Genetic Algorithm

● Describe how a GA searches for the global optimum.

Optimization methods we have learnt are to find the local maximizer or minimizer. Now, we are going to introduce the Genetic Algorithm which can find the global optimum. Figure 1 presents its flowchart.

■ Step 1

We have to set the initial population named P(0) and k is the iteration times from zero. Generally, the population size is 40 or 60. They are random values.

■ Step 2

If we want to find the minimizer, evaluate our population values. Then, choose and keep better point. There are two ways to select including roulette wheel selection and tournament selection.

■ Step 3

The next step is to generate a second generation population of solutions from those selected points. We can use Crossover and Mutation. The children are P(k+1).

■ Step 4

This generational process is repeated until a termination condition has been reached. Common situations are as following, the children are similar that they cannot generate the better one and the process reach the maximum iteration times.

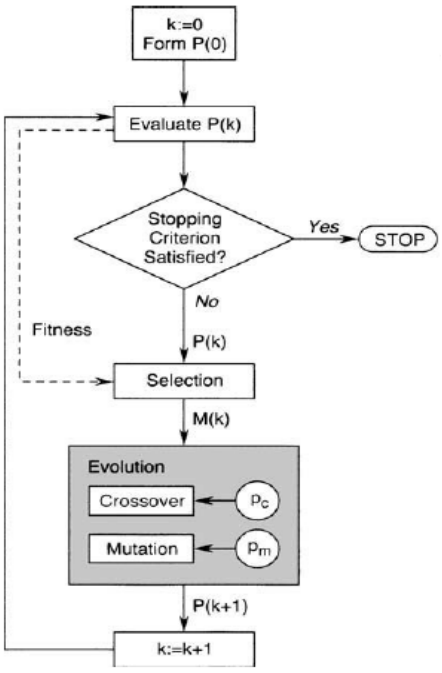

Figure 1 flowchart for GA

● Question 1

f(x) = -15*(sin(2*x))^2-(x-2)^2+160, and -10 ≤ x ≤ 10.

It will be the different solution by different bound and different times. The basic MATLAB code is

```
f = @(x)(-15*(sin(2*x))^2-(x-2)^2+160);      %set the function
for i = -12:0.01:12                          %plot our question
    x = i;
    plot(i,subs(f))
end
 [x,fval,exitflag] = ga(f,1,[],[],[],[],-10,10) %get the solution
xf = (-15*(sin(2*x))^2-(x-2)^2+160);
plot(x,xf,'rx')                              %plot the solution
```

The global minimizer is - 0.8329, fitness function is 137.1097 and exitflag is 1 which means the process is successful, as shown in Figure 2.

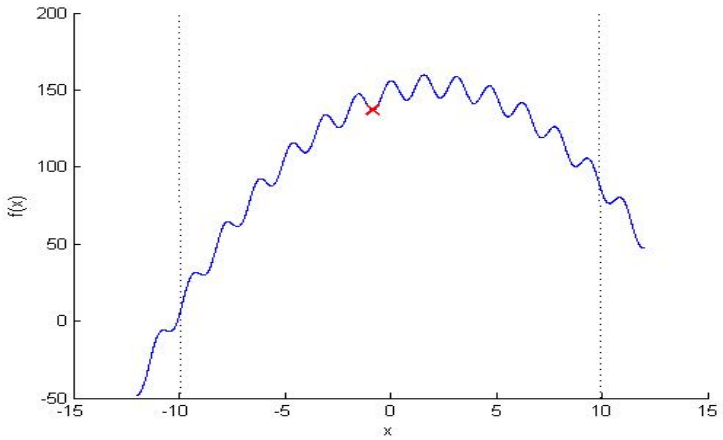

Figure 2 the output of question 1

As we can see in Figure 2, the final solution is not the global minimizer. The reason is the initial values or the constrained bound we set so I had followed test.

Table I the test output of question 1

No.	Lower bound	Upper bound	x	No.	Lower bound	Upper bound	x
1	-10	10	-0.8329	**7**	-10	1	-0.8329
2	-10	10	0.7648	**8**	-10	1	-7.2343
3	-10	10	-0.8329	**9**	-10	1	-0.8329
4	-10	5	-2.4312	**10**	-10	0	-10
5	-10	5	-2.4312	**11**	-10	0	-10
6	-10	5	-4.0305	**12**	-10	0	-9.9999

Table I show us, only we set upper bound is 0, the f(x) equals -10 which is the global minimizer in our constrained bound.

● Question 2

$f(x,y) = 3*(1-x)^2*\exp(-x^2-(y+1)^2)-10*((x/5)-x^3-y^5)*\exp(-x^2-y^2)-(\exp(-(x+1)^2-y^2))/3$

It will be the different solution by different bound and different times. The basic MATLAB code is

```
x = -5:0.1:5;                          %plot our question
y = -5:0.1:5;
[xx,yy] = meshgrid(x,y);
ff =
3.*(1-xx).^2.*exp(-xx.^2-(yy+1).^2)-10.*((xx./5)-xx.^3-yy.^5).*exp(-x
x.^2-yy.^2)-(exp(-(xx+1).^2-yy.^2))./3;
mesh(xx,yy,ff)
%set the function
f =
@(x)(3*(1-x(1))^2*exp(-x(1)^2-(x(2)+1)^2)-10*((x(1)/5)-x(1)^3-x(2)^5)
*exp(-x(1)^2-x(2)^2)-(exp(-(x(1)+1)^2-x(2)^2))/3);
%get the solution
[x,fval,exitflag] = ga(f,2,[],[],[],[],[-3 -3]',[3 3]')
xf =
(3*(1-x(1))^2*exp(-x(1)^2-(x(2)+1)^2)-10*((x(1)/5)-x(1)^3-x(2)^5)*exp
(-x(1)^2-x(2)^2)-(exp(-(x(1)+1)^2-x(2)^2))/3);
plot3(x(1),x(2),xf,'rx')               %plot the solution
```

The global minimizer is [0.2283 -1.6256], fitness function is -6.5511 and exitflag is 1 which means the process is successful, as shown in Figure 3.

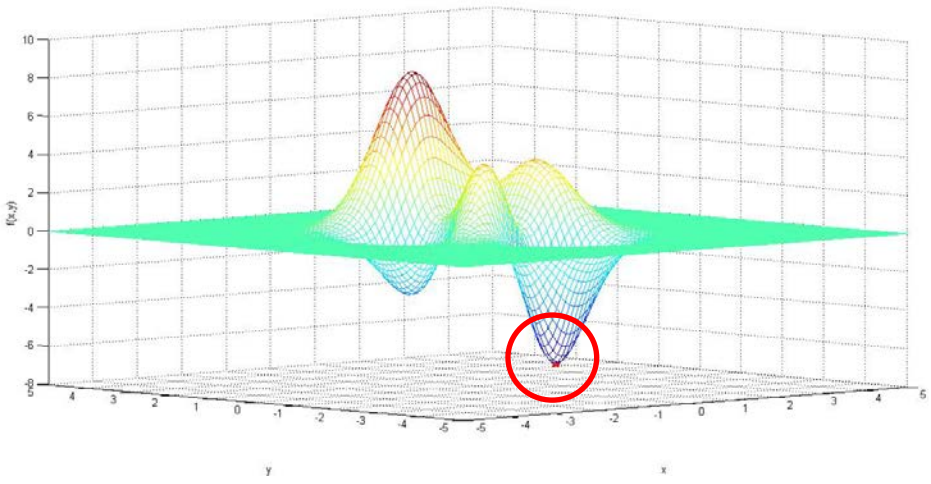

Figure 3 the output of question 2

Although the solution is correct, I try followed test in Table II.

Table II the test output of question 2

No.	Lower bound	Upper bound	fval	x y
1	[-3 -3]	[3 3]	-3.0498	-1.3474 0.2046
2	[-3 -3]	[3 3]	-3.0498	-1.3474 0.2046
3	[-3 -3]	[3 3]	-6.5511	0.2282 -1.6253
4	[-3 -3]	[3 3]	-3.0498	-1.3474 0.2045
5	[-3 -3]	[3 3]	-3.0498	-1.3474 0.2045
6	[-3 -3]	[3 3]	-6.5511	0.2282 -1.6253
7	[-3 -3]	[3 3]	-3.0498	-1.3474 0.2045
8	[-3 -3]	[3 3]	-3.0498	-1.3474 0.2045
9	[-3 -3]	[3 3]	-6.5511	0.2282 -1.6253
10	[-3 -3]	[3 3]	-3.0498	-1.3474 0.2045

Table II can show us that we only have 30% chances to find the correct global minimizer. The point [-1.3474 0.2045] is the other local minimizer. It's not the global minimizer. To sum up, this situation maybe is from the function ga. I don't know how its crossover rate and mutation rate are set.