Traditional and Non-Traditional Optimization Tools
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Lecture - 08
Binary – Coded Genetic Algorithm (BCGA) (Contd.)

Now, there are several ways through which we can determine the set of optimal GA parameters. Now, if you see the literature, this said of optimal parameters have been determined in a number of ways, out of all such ways one is your regression analysis.

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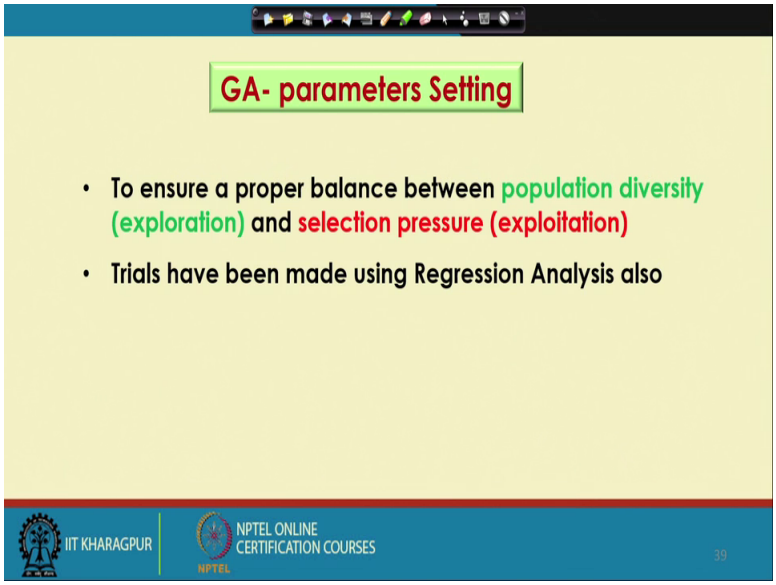

So, what I do is we run GA for some parameters, for a few combination of the parameters and we get the results and to we collect the data in a particular fashion. So, might be the full factorial design or fractional factorial design or central composite design. And based on the data collected using the design of experiments we try to find out the regression equation; that means the fitness as a function of the GA parameters. And if I can get fitness as a function of the GA parameters, now depending on the fitness I need. So, we will be able to select that particular the GA parameters. So, that is possible, but this particular method is actually could not reach much popularity.

Now, instead I am just going to discuss one method which actually could reach that particular the popularity. The method is very simple and let me discuss that particular method in much more details.

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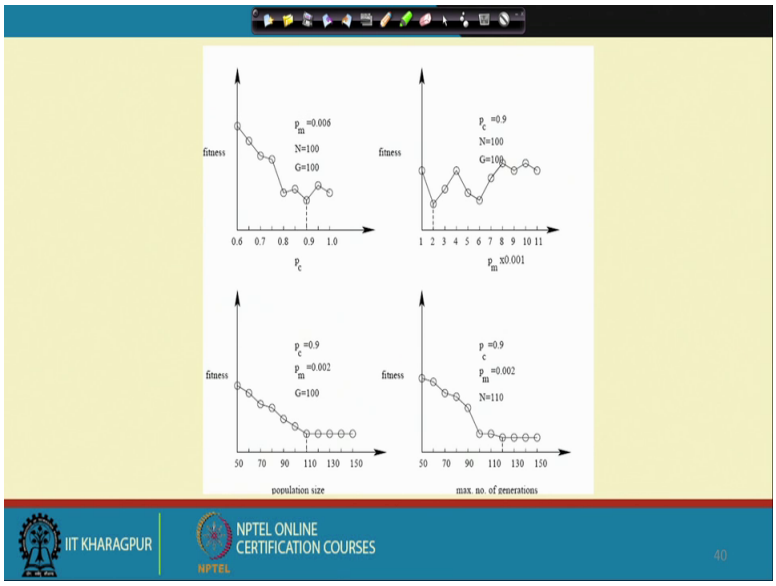

Now, supposing that I am going to decide what should be the set of optimal GA parameters in order to solve one minimization problem. Now, as I discuss that on principle GA can solve maximization problem, but I have also discuss that if I use tournament selection then directly I can use the GA to solve the minimization problem. So, let us assume that we are using tournament selection here and we are solving one minimization problem. Now, if I start carrying out this particular analysis, what I will have to do is I will have to first set the range for this particular the GA parameters. Now, we have already discussed that what happens if I take a very high value for the parameters and the low values for the parameters.

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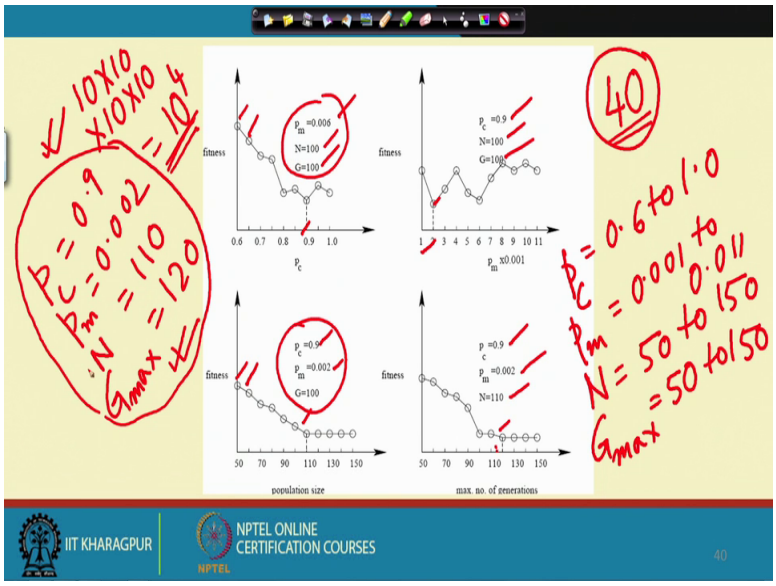

Now, based on that particular knowledge let us assume that I am going to vary the probability of crossover starting from say 0.6 to say 1.0. The next is the probability of mutation starting from say 0.001 to 0.011. The population size starting from 50 say I am just going to very up to say 150. Similarly the maximum number of generation that is G max I am going to start from 50 up to say 150. So, this particular range actually will have to fix first and. Now, I am in a position to find out what should be the set of optimal parameter so that I can ensure a very efficient search for the GA.

Now, what I do is we first concentrate on a particular parameter at a time. So, supposing that I am just going to vary the p c first keeping the other parameters fixed at the respective mid value. For example, say the p m I am just going to fix at 0.006. The population size I am going to keep it fixed at 100 the maximum number of generation I am going to fix at 100 and I am just going to vary the probability of crossover starting from 0.6 up to 1.

Now, I will run GA for a p c of 0.6 and these parameter and find out what should be the best fitness supposing that I am getting this has the fitness. Next time we keep the other parameters fixed and will consider another p c value might be say 0.65 and I will run GA and try to find out what is the best fitness; that means, what is the minimum fitness supposing this is something like this. And in this way with different values of p c, I will carry out this particular experiment by keeping the other three parameters constant.

Supposing that corresponding to p c equals to 0.9. So, I am getting the maximum fitness. So, we store this particular the p c value that is p c equals to 0.9. And now, I am just going to very this particular the probability of mutation that is p m. And other parameters like your population size is kept fixed to 100, G max is kept fix to 100 and we carry out this experiment one after another and we are noting the fitness values. Supposing that I am getting the minimum value of fitness corresponding to 0.002, this is the minimum fitness.

So, I will store that particular p m that is 0.002 and p c I have already selected and, now I am in a position to change this particular population size. So, what I do is, this parent three parameters are kept constant and I am wearing population starting from 50 up to say 150. Now, for one set of parameters we run GA note down the minimum fitness, another set of parameters we run the GA note down the minimum fitness and this process will go on and go on up to 150 population size and we just plot this particular the fitness information.

Now, here we can see that corresponding to this 110 population size. So, I am getting the minimum fitness after that the fitness remains the constant and there is no change and it indicates that GA has reached the globally minimum solution. So, what I do is we select the population size corresponding to which we are getting the minimum fitness. Now, here actually what I do is we keep p c is equals to 0.9, p m equals to 0.002, population size is 110 and maximum number of generation I am wearing starting from 50 up to 150.

So, we run GA several times and we noted down the fitness information. And here the fitness is decreasing and if you see that corresponding to this 120, 120 the fitness is found to be the minimum and after that there is a no change and if there is no such change it indicates that GA might have reach that globally minimum solution.

Now, by doing that actually we can select the maximum number of generation is equals to 120. So, what should be that optimal set of GA parameters? The optimal parameter should be p c equals to 0.9, the p m is equals to 0.002, now population size is equals to 110 and G max that is the maximum number of generation is equals to 120. Now, this is actually the optimal parameters for the GA.

Now, will run the GA once again with this particular optimal parameter and find out what is the solution. So, this is the way actually approximately we can carry out the

parametric study to find out what should be the set of optimal GA parameters. Now, remember this is an approximate way of doing. Why did I call that this is an approximate way? The reason is very simple. Now, let me take a very simple example. Supposing that for this p c, so I am considering 10 numerical values, for p m I am considering 10 numerical values, population size I am considering 10 numerical values and here also I am considering 10 numerical values, then how many times I am running GA, 10 plus 10 plus 10 plus 10. So, I am running GA only 40 times to find out this particular optimal or the near optimal set of GA parameters.

But truly speaking I should run how many times I should run 10 multiplied by 10 multiplied by 10, multiplied by 10. The reason is for p c I have got 10 possibilities 10 numerical values, for p m I have got 10 numerical values, for population size I have got 10 numerical values, for maximum number of generation I have got 10 numerical values that is 10 raise to the power 4.

So, I have got 10 raise to the power 4 combination of the GA parameters. So, I should run GA for 10 raise to the power 4 that is 10000 times to decide this particular the GA parameter. So, in place of this 10 raise to the power 4 I am running only 40 times; that means, this type of method of determining the parameter for the GA is an approximate method and approximately we can find out what should be the optimal or the near optimal set of this particular the GA parameters.

Now, here I just want to mention one very important issue. Now, supposing that you are going to solve some optimization problem it could be maximization problem or a minimization problem. Now, if you do not select the GA parameters in the optimal way there is no guarantee that the GA is going to hit that globally optimal solution.

And if you want to run the GA in a very efficient way the first thing will have to do is will have to carry out some sort of parametric study in order to find out what should be the set of optimal GA parameters. Now, if you run GA with the set of optimal parameters there is almost a guarantee that you will be getting that globally optimal solution using this particular the genetic algorithm.

Now in fact, I am just going to discuss another very important issue of this particular the binary coded GA. Now, as I told several times that binary coded GA is actually the first version of GA which was proposed in the year 1965, but this particular GA is having a

few limitations or demerits. Now, those demerits or the limitations I am just going to discuss after sometime in much more details, but before that I am just going to discuss one issue which is very important and we should be careful if you want to use the binary coded GA particularly for a problem having a large number of real variables.

Now, let me take one example supposing that I am just going to solve one optimization problem having say 20 design variables and all to design variables are real in nature. And supposing that let me assume that I am just going to consider so 20 real variables, real variables and I am just going to consider 10 bits to represent each of the real variables.

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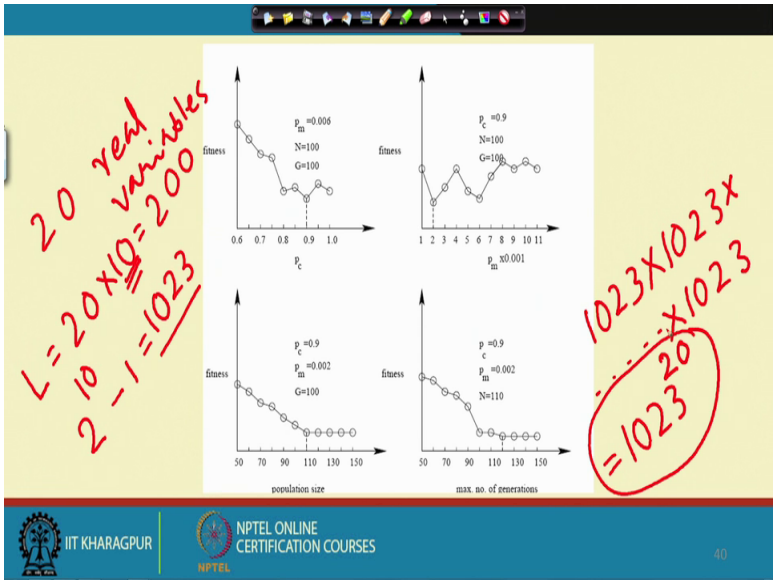

So, what should be the GA string length capital L that should be 20 multiplied by 10. So, it is 200, so there will be 200 bits. Now, the issue which I am going to discuss, I am using 10 bits to represent a particular the variable. That means, the range of this particular variable I am going to divide into how many equal parts, 2 raise to the power 10 minus 1 that is nothing but 1024 minus 1, so 1023.

That means, the range the whole range of a particular variable I am going to divide into 1023 equal parts. And now, I have got 20 such variables. So, for each variable 1023 equal parts, for the second variable one second 1023, for the third variable 1023 and this will go on up to the twentieth variable that is 1023 that is nothing but 1023 raise to the power 20. So, if the GA wants to find out that globally optimal solution. So, all such

combinations of the different, the different values of the variables are to be tested and compared before it can declare the globally optimal solution.

Now, 1023 raised to the power 20 combination is a very large number of combination and there is a possibility if I use a binary coded GA, it may take a few hours few days few months time just to hit that globally optimal solution. That means, if I have got a problem having a large number of real variables, it is advisable not to use this type of binary coded GA.

Now, in place of binary coded GA we can use some other type of GA like real coded GA or the grey coded GA and those things will be discussed opt after sometime. And of course, this binary coded GA has got a few other limitations those things I will be discussing with the help of some examples after sometime. But before that another issue I will have to solve that is actually till now, there is no convergence proved the concrete mathematical convergence proof for this particular the binary coded GA.

Now, the question is if there is no such concrete mathematical proof then how to believe this binary coded GA. Now, to give actually some sort of indication that GA can improve the solution, GA can find out the globally optimal solution, so what I did we generally take the help of some sort of hand calculations which I have already done. Now, I am just going to discuss another technique and with the help of that particular technique.

So, it is going to say that, yes GA can move in the right direction to find out the globally optimal solution. Now, actually there is lot of confusion among the GA users as there is no concrete mathematical proof, but the method which I am going to discuss that method is at least some indirect proof that GA can find out the globally optimal solution.

Thank you.