# Practical No: 01

**A. Design a simple neural network model.**

**CODE:**

inputs = float(input("Enter the input: "))

weights = float(input("Enter the weight: "))

bias = float(input("Enter bias: "))

print(' ')

yin = bias + (inputs \* weights)

if yin < 0:

out = 0

elif yin > 1:

out= 1

else:

out = yin

print("Output is: ",out)

print(' ')

print('Ayush Patel : 53004230035')

**B. Calculate the output of neural net. using both binary and bipolar sigmoidal function.**

**CODE:**

import math

n = int(input("Enter no. of elements: "))

yin = 0

for i in range(0,n):

x=float(input("x= "))

w=float(input("w= "))

yin = yin + (x\*w)

b = float(input("b= "))

yin = yin + b

print(' ')

print("yin",yin)

print(' ')

binary\_sigmoidal = (1/(1+(math.e\*\*(-yin))))

print("Binary Sigmoidal= ",round(binary\_sigmoidal,3))

print(' ')

bipolar\_sigmoidal = (2/(1+(math.e\*\*(-yin)))) - 1

print("Bipolar Sigmoidal= ",round(bipolar\_sigmoidal,3))

print(' ')

print('Ayush Patel : 53004230035')

# Practical No: 02

**A. Generate AND/NOT function using McCulloch-Pitts neural network**.

**CODE:**

print("\nANDNOT function using MP\n")

x1inputs = [1,1,0,0]

x2inputs = [1,0,1,0]

print("Considering all weights as excitatory");

w1 = [1,1,1,1]

w2 = [1,1,1,1]

yin = []

print("x1","x2","yin")

for i in range(0,4):

yin.append(x1inputs[i]\*w1[i] + x2inputs[i]\*w2[i])

print(x1inputs[i]," ",x2inputs[i]," ", yin[i])

print("\nConsidering all weights as excitatory");

w1 = [1,1,1,1]

w2 = [-1,-1,-1,-1]

yin = []

print("x1","x2","yin")

for i in range(0,4):

yin.append(x1inputs[i]\*w1[i] + x2inputs[i]\*w2[i])

print(x1inputs[i]," ",x2inputs[i]," ", yin[i])

theta = 2\*1-1

print("Threshold -Theta =",theta)

print("\nApplying Threshold ")

y = []

for i in range(0,4):

if(yin[i]>=theta):

value = 1

y.append(value)

else:

value = 0

y.append(value)

print("x1","x2"," y")

for i in range(0,4):

print(x1inputs[i]," ",x2inputs[i]," ",y[i])

print('\nAyush : 53004230035')

**B. Generate XOR function using McCulloch-Pitts neural net.**

**CODE:**

print("\nXOR function using McClloch-Pitts")

x1inputs = [1,1,0,0]

x2inputs = [1,0,1,0]

print("Calculating z1 = x1w11 + x2w12")

print("Considering one weight as exciatatory and other as inhibitory ")

w11 = [1,1,1,1]

w21 = [-1,-1,-1,-1]

print("x1","x2","z1")

z1 = []

for i in range(0,4):

z1.append(x1inputs[i]\*w11[i] + x2inputs[i]\*w21[i])

print(x1inputs[i]," ",x2inputs[i]," ",z1[i])

print("\nCalculating z1 = x1w21 + x2w22")

print("Considering one weight as exciatatory and other as inhibitory ")

w21 = [-1,-1,-1,-1]

w22 = [1,1,1,1]

print("x1","x2","z2")

z2 = []

for i in range(0,4):

z2.append(x1inputs[i]\*w21[i] + x2inputs[i]\*w22[i])

print(x1inputs[i]," ",x2inputs[i]," ",z2[i])

print("\nApplying Threshold = 1 for z1 and z2")

for i in range(0,4):

if(z1[i]>=1):

z1[i] = 1

else:

z1[i] = 0

if(z2[i]>=1):

z2[i]=1

else:

z2[i]=0

print("z1","z2")

for i in range(0,4):

print(z1[i]," ",z2[i]," ")

print("x1" , "x2" , "yin")

yin = []

v1 = 1

v2 = 1

for i in range(0,4):

yin.append(z1[i]\*v1 + z2[i]\*v2)

print(x1inputs[i]," ",x2inputs[i]," ",yin[i])

y=[]

for i in range(0,4):

if(yin[i]>=1):

y.append(1)

else:

y.append(0)

print("x1","x2","y")

for i in range(0,4):

print(x1inputs[i]," ",x2inputs[i]," ",y[i])

print('\nAyush Patel : 53004230035')

# Practical No: 03

**A. Write a program to implement Hebb’s rule.**

**CODE:**

import numpy as np

x1 = np.array([1,-1,-1,1,-1,-1,1,1,1,1])

x2 = np.array([1,-1,1,1,-1,1,1,1,1,1])

y = np.array([1,-1])

b = 0

wtold = np.zeros((9,)).astype(int)

wtnew = np.zeros((9,)).astype(int)

print("--",wtold)

print("First input with target 1")

for i in range(0,9):

wtnew[i] = wtold[i] + x1[i]\*y[0]

wtold = wtnew

b = b + y[0]

print("New Weights:",wtnew)

print("Bias Value:",b)

print("Second input with target -1")

for i in range(0,9):

wtnew[i] = wtold[i] + x2[i]\*y[1]

b = b + y[1]

print("New Weights:",wtnew)

print("Bias Value:",b)

print('\nAyush Patel : 53004230035')

**B. Write a program to implement delta rule.**

**CODE:**

import numpy as np

np.set\_printoptions(precision = 2)

x = np.zeros((3,))

weights = np.zeros((3,))

desired = np.zeros((3,))

actual = np.zeros((3,))

for i in range(0,3):

x[i] = float(input("Initial Inputs: "))

for i in range(0,3):

weights[i] = float(input("Initial weights: "))

for i in range(0,3):

desired[i] = float(input("Initial Desired: "))

a = float(input("Enter learning rate: "))

print("\nActual",actual)

print("Desired\n",desired)

while True:

if np.array\_equal(desired,actual):

break

else:

for i in range(0,3):

weights[i] = weights[i] + a \*(desired[i] - actual[i])

actual = x\*weights

print("Weights:",weights)

print('\nAyush Patel : 53004230035')

**Practical No: 04**

**A. Write a program for Backpropagation Algorithm**.

**CODE:**

import numpy as np

X=np.array(([2,9],[1,5],[3,6]),dtype=float)

Y=np.array(([92],[86],[89]),dtype=float)

#scale units

X=X/np.amax(X,axis=0)

Y=Y/100;

class NN(object):

def \_\_init\_\_(self):

self.inputsize=2

self.outputsize=1

self.hiddensize=3

self.W1=np.random.randn(self.inputsize,self.hiddensize)

self.W2=np.random.randn(self.hiddensize,self.outputsize)

def forward(self,X):

self.z=np.dot(X,self.W1)

self.z2=self.sigmoidal(self.z)

self.z3=np.dot(self.z2,self.W2)

op=self.sigmoidal(self.z3)

return op;

def sigmoidal(self,s):

return 1/(1+np.exp(-s))

obj=NN()

op=obj.forward(X)

print("actual output\n"+str(op))

print("expected output\n"+str(Y))

print('\nAyush Patel : 53004230035')

**B. Write a program for Error Backpropagation Algorithm.**

**CODE:**

import numpy as np

X=np.array(([2,9],[1,5],[3,6]),dtype=float)

Y=np.array(([92],[86],[89]),dtype=float)

X=X/np.amax(X,axis=0)

Y=Y/100;

class NN(object):

def \_\_init\_\_(self):

self.inputsize=2

self.outputsize=1

self.hiddensize=1

self.W1=np.random.randn(self.inputsize,self.hiddensize)

self.W2=np.random.randn(self.hiddensize,self.outputsize)

def forward(self,X):

self.z=np.dot(X,self.W1)

self.z2=self.sigmoidal(self.z)

self.z3=np.dot(self.z2,self.W2)

op=self.sigmoidal(self.z3)

return op;

def sigmoidal(self,s):

return 1/(1+np.exp(-s))

def sigmoidalprime(self,s):

return s\* (1-s)

def backward(self,X,Y,o):

self.o\_error=Y-o

self.o\_delta=self.o\_error \* self.sigmoidalprime(o)

self.z2\_error=self.o\_delta.dot(self.W2.T)

self.z2\_delta=self.z2\_error \* self.sigmoidalprime(self.z2)

self.W1 = self.W1 + X.T.dot(self.z2\_delta)

self.W2= self.W2+ self.z2.T.dot(self.o\_delta)

def train(self,X,Y):

o=self.forward(X)

self.backward(X,Y,o)

obj=NN()

for i in range(2000):

print("input"+str(X))

print("Actual output"+str(Y))

print("Predicted output"+str(obj.forward(X)))

print("loss"+str(np.mean(np.square(Y-obj.forward(X)))))

obj.train(X,Y)

print('\nAyush Patel: 53004230035')

# Practical No: 05

**A. Write a program for Hopfield Network .**

**CODE:**

import numpy as np

def compute\_next\_state(state,weight):

next\_state = np.where(weight @ state>= 0, +1, -1)

return next\_state

def compute\_final\_state(initial\_state,weight,max\_iter=1000):

previous\_state = initial\_state

next\_state =compute\_next\_state(previous\_state,weight)

is\_stable = np.all(previous\_state == next\_state)

n\_iter = 0

while(not is\_stable) and (n\_iter <= max\_iter):

previous\_state = next\_state;

next\_state = compute\_next\_state(previous\_state,weight)

is\_stable = np.all(previous\_state==next\_state)

n\_iter +=1

return previous\_state, is\_stable,n\_iter

initial\_state = np.array([+1,-1,-1,-1])

weight = np.array([

[0, -1, -1, +1],

[-1, 0, +1, -1],

[-1,+1, 0, -1],

[+1,-1, -1, 0]])

final\_state, is\_stable, n\_iter = compute\_final\_state(initial\_state,weight)

print("Final state",final\_state)

print("is\_Stable",is\_stable)

print('\nAyush Patel : 53004230035')

**B. Write a program for Radial Basis function.**

**CODE:**

**:** R Compiler

D <- matrix(c(-3,1,4), ncol=1)

N <- length(D)

rbf.gauss <- function(gamma=1.0) {

function(x){

exp(-gamma \* norm(as.matrix(x),"F")^2)

}

}

xlim <- c(-5,7)

print(N)

print(xlim)

plot(NULL,xlim=xlim,ylim=c(0,1.25), type = "n")

points(D,rep(0,length(D)), col= 1:N,pch=19)

x.coord = seq(-7,7,length=250)

gamma <- 1.5

for (i in 1:N){

points(x.coord, lapply(x.coord - D[i,],rbf.gauss(gamma)),type="l",col=i)

}

# Practical No: 06

**A. Kohonen Self organizing map .**

**CODE:**

!pip install minisom

import minisom

from minisom import MiniSom

import matplotlib.pyplot as plt

data = [[ 0.80, 0.55, 0.22, 0.03],

[ 0.82, 0.50, 0.23, 0.03],

[ 0.80, 0.54, 0.22, 0.03],

[ 0.80, 0.53, 0.26, 0.03],

[ 0.79, 0.56, 0.22, 0.03],

[ 0.75, 0.60, 0.25, 0.03],

[ 0.77, 0.59, 0.22, 0.03]]

som = MiniSom(6, 6, 4, sigma=0.3, learning\_rate=0.5) # initialization of 6x6 SOM

som.train\_random(data, 100) # trains the SOM with 100 iterations

plt.imshow(som.distance\_map())

print('\nAyush Patel : 53004230035')

**B. Adaptive Resonance Theory .**

**CODE:**

from \_\_future\_\_ import print\_function

from \_\_future\_\_ import division

import numpy as np

class ART:

def \_\_init\_\_(self, n=5, m=10, rho=.5):

self.F1 = np.ones(n)

self.F2 = np.ones(m)

self.Wf = np.random.random((m,n))

self.Wb = np.random.random((n,m))

self.rho = rho

self.active = 0

def learn(self, X):

self.F2[...] = np.dot(self.Wf, X)

I = np.argsort(self.F2[:self.active].ravel())[::-1]

for i in I:

d = (self.Wb[:,i]\*X).sum()/X.sum()

if d >= self.rho:

self.Wb[:,i] \*= X

self.Wf[i,:] = self.Wb[:,i]/(0.5+self.Wb[:,i].sum())

return self.Wb[:,i], i

if self.active < self.F2.size:

i = self.active

self.Wb[:,i] \*= X

self.Wf[i,:] = self.Wb[:,i]/(0.5+self.Wb[:,i].sum())

self.active += 1

return self.Wb[:,i], i

return None,None

if \_\_name\_\_ == '\_\_main\_\_':

np.random.seed(1)

network = ART( 5, 10, rho=0.5)

data = [" O ",

" O O",

" O",

" O O",

" O",

" O O",

" O",

" OO O",

" OO ",

" OO O",

" OO ",

"OOO ",

"OO ",

"O ",

"OO ",

"OOO ",

"OOOO ",

"OOOOO",

"O ",

" O ",

" O ",

" O ",

" O",

" O O",

" OO O",

" OO ",

"OOO ",

"OO ",

"OOOO ",

"OOOOO"]

X = np.zeros(len(data[0]))

for i in range(len(data)):

for j in range(len(data[i])):

X[j] = (data[i][j] == 'O')

Z, k = network.learn(X)

print("|%s|"%data[i],"-> class", k)

print('\nAyush Patel : 53004230035')

**Practical No: 07**

**A. Write a program for Linear Separation .**

**CODE:**

import numpy as np

import matplotlib.pyplot as plt

def create\_distance\_function(a, b, c):

""" 0 = ax + by + c """

def distance(x, y):

""" returns tuple (d, pos)

d is the distance

If pos == -1 point is below the line,

0 on the line and +1 if above the line

"""

nom = a \* x + b \* y + c

if nom == 0:

pos = 0

elif (nom<0 and b<0) or (nom>0 and b>0):

pos = -1

else:

pos = 1

return (np.absolute(nom) / np.sqrt( a \*\* 2 + b \*\* 2), pos)

return distance

points = [ (3.5, 1.8), (1.1, 3.9) ]

fig, ax = plt.subplots()

ax.set\_xlabel("Sweet")

ax.set\_ylabel("Sour")

ax.set\_xlim([-1, 6])

ax.set\_ylim([-1, 8])

X = np.arange(-0.5, 5, 0.1)

colors = ["r", ""] # for the samples

size = 10

for (index, (x, y)) in enumerate(points):

if index== 0:

ax.plot(x, y, "o",

color="darkorange",

markersize=size)

else:

ax.plot(x, y, "oy",

markersize=size)

step = 0.05

for x in np.arange(0, 1+step, step):

slope = np.tan(np.arccos(x))

dist4line1 = create\_distance\_function(slope, -1, 0)

#print("x: ", x, "slope: ", slope)

Y = slope \* X

results = []

for point in points:

results.append(dist4line1(\*point))

#print(slope, results)

if (results[0][1] != results[1][1]):

ax.plot(X, Y, "g-")

else:

ax.plot(X, Y, "r-")

plt.show()

print('\nAyush Patel : 53004230035')

**B. Write a program for Hopfield Network model for associative memory .**

**CODE:**

!pip install neurodynex

from neurodynex.hopfield\_network import network, pattern\_tools, plot\_tools

import matplotlib.pyplot as plt

pattern\_size = 5

# create an instance of the class HopfieldNetwork

hopfield\_net = network.HopfieldNetwork(nr\_neurons= pattern\_size\*\*2)

# instantiate a pattern factory

factory = pattern\_tools.PatternFactory(pattern\_size, pattern\_size)

# create a checkerboard pattern and add it to the pattern list

checkerboard = factory.create\_checkerboard()

pattern\_list = [checkerboard]

# add random patterns to the list

pattern\_list.extend(factory.create\_random\_pattern\_list(nr\_patterns=3, on\_probability=0.5))

plot\_tools.plot\_pattern\_list(pattern\_list)

# how similar are the random patterns and the checkerboard? Check the overlaps

overlap\_matrix = pattern\_tools.compute\_overlap\_matrix(pattern\_list)

plot\_tools.plot\_overlap\_matrix(overlap\_matrix)

# let the hopfield network "learn" the patterns. Note: they are not stored

# explicitly but only network weights are updated !

hopfield\_net.store\_patterns(pattern\_list)

# create a noisy version of a pattern and use that to initialize the network

noisy\_init\_state = pattern\_tools.flip\_n(checkerboard, nr\_of\_flips=4)

hopfield\_net.set\_state\_from\_pattern(noisy\_init\_state)

# from this initial state, let the network dynamics evolve.

states = hopfield\_net.run\_with\_monitoring(nr\_steps=4)

# each network state is a vector. reshape it to the same shape used to create the patterns.

states\_as\_patterns = factory.reshape\_patterns(states)

# plot the states of the network

plot\_tools.plot\_state\_sequence\_and\_overlap(states\_as\_patterns, pattern\_list,

reference\_idx=0, suptitle="Network dynamics")

# Practical No: 08

**A. Membership and Identity Operators | in, not in** .

**1- In Operator**

**CODE:**

list1=[]

print("Enter 5 numbers: ")

for i in range(0,5):

v=int(input())

list1.append(v)

list2=[]

print("Enter 5 numbers: ")

for i in range(0,5):

v=int(input())

list2.append(v)

flag=0

for i in list1:

if i in list2:

flag=1

if(flag==1):

print("The Lists Overlap")

else:

print("The Lists do Not overlap")

print('\nAyush Patel : 53004230035')

**2- not In Operator**

**CODE:**

#Aim: Not in operator in python

list1=[]

c=int(input("Enter the number of elements that you want to insert in List: "))

for i in range(0,c):

ele = int(input("Enter the element: "))

list1.append(ele)

a = int(input("Enter the number that you want to find in List: "))

if a not in list1:

print("\nThe list does not contain", a )

else:

print("\nThe list contains", a )

print('\nAyush Patel : 53004230035')

**B. Membership and Identity Operators | is, is not**.

**1: Implement Membership and Identity Operators is.**

**CODE:**

details =[]

name=input("Enter your name : ")

details.append(name)

age=float(input("Enter your exact age : "))

details.append(age)

roll\_no=int(input("Enter your roll no : "))

details.append(roll\_no)

for i in details:

print(i)

print("Int = ",type(i) is int)

print("Float = ",type(i) is float)

print("String = ",type(i) is str)

print()

print('\nAyush Patel : 53004230035')

**2: Implement Membership and Identity Operators is not.**

**CODE:**

details =[]

name=input("Enter your name : ")

details.append(name)

age=float(input("Enter your exact age : "))

details.append(age)

roll\_no=int(input("Enter your roll no : "))

details.append(roll\_no)

print()

for i in details:

print(i)

print("Not Int = ",type(i) is not int)

print("Not Float = ",type(i) is not float)

print("Not String = ",type(i) is not str)

print('\nAyush Patel : 53004230035')

# Practical No: 09

**A. Find ratios using Fuzzy logic**.

**CODE:**

!pip install fuzzywuzzy

from fuzzywuzzy import fuzz

from fuzzywuzzy import process

print('Ayush Patel - 53004230035')

s1 = "I love fuzzysforfuzzys"

s2 = "I am loving fuzzysforfuzzys"

print ("FuzzyWuzzy Ratio:", fuzz.ratio(s1, s2))

print ("FuzzyWuzzy PartialRatio: ", fuzz.partial\_ratio(s1, s2))

print ("FuzzyWuzzy TokenSortRatio: ", fuzz.token\_sort\_ratio(s1, s2))

print ("FuzzyWuzzy TokenSetRatio: ", fuzz.token\_set\_ratio(s1, s2))

print ("FuzzyWuzzy WRatio: ", fuzz.WRatio(s1, s2),'\n\n')

# for process library,

query = 'fuzzys for fuzzys'

choices = ['fuzzy for fuzzy', 'fuzzy fuzzy', 'g. for fuzzys']

print ("List of ratios: ")

print (process.extract(query, choices), '\n')

print ("Best among the above list: ",process.extractOne(query, choices))

**B. Solve Tipping problem using Fuzzy logic**.

**CODE:**

!pip install fuzzywuzzy

!pip install -U scikit-fuzzy

import skfuzzy as fuzz

from skfuzzy import control as ctrl

import numpy as np

quality = ctrl.Antecedent(np.arange(0, 11, 1), 'quality')

service = ctrl.Antecedent(np.arange(0, 11, 1), 'service')

tip = ctrl.Consequent(np.arange(0, 26, 1), 'tip')

quality.automf(3)

service.automf(3)

tip['low'] = fuzz.trimf(tip.universe, [0, 0, 13])

tip['medium'] = fuzz.trimf(tip.universe, [0, 13, 25])

tip['high'] = fuzz.trimf(tip.universe, [13, 25, 25])

quality['average'].view()

service.view()

tip.view()

rule1 = ctrl.Rule(quality['poor'] | service['poor'], tip['low'])

rule2 = ctrl.Rule(service['average'], tip['medium'])

rule3 = ctrl.Rule(service['good'] | quality['good'], tip['high'])

rule1.view()

tipping\_ctrl = ctrl.ControlSystem([rule1, rule2, rule3])

tipping = ctrl.ControlSystemSimulation(tipping\_ctrl)

tipping.input['quality'] = 6.5

tipping.input['service'] = 9.8

tipping.compute()

print (tipping.output['tip'])

tip.view(sim=tipping)

print('Ayush Patel - 53004230035')

# Practical No: 10

**A. Implementation of a Simple Genetic Algorithm.**

**CODE:**

import random

# Number of individuals in each generation

POPULATION\_SIZE = 100

# Valid genes

GENES = '''abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOP

QRSTUVWXYZ 1234567890, .-;:\_!"#%&/()=?@${[]}'''

# Target string to be generated

TARGET = "UPG College Student "

class Individual(object):

'''

Class representing individual in population

'''

def \_\_init\_\_(self, chromosome):

self.chromosome = chromosome

self.fitness = self.cal\_fitness()

@classmethod

def mutated\_genes(self):

'''

create random genes for mutation

'''

global GENES

gene = random.choice(GENES)

return gene

@classmethod

def create\_gnome(self):

'''

create chromosome or string of genes

'''

global TARGET

gnome\_len = len(TARGET)

return [self.mutated\_genes() for \_ in range(gnome\_len)]

def mate(self, par2):

'''

Perform mating and produce new offspring

'''

# chromosome for offspring

child\_chromosome = []

for gp1, gp2 in zip(self.chromosome, par2.chromosome):

# random probability

prob = random.random()

# if prob is less than 0.45, insert gene

# from parent 1

if prob < 0.45:

child\_chromosome.append(gp1)

# if prob is between 0.45 and 0.90, insert

# gene from parent 2

elif prob < 0.90:

child\_chromosome.append(gp2)

# otherwise insert random gene(mutate),

# for maintaining diversity

else:

child\_chromosome.append(self.mutated\_genes())

# create new Individual(offspring) using

# generated chromosome for offspring

return Individual(child\_chromosome)

def cal\_fitness(self):

'''

Calculate fittness score, it is the number of

characters in string which differ from target

string.

'''

global TARGET

fitness = 0

for gs, gt in zip(self.chromosome, TARGET):

if gs != gt: fitness+= 1

return fitness

# Driver code

def main():

global POPULATION\_SIZE

#current generation

generation = 1

found = False

population = []

# create initial population

for \_ in range(POPULATION\_SIZE):

gnome = Individual.create\_gnome()

population.append(Individual(gnome))

while not found:

# sort the population in increasing order of fitness score

population = sorted(population, key = lambda x:x.fitness)

# if the individual having lowest fitness score ie.

# 0 then we know that we have reached to the target

# and break the loop

if population[0].fitness <= 0:

found = True

break

# Otherwise generate new offsprings for new generation

new\_generation = []

# Perform Elitism, that mean 10% of fittest population

# goes to the next generation

s = int((10\*POPULATION\_SIZE)/100)

new\_generation.extend(population[:s])

# From 50% of fittest population, Individuals

# will mate to produce offspring

s = int((90\*POPULATION\_SIZE)/100)

for \_ in range(s):

parent1 = random.choice(population[:50])

parent2 = random.choice(population[:50])

child = parent1.mate(parent2)

new\_generation.append(child)

population = new\_generation

print("Generation: {}\tString: {}\tFitness: {}".\

format(generation,

"".join(population[0].chromosome),

population[0].fitness))

generation += 1

print("Generation: {}\tString: {}\tFitness: {}".\

format(generation,

"".join(population[0].chromosome),

population[0].fitness))

if \_\_name\_\_ == '\_\_main\_\_':

main()

print('Ayush Patel : 53004230035')

**B. Create two classes: City and Fitness using Genetic Algorithm.**

**CODE:**

import numpy as np, random, operator, pandas as pd, matplotlib.pyplot as plt

class City:

def \_\_init\_\_(self, x, y):

self.x = x

self.y = y

def distance(self, city):

xDis = abs(self.x - city.x)

yDis = abs(self.y - city.y)

distance = np.sqrt((xDis \*\* 2) + (yDis \*\* 2))

return distance

def \_\_repr\_\_(self):

return "(" + str(self.x) + "," + str(self.y) + ")"

class Fitness:

def \_\_init\_\_(self, route):

self.route = route

self.distance = 0

self.fitness= 0.0

def routeDistance(self):

if self.distance ==0:

pathDistance = 0

for i in range(0, len(self.route)):

fromCity = self.route[i]

toCity = None

if i + 1 < len(self.route):

toCity = self.route[i + 1]

else:

toCity = self.route[0]

pathDistance += fromCity.distance(toCity)

self.distance = pathDistance

return self.distance

def routeFitness(self):

if self.fitness == 0:

self.fitness = 1 / float(self.routeDistance())

return self.fitness

def createRoute(cityList):

route = random.sample(cityList, len(cityList))

return route

def initialPopulation(popSize, cityList):

population = []

for i in range(0, popSize):

population.append(createRoute(cityList))

return population

def rankRoutes(population):

fitnessResults = {}

for i in range(0,len(population)):

fitnessResults[i] = Fitness(population[i]).routeFitness()

return sorted(fitnessResults.items(), key = operator.itemgetter(1), reverse = True)

def selection(popRanked, eliteSize):

selectionResults = []

df = pd.DataFrame(np.array(popRanked), columns=["Index","Fitness"])

df['cum\_sum'] = df.Fitness.cumsum()

df['cum\_perc'] = 100\*df.cum\_sum/df.Fitness.sum()

for i in range(0, eliteSize):

selectionResults.append(popRanked[i][0])

for i in range(0, len(popRanked) - eliteSize):

pick = 100\*random.random()

for i in range(0, len(popRanked)):

if pick <= df.iat[i,3]:

selectionResults.append(popRanked[i][0])

break

return selectionResults

def matingPool(population, selectionResults):

matingpool = []

for i in range(0, len(selectionResults)):

index = selectionResults[i]

matingpool.append(population[index])

return matingpool

def breed(parent1, parent2):

child = []

childP1 = []

childP2 = []

geneA = int(random.random() \* len(parent1))

geneB = int(random.random() \* len(parent1))

startGene = min(geneA, geneB)

endGene = max(geneA, geneB)

for i in range(startGene, endGene):

childP1.append(parent1[i])

childP2 = [item for item in parent2 if item not in childP1]

child = childP1 + childP2

return child

def breedPopulation(matingpool, eliteSize):

children = []

length = len(matingpool) - eliteSize

pool = random.sample(matingpool, len(matingpool))

for i in range(0,eliteSize):

children.append(matingpool[i])

for i in range(0, length):

child = breed(pool[i], pool[len(matingpool)-i-1])

children.append(child)

return children

def mutate(individual, mutationRate):

for swapped in range(len(individual)):

if(random.random() < mutationRate):

swapWith = int(random.random() \* len(individual))

city1 = individual[swapped]

city2 = individual[swapWith]

individual[swapped] = city2

individual[swapWith] = city1

return individual

def mutatePopulation(population, mutationRate):

mutatedPop = []

for ind in range(0, len(population)):

mutatedInd = mutate(population[ind], mutationRate)

mutatedPop.append(mutatedInd)

return mutatedPop

def nextGeneration(currentGen, eliteSize, mutationRate):

popRanked = rankRoutes(currentGen)

selectionResults = selection(popRanked, eliteSize)

matingpool = matingPool(currentGen, selectionResults)

children = breedPopulation(matingpool, eliteSize)

nextGeneration = mutatePopulation(children, mutationRate)

return nextGeneration

def geneticAlgorithm(population, popSize, eliteSize, mutationRate, generations):

pop = initialPopulation(popSize, population)

print("Initial distance: " + str(1 / rankRoutes(pop)[0][1]))

for i in range(0, generations):

pop = nextGeneration(pop, eliteSize, mutationRate)

print("Final distance: " + str(1 / rankRoutes(pop)[0][1]))

bestRouteIndex = rankRoutes(pop)[0][0]

bestRoute = pop[bestRouteIndex]

return bestRoute

def geneticAlgorithmPlot(population, popSize, eliteSize, mutationRate, generations):

pop = initialPopulation(popSize, population)

progress = []

progress.append(1 / rankRoutes(pop)[0][1])

for i in range(0, generations):

pop = nextGeneration(pop, eliteSize, mutationRate)

progress.append(1 / rankRoutes(pop)[0][1])

plt.plot(progress)

plt.ylabel('Distance')

plt.xlabel('Generation')

plt.show()

def main():

cityList = []

for i in range(0,25):

cityList.append(City(x=int(random.random() \* 200), y=int(random.random() \* 200)))

geneticAlgorithmPlot(population=cityList, popSize=100, eliteSize=20, mutationRate=0.01, generations=500)

main()

print('Ayush Patel : 53004230035')