered individuals gen 1 ###
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 0, 1, 0]
[0, 1, 0, 0, 0, 1, 0]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 0, 1, 0]
[0, 1, 0, 0, 1, 1, 1]

#################### GENERATION NO 2 ####################

### New individuals gen 2 ###
A [0, 1, 0, 0, 1, 1, 1] 22 28
B [0, 1, 0, 0, 1, 1, 1] 22 28
C [0, 1, 0, 0, 1, 1, 1] 22 28
D [0, 1, 0, 0, 0, 1, 0] 14 17
E [0, 1, 0, 0, 0, 1, 0] 14 17
F [0, 1, 0, 0, 1, 1, 1] 22 28
G [0, 1, 0, 0, 0, 1, 0] 14 17
H [0, 1, 0, 0, 1, 1, 1] 22 28

### Sorted individuals gen 2 ###
A [0, 1, 0, 0, 1, 1, 1] 22 28
B [0, 1, 0, 0, 1, 1, 1] 22 28
C [0, 1, 0, 0, 1, 1, 1] 22 28
F [0, 1, 0, 0, 1, 1, 1] 22 28
H [0, 1, 0, 0, 1, 1, 1] 22 28
D [0, 1, 0, 0, 0, 1, 0] 14 17
E [0, 1, 0, 0, 0, 1, 0] 14 17
G [0, 1, 0, 0, 0, 1, 0] 14 17

### Probability of individuals gen 2 ###
A [0, 1, 0, 0, 1, 1, 1] 22 28 0.14659685863874344
B [0, 1, 0, 0, 1, 1, 1] 22 28 0.14659685863874344
C [0, 1, 0, 0, 1, 1, 1] 22 28 0.14659685863874344
F [0, 1, 0, 0, 1, 1, 1] 22 28 0.14659685863874344
H [0, 1, 0, 0, 1, 1, 1] 22 28 0.14659685863874344
D [0, 1, 0, 0, 0, 1, 0] 14 17 0.08900523560209424
E [0, 1, 0, 0, 0, 1, 0] 14 17 0.08900523560209424
G [0, 1, 0, 0, 0, 1, 0] 14 17 0.08900523560209424

### Cumulative probability of individuals gen 2 ###
A 0.14659685863874344
B 0.2931937172774869
C 0.43979057591623033
F 0.5863874345549738
H 0.7329842931937172
D 0.8219895287958114
E 0.9109947643979057
G 1.0

### Generated random values to perform RWS selection gen 2 ###
0.2590084917154736
0.6852579929645369
0.6840819180161107
0.8493361613899302
0.1857241738737354
0.2305586089654681
0.14715991816841778
0.22516293556211264

### Selected individuals gen 2 ###
B 28 [0, 1, 0, 0, 1, 1, 1]
H 28 [0, 1, 0, 0, 1, 1, 1]
H 28 [0, 1, 0, 0, 1, 1, 1]
E 17 [0, 1, 0, 0, 0, 1, 0]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]

### Sorted selected individuals based on fitness gen 2 (the two best individuals will not be cross
overed)###
```

```
B 28 [0, 1, 0, 0, 1, 1, 1]
H 28 [0, 1, 0, 0, 1, 1, 1]
H 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
E 17 [0, 1, 0, 0, 0, 1, 0]

### Multipoint crossover (index 0, 2, 4, 6) gen 2 ###
Before crossover
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 0, 1, 0]

After crossover
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 0, 1, 0]
[0, 1, 0, 0, 1, 1, 1]

### Elitism individuals + crossovered individuals gen 2 ###
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 0, 1, 0]
[0, 1, 0, 0, 1, 1, 1]

#################### GENERATION NO 3 ####################

### New individuals gen 3 ###
A [0, 1, 0, 0, 1, 1, 1] 22 28
B [0, 1, 0, 0, 1, 1, 1] 22 28
C [0, 1, 0, 0, 1, 1, 1] 22 28
D [0, 1, 0, 0, 1, 1, 1] 22 28
E [0, 1, 0, 0, 1, 1, 1] 22 28
F [0, 1, 0, 0, 1, 1, 1] 22 28
G [0, 1, 0, 0, 0, 1, 0] 14 17
H [0, 1, 0, 0, 1, 1, 1] 22 28

### Sorted individuals gen 3 ###
A [0, 1, 0, 0, 1, 1, 1] 22 28
B [0, 1, 0, 0, 1, 1, 1] 22 28
C [0, 1, 0, 0, 1, 1, 1] 22 28
D [0, 1, 0, 0, 1, 1, 1] 22 28
E [0, 1, 0, 0, 1, 1, 1] 22 28
F [0, 1, 0, 0, 1, 1, 1] 22 28
H [0, 1, 0, 0, 1, 1, 1] 22 28
G [0, 1, 0, 0, 0, 1, 0] 14 17

### Probability of individuals gen 3 ###
A [0, 1, 0, 0, 1, 1, 1] 22 28 0.13145539906103287
B [0, 1, 0, 0, 1, 1, 1] 22 28 0.13145539906103287
C [0, 1, 0, 0, 1, 1, 1] 22 28 0.13145539906103287
D [0, 1, 0, 0, 1, 1, 1] 22 28 0.13145539906103287
E [0, 1, 0, 0, 1, 1, 1] 22 28 0.13145539906103287
F [0, 1, 0, 0, 1, 1, 1] 22 28 0.13145539906103287
H [0, 1, 0, 0, 1, 1, 1] 22 28 0.13145539906103287
G [0, 1, 0, 0, 0, 1, 0] 14 17 0.07981220657276995

### Cumulative probability of individuals gen 3 ###
A 0.13145539906103287
B 0.26291079812206575
C 0.3943661971830986
D 0.5258215962441315
E 0.6572769953051644
F 0.7887323943661972
H 0.9201877934272301
G 1.0
```

```
### Generated random values to perform RWS selection gen 3 ###
0.2590084917154736
0.6852579929645369
0.6840819180161107
0.8493361613899302
0.1857241738737354
0.2305586089654681
0.14715991816841778
0.22516293556211264

### Selected individuals gen 3 ###
B 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
H 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]

### Sorted selected individuals based on fitness gen 3 (the two best individuals will not be cross
overed)###
B 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
H 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]

### Multipoint crossover (index 0, 2, 4, 6) gen 3 ###
Before crossover
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]

After crossover
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]

### Elitism individuals + crossovered individuals gen 3 ###
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]

#################### GENERATION NO 4 ####################

### New individuals gen 4 ###
A [0, 1, 0, 0, 1, 1, 1] 22 28
B [0, 1, 0, 0, 1, 1, 1] 22 28
C [0, 1, 0, 0, 1, 1, 1] 22 28
D [0, 1, 0, 0, 1, 1, 1] 22 28
E [0, 1, 0, 0, 1, 1, 1] 22 28
F [0, 1, 0, 0, 1, 1, 1] 22 28
G [0, 1, 0, 0, 1, 1, 1] 22 28
H [0, 1, 0, 0, 1, 1, 1] 22 28

### Sorted individuals gen 4 ###
A [0, 1, 0, 0, 1, 1, 1] 22 28
B [0, 1, 0, 0, 1, 1, 1] 22 28
C [0, 1, 0, 0, 1, 1, 1] 22 28
D [0, 1, 0, 0, 1, 1, 1] 22 28
E [0, 1, 0, 0, 1, 1, 1] 22 28
```

```
F [0, 1, 0, 0, 1, 1, 1] 22 28
G [0, 1, 0, 0, 1, 1, 1] 22 28
H [0, 1, 0, 0, 1, 1, 1] 22 28

### Probability of individuals gen 4 ###
A [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
B [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
C [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
D [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
E [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
F [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
G [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
H [0, 1, 0, 0, 1, 1, 1] 22 28 0.125

### Cumulative probability of individuals gen 4 ###
A 0.125
B 0.25
C 0.375
D 0.5
E 0.625
F 0.75
G 0.875
H 1.0

### Generated random values to perform RWS selection gen 4 ###
0.2590084917154736
0.6852579929645369
0.6840819180161107
0.8493361613899302
0.1857241738737354
0.2305586089654681
0.14715991816841778
0.22516293556211264

### Selected individuals gen 4 ###
C 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
G 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]

### Sorted selected individuals based on fitness gen 4 (the two best individuals will not be cross
overed)###
C 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
G 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]

### Multipoint crossover (index 0, 2, 4, 6) gen 4 ###
Before crossover
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]

After crossover
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]

### Elitism individuals + crossovered individuals gen 4 ###
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
```

```
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]

#################### GENERATION NO 5 ####################

### New individuals gen 5 ###
A [0, 1, 0, 0, 1, 1, 1] 22 28
B [0, 1, 0, 0, 1, 1, 1] 22 28
C [0, 1, 0, 0, 1, 1, 1] 22 28
D [0, 1, 0, 0, 1, 1, 1] 22 28
E [0, 1, 0, 0, 1, 1, 1] 22 28
F [0, 1, 0, 0, 1, 1, 1] 22 28
G [0, 1, 0, 0, 1, 1, 1] 22 28
H [0, 1, 0, 0, 1, 1, 1] 22 28

### Sorted individuals gen 5 ###
A [0, 1, 0, 0, 1, 1, 1] 22 28
B [0, 1, 0, 0, 1, 1, 1] 22 28
C [0, 1, 0, 0, 1, 1, 1] 22 28
D [0, 1, 0, 0, 1, 1, 1] 22 28
E [0, 1, 0, 0, 1, 1, 1] 22 28
F [0, 1, 0, 0, 1, 1, 1] 22 28
G [0, 1, 0, 0, 1, 1, 1] 22 28
H [0, 1, 0, 0, 1, 1, 1] 22 28

### Probability of individuals gen 5 ###
A [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
B [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
C [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
D [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
E [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
F [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
G [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
H [0, 1, 0, 0, 1, 1, 1] 22 28 0.125

### Cumulative probability of individuals gen 5 ###
A 0.125
B 0.25
C 0.375
D 0.5
E 0.625
F 0.75
G 0.875
H 1.0

### Generated random values to perform RWS selection gen 5 ###
0.2590084917154736
0.6852579929645369
0.6840819180161107
0.8493361613899302
0.1857241738737354
0.2305586089654681
0.14715991816841778
0.22516293556211264

### Selected individuals gen 5 ###
C 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
G 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]

### Sorted selected individuals based on fitness gen 5 (the two best individuals will not be cross
overed)###
C 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
G 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
```

```
### Multipoint crossover (index 0, 2, 4, 6) gen 5 ###
Before crossover
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]

After crossover
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]

### Elitism individuals + crossovered individuals gen 5 ###
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]

#################### GENERATION NO 6 ####################

### New individuals gen 6 ###
A [0, 1, 0, 0, 1, 1, 1] 22 28
B [0, 1, 0, 0, 1, 1, 1] 22 28
C [0, 1, 0, 0, 1, 1, 1] 22 28
D [0, 1, 0, 0, 1, 1, 1] 22 28
E [0, 1, 0, 0, 1, 1, 1] 22 28
F [0, 1, 0, 0, 1, 1, 1] 22 28
G [0, 1, 0, 0, 1, 1, 1] 22 28
H [0, 1, 0, 0, 1, 1, 1] 22 28

### Sorted individuals gen 6 ###
A [0, 1, 0, 0, 1, 1, 1] 22 28
B [0, 1, 0, 0, 1, 1, 1] 22 28
C [0, 1, 0, 0, 1, 1, 1] 22 28
D [0, 1, 0, 0, 1, 1, 1] 22 28
E [0, 1, 0, 0, 1, 1, 1] 22 28
F [0, 1, 0, 0, 1, 1, 1] 22 28
G [0, 1, 0, 0, 1, 1, 1] 22 28
H [0, 1, 0, 0, 1, 1, 1] 22 28

### Probability of individuals gen 6 ###
A [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
B [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
C [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
D [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
E [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
F [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
G [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
H [0, 1, 0, 0, 1, 1, 1] 22 28 0.125

### Cumulative probability of individuals gen 6 ###
A 0.125
B 0.25
C 0.375
D 0.5
E 0.625
F 0.75
G 0.875
H 1.0

### Generated random values to perform RWS selection gen 6 ###
0.2590084917154736
0.6852579929645369
0.6840819180161107
0.8493361613899302
0.1857241738737354
0.2305586089654681
```

```
0.14715991816841778
0.22516293556211264

### Selected individuals gen 6 ###
C 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
G 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]

### Sorted selected individuals based on fitness gen 6 (the two best individuals will not be cross
overed)###
C 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
G 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]

### Multipoint crossover (index 0, 2, 4, 6) gen 6 ###
Before crossover
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]

After crossover
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]

### Elitism individuals + crossovered individuals gen 6 ###
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]

#################### GENERATION NO 7 ####################

### New individuals gen 7 ###
A [0, 1, 0, 0, 1, 1, 1] 22 28
B [0, 1, 0, 0, 1, 1, 1] 22 28
C [0, 1, 0, 0, 1, 1, 1] 22 28
D [0, 1, 0, 0, 1, 1, 1] 22 28
E [0, 1, 0, 0, 1, 1, 1] 22 28
F [0, 1, 0, 0, 1, 1, 1] 22 28
G [0, 1, 0, 0, 1, 1, 1] 22 28
H [0, 1, 0, 0, 1, 1, 1] 22 28

### Sorted individuals gen 7 ###
A [0, 1, 0, 0, 1, 1, 1] 22 28
B [0, 1, 0, 0, 1, 1, 1] 22 28
C [0, 1, 0, 0, 1, 1, 1] 22 28
D [0, 1, 0, 0, 1, 1, 1] 22 28
E [0, 1, 0, 0, 1, 1, 1] 22 28
F [0, 1, 0, 0, 1, 1, 1] 22 28
G [0, 1, 0, 0, 1, 1, 1] 22 28
H [0, 1, 0, 0, 1, 1, 1] 22 28

### Probability of individuals gen 7 ###
A [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
B [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
C [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
```

```
D [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
E [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
F [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
G [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
H [0, 1, 0, 0, 1, 1, 1] 22 28 0.125

### Cumulative probability of individuals gen 7 ###
A 0.125
B 0.25
C 0.375
D 0.5
E 0.625
F 0.75
G 0.875
H 1.0

### Generated random values to perform RWS selection gen 7 ###
0.2590084917154736
0.6852579929645369
0.6840819180161107
0.8493361613899302
0.1857241738737354
0.2305586089654681
0.14715991816841778
0.22516293556211264

### Selected individuals gen 7 ###
C 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
G 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]

### Sorted selected individuals based on fitness gen 7 (the two best individuals will not be cross
overed)###
C 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
G 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]

### Multipoint crossover (index 0, 2, 4, 6) gen 7 ###
Before crossover
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]

After crossover
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]

### Elitism individuals + crossovered individuals gen 7 ###
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]

#################### GENERATION NO 8 ####################

### New individuals gen 8 ###
```

A [0, 1, 0, 0, 1, 1, 1] 22 28
B [0, 1, 0, 0, 1, 1, 1] 22 28
C [0, 1, 0, 0, 1, 1, 1] 22 28
D [0, 1, 0, 0, 1, 1, 1] 22 28
E [0, 1, 0, 0, 1, 1, 1] 22 28
F [0, 1, 0, 0, 1, 1, 1] 22 28
G [0, 1, 0, 0, 1, 1, 1] 22 28
H [0, 1, 0, 0, 1, 1, 1] 22 28

Sorted individuals gen 8
A [0, 1, 0, 0, 1, 1, 1] 22 28
B [0, 1, 0, 0, 1, 1, 1] 22 28
C [0, 1, 0, 0, 1, 1, 1] 22 28
D [0, 1, 0, 0, 1, 1, 1] 22 28
E [0, 1, 0, 0, 1, 1, 1] 22 28
F [0, 1, 0, 0, 1, 1, 1] 22 28
G [0, 1, 0, 0, 1, 1, 1] 22 28
H [0, 1, 0, 0, 1, 1, 1] 22 28

Probability of individuals gen 8
A [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
B [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
C [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
D [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
E [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
F [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
G [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
H [0, 1, 0, 0, 1, 1, 1] 22 28 0.125

Cumulative probability of individuals gen 8
A 0.125
B 0.25
C 0.375
D 0.5
E 0.625
F 0.75
G 0.875
H 1.0

Generated random values to perform RWS selection gen 8
0.2590084917154736
0.6852579929645369
0.6840819180161107
0.8493361613899302
0.1857241738737354
0.2305586089654681
0.14715991816841778
0.22516293556211264

Selected individuals gen 8
C 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
G 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]

Sorted selected individuals based on fitness gen 8 (the two best individuals will not be cross overed)###
C 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
G 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]

Multipoint crossover (index 0, 2, 4, 6) gen 8
Before crossover
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]

[0, 1, 0, 0, 1, 1, 1]

After crossover
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]

Elitism individuals + crossovered individuals gen 8
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]

#################### GENERATION NO 9 ####################

New individuals gen 9
A [0, 1, 0, 0, 1, 1, 1] 22 28
B [0, 1, 0, 0, 1, 1, 1] 22 28
C [0, 1, 0, 0, 1, 1, 1] 22 28
D [0, 1, 0, 0, 1, 1, 1] 22 28
E [0, 1, 0, 0, 1, 1, 1] 22 28
F [0, 1, 0, 0, 1, 1, 1] 22 28
G [0, 1, 0, 0, 1, 1, 1] 22 28
H [0, 1, 0, 0, 1, 1, 1] 22 28

Sorted individuals gen 9
A [0, 1, 0, 0, 1, 1, 1] 22 28
B [0, 1, 0, 0, 1, 1, 1] 22 28
C [0, 1, 0, 0, 1, 1, 1] 22 28
D [0, 1, 0, 0, 1, 1, 1] 22 28
E [0, 1, 0, 0, 1, 1, 1] 22 28
F [0, 1, 0, 0, 1, 1, 1] 22 28
G [0, 1, 0, 0, 1, 1, 1] 22 28
H [0, 1, 0, 0, 1, 1, 1] 22 28

Probability of individuals gen 9
A [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
B [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
C [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
D [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
E [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
F [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
G [0, 1, 0, 0, 1, 1, 1] 22 28 0.125
H [0, 1, 0, 0, 1, 1, 1] 22 28 0.125

Cumulative probability of individuals gen 9
A 0.125
B 0.25
C 0.375
D 0.5
E 0.625
F 0.75
G 0.875
H 1.0

Generated random values to perform RWS selection gen 9
0.2590084917154736
0.6852579929645369
0.6840819180161107
0.8493361613899302
0.1857241738737354
0.2305586089654681
0.14715991816841778
0.22516293556211264

Selected individuals gen 9
C 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
G 28 [0, 1, 0, 0, 1, 1, 1]

```
C 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]

### Sorted selected individuals based on fitness gen 9 (the two best individuals will not be cross
overed)###
C 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
F 28 [0, 1, 0, 0, 1, 1, 1]
G 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]
B 28 [0, 1, 0, 0, 1, 1, 1]

### Multipoint crossover (index 0, 2, 4, 6) gen 9 ###
Before crossover
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]

After crossover
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]

### Elitism individuals + crossovered individuals gen 9 ###
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
[0, 1, 0, 0, 1, 1, 1]
```