Computer Aided Applied Single Objective Optimization
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Lecture - 09
Implementation of TLBO in MATLAB

This is a supplementary session right. So, in this session we will see how to deploy multiple runs and do a statistical analysis right.

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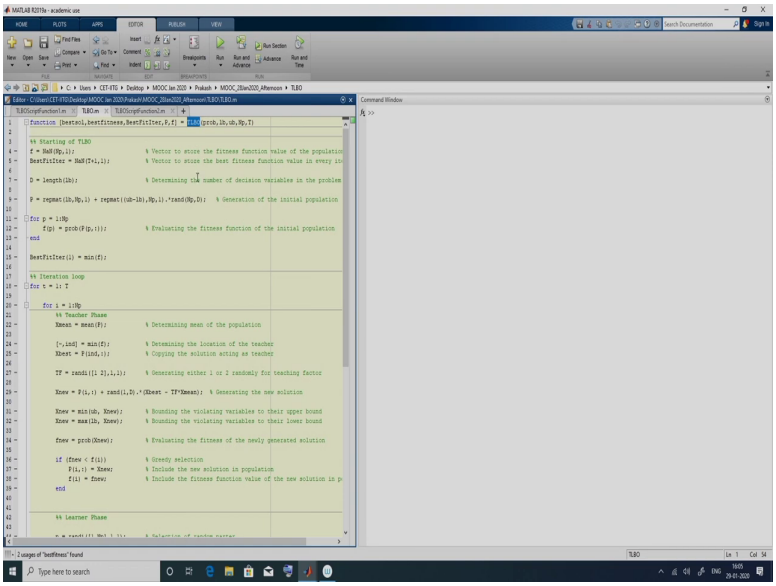

So, this TLBO function you might be remembering that we had made this TLBO function right. So right now it is a function file right. So, we need to only provide the detail of the problem right.

So, this has to be a function handle, the lower bounds of the problem, the upper bound, the number of population the population size and the number of iterations that we want to work with.

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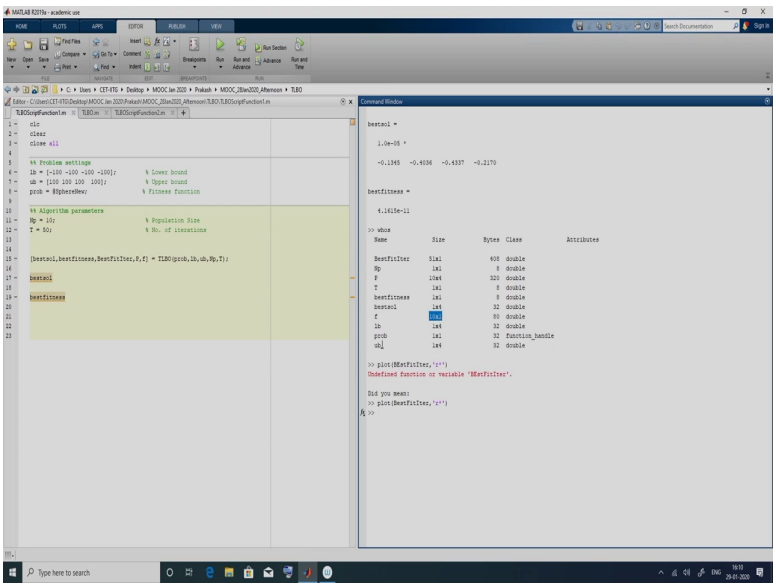

So, this is the script file, again this we have discussed right. So, here what we are doing is we are defining lb, ub problem right. So, let us just work with the sphere new function. So, we are setting the population size to be 10 and that the number of iterations to be 50, right. So, here we are calling the TLBO function and we are passing this details right and what we will be getting back is the best solution, the fitness corresponding to the best solution right, in each iteration what was the best fitness right, the final population right and the final fitness function value right.

So, remember this is different this BestFitIter is different from f, f is the fitness function value corresponding to each population member right. So, this is only of the last generation P comma f is of the last iteration whereas BestFitIter is the best fitness function value in every iteration; bestsolve again is the set of decision variable at the end of the algorithm the best solution that we have discovered right. So, this is decision variable and this is objective function right.

So, bestsolve if you see it will have in this case we have a 4 variable problem. So, it will be having 1 row 4 column, this will be a scalar 1 cross 1, we are having 50 iterations and remember we also have the initial evaluation of 50. So, this will be a vector of 51 rows and 1 column right we are working with the population size of 10. So, at the end of the iteration this will be 10 cross 4; P will be 10 cross 4 because we are working with the population size of 10 and the number of decision variable is 4 right. So, this will be 10 cross 4 and f will be a 10 cross 1 vector. Let me execute this right. So, if we execute this, let us do a whos. So, whos is going to show all the variables and their size right.

So, bestsolve it supposed to be a 1 cross 4 right. So, this is the best solution at the end of 50 iteration this is the best solution that TLBO has discovered this is the fitness function value corresponding to this solution right; BestFitIter if you see it is it has 51 rows and 1 column right. So, if we plot this, plot BestFitIter right. So, here I had used a upper case E right. So, that was the problem ok.

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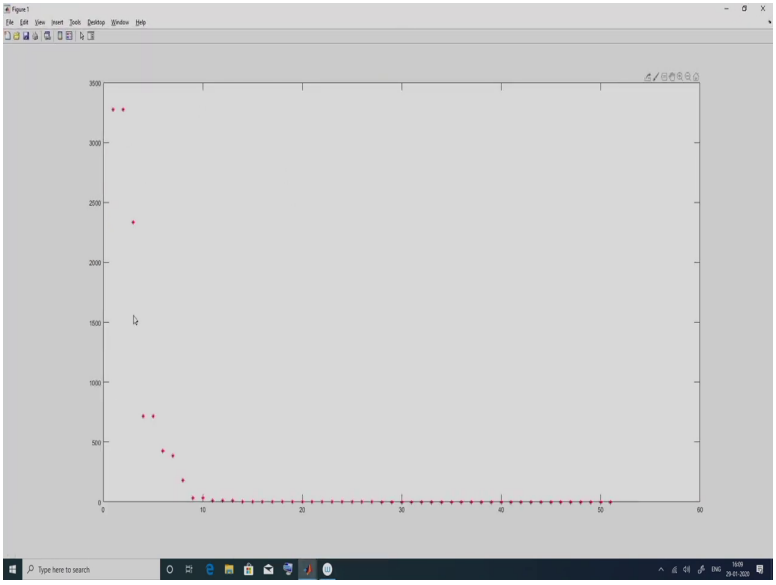

So, this is the convergence curve right, the x axis is iteration the y axis is the best functional value obtained at the end of that iteration. So, P if you see it will be a 10 cross 4 because 10 rows corresponding to each population member and 4 columns. Similarly f is 10 cross 1, 10 rows and 1 column, fitness function value for one solution is a scalar value.

So, we have 10 solutions over here. So, this will be 10 cross 1 right.

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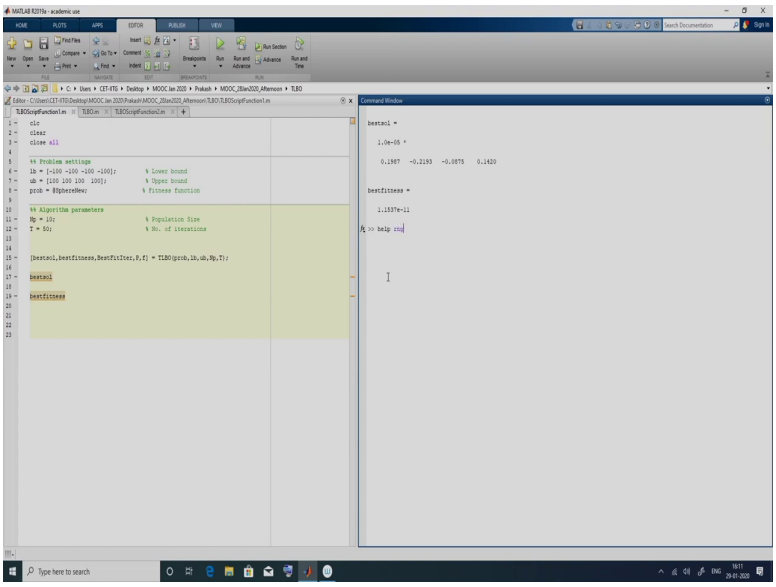

So, now, if you if you execute this, so, now we have a value of fitness function is 7.95, right. So, if you again execute this I get a different fitness function value 4.10, 4.56, 2.2, 1.24, 1.15..

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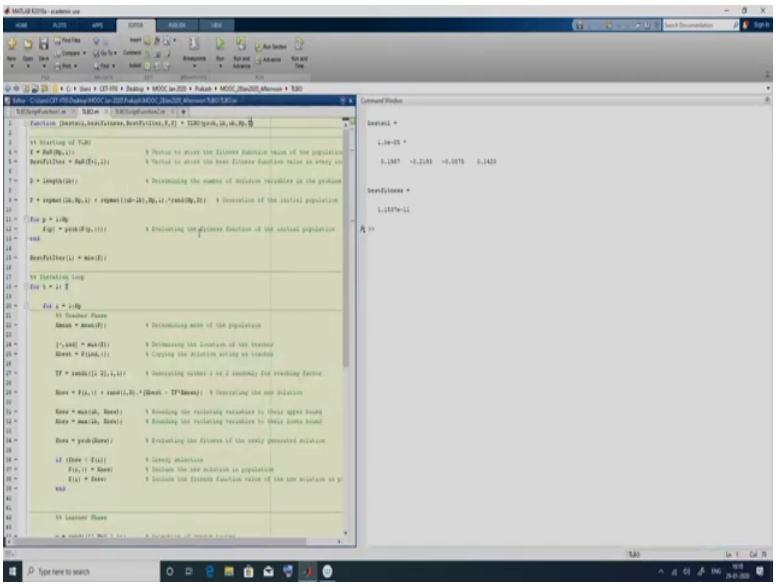

So, this is happening because the algorithm is stochastic, remember this algorithm the very starting we are saying that randomly initialize a population right.

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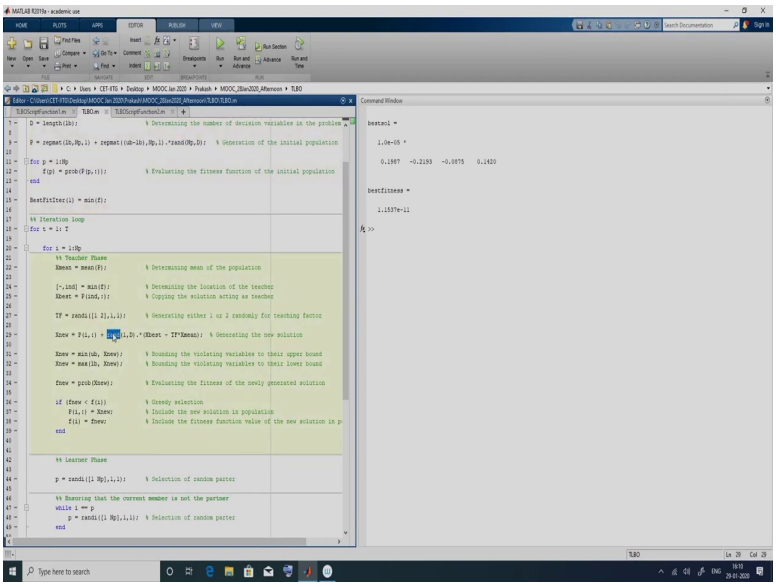

So, every time we run it is going to randomly initialize the population right and in multiple places we are using this random selection right. Here again we are using generating random numbers, here we are randomly choosing the TF to be 1 or 2. So, every time we executed we are going to get a different solution..

So, in this case the question is how do we reproduce the results right. So, what we can do is we can make use of this function rng in MATLAB right help rng right to.

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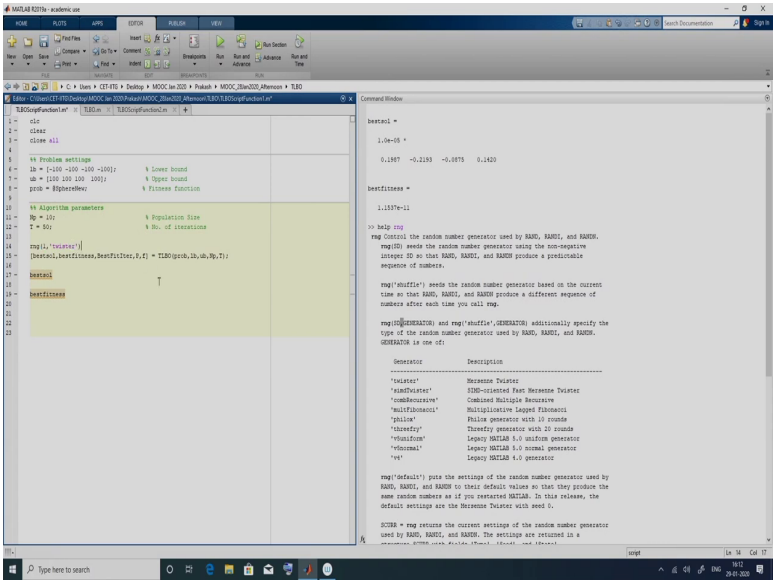

So, it will help us to control the random number generate, that is generated right. So, what the syntax of rng that we will be using is rng SD comma GENERATOR right. So, generator can be any of this 9 values right. So, they have 9 different algorithms to generate random numbers, the MATLAB generate pseudo random number right using one of these algorithms right and SD is a integer value right..

So, if we have over here rng 1 comma let us say twister right and if we save this and if we execute it right, every time we will get the same set same solution right because every time before executing this function we are resetting the random number generator right.

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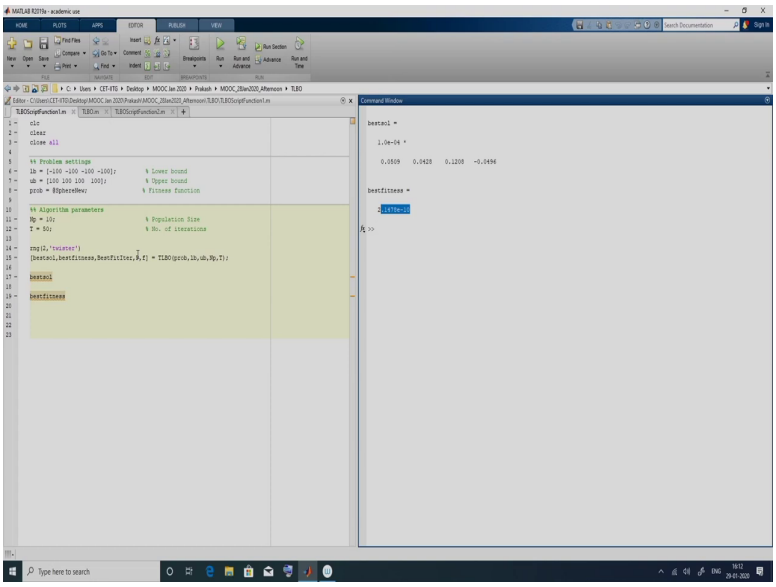

So, in this way we will be able to reproduce the results right. So, now, the question is if you are able to reproduce the results why should I have it as just 1 why not 2 right. So, if I change that the value would change right. So, now, we have the fitness function to be 2.47 into 10 power minus 10 right. So, since this algorithms are stochastic we are supposed to run it multiple times right.

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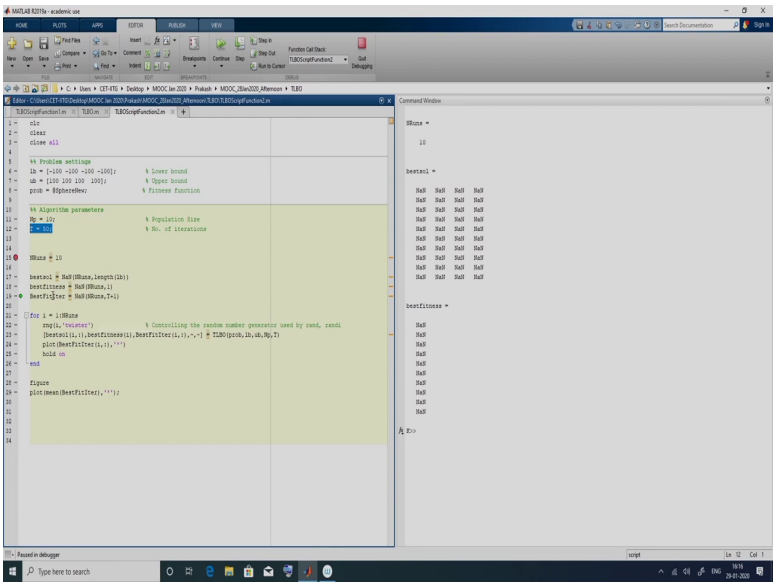

So, we run multiple times and then we do a statistical analysis right. In this function we are going to implement the multiple runs right. So, over here we have define the number of runs to be 10 right.

So, then we will define some of the variables which we will be using right. So, the first variable that we would require is bestsol. So, every time we run it. We will get a 1 row and as many columns as the number of decision variables right. So, we are defining bestsol with Na with the values of NaN right and that matrix will have 10 rows or the number of runs NRuns comma 4 columns in this case right because we have a 4 variable problem right..

So, this length of lb will give us 4 and this NRuns is 10 right. So, this is just initialization. So, every time we run this problem we will store the best solution over here right and we will

save the fitness function in best fitness right. So, best fitness if you remember it was a scalar value it is a scalar value for 1 run. So, for 10 runs it is going to be a column vector right.

So, we have 10 rows and 1 column, for every run we will get 51 column because there are 50 iteration and the first initial population will also have the best fitness function value right. So, this will be 51. So, that is why we are doing T plus 1; number of iterations plus 1 and for every run we will have a convergence curve right. So, that is why we have this BestFitIter right.

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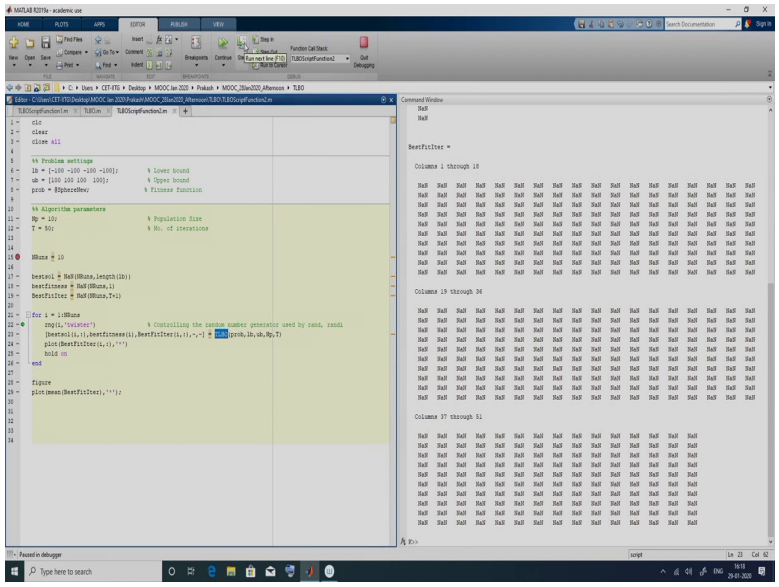

So, BestFitIter if you see now we have 51 columns and the number of rows would be 10 right. So, if you do whos over here.

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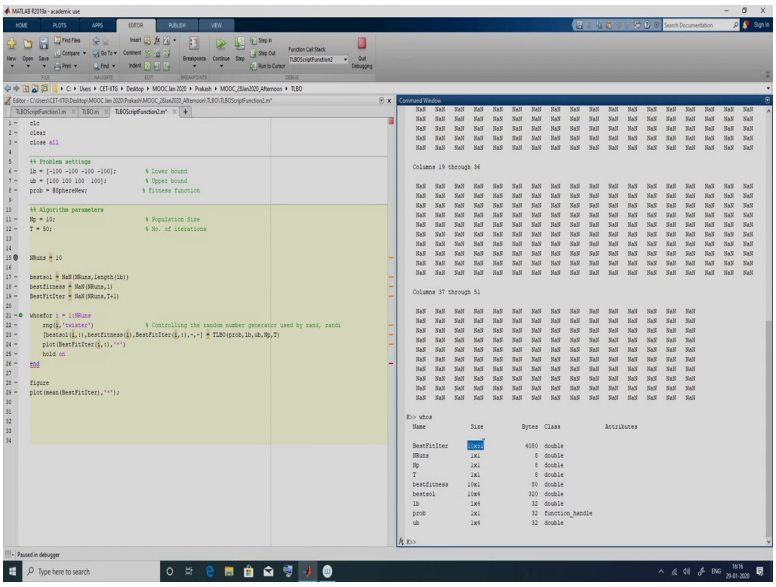

So, here we will be able to see 10 rows 51 columns. So, every time the first the first time when we run the convergence curve will be stored in the first row right all the 51 values will be saved in the first row, the second time when we run it all the 51 columns will have the convergence curve of the second run right. So, that is why, that is how we have initialize this variables right..

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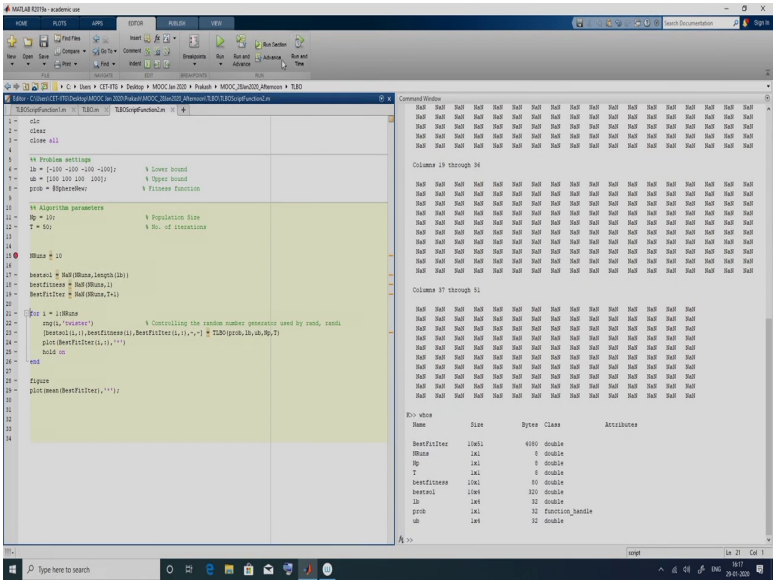

So, this whos is not required over here right. So, now, we are going into the algorithm. Remember every time I need to run with the different seed.

So, that is why we are doing rng of i comma twister. So, the algorithm remains the same, every time we are changing the seed of the algorithm right. So, every time we expect to have different set of random numbers used right. So, Step right. So, let me if I do Step in it is going to go into TLBO right I do not want to going to TLBO because we know what is going to happen in that function right. So, let me just give a Step right and again a Step.

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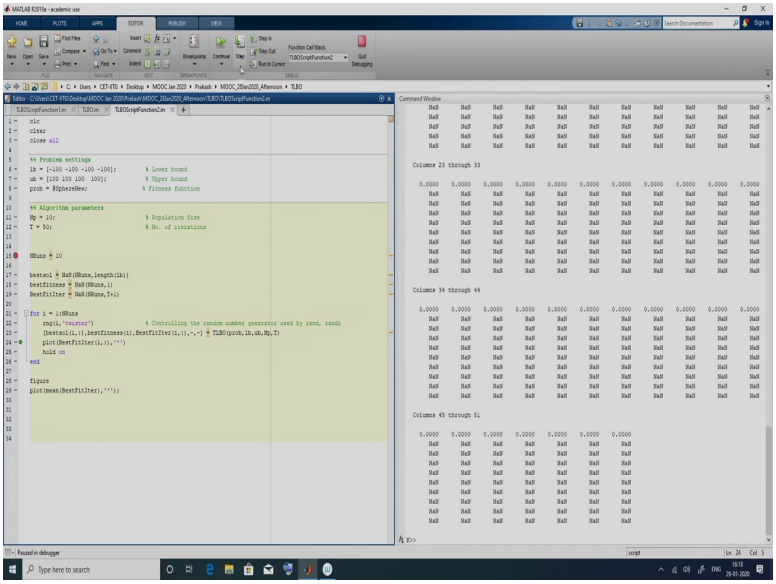

So, it has completed the first run. So, after completion of the first run if you see the best solution the first row has been populated.

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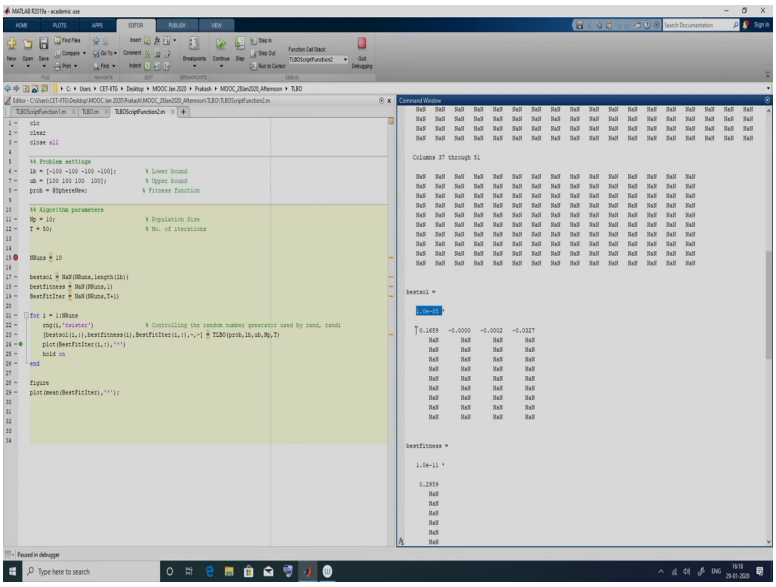

So, this is the best solution obtained by TLBO in the first run right and this is its fitness function right and this is the convergence curve right.

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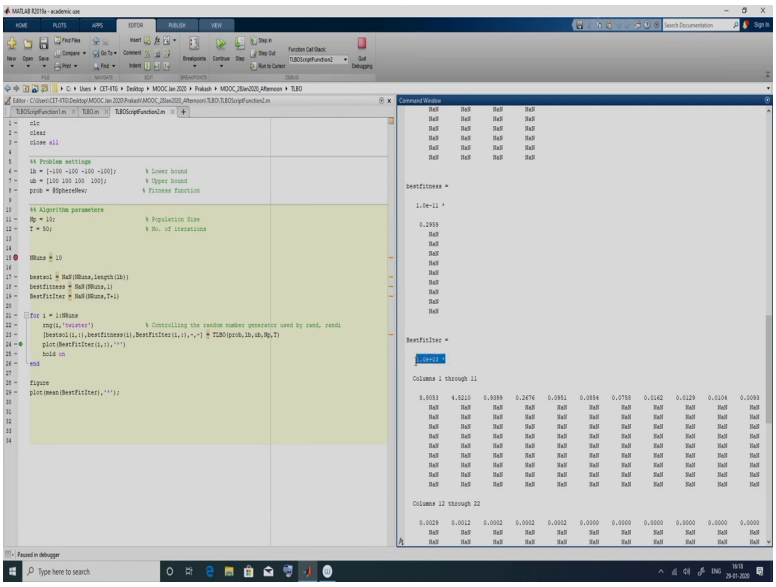

So, in the in the 0th iteration the fitness function value was 8.8053 into 10 power 3 right.

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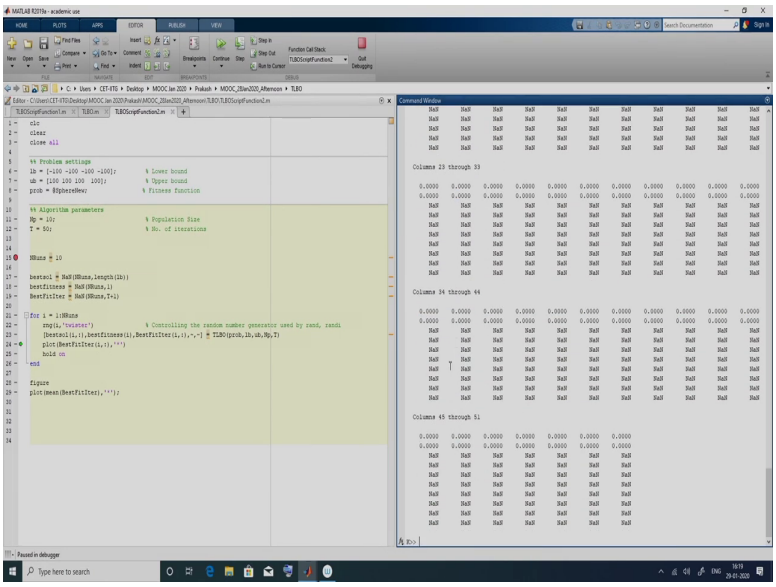

So, this has 51 columns right. So, then we are plotting it right.

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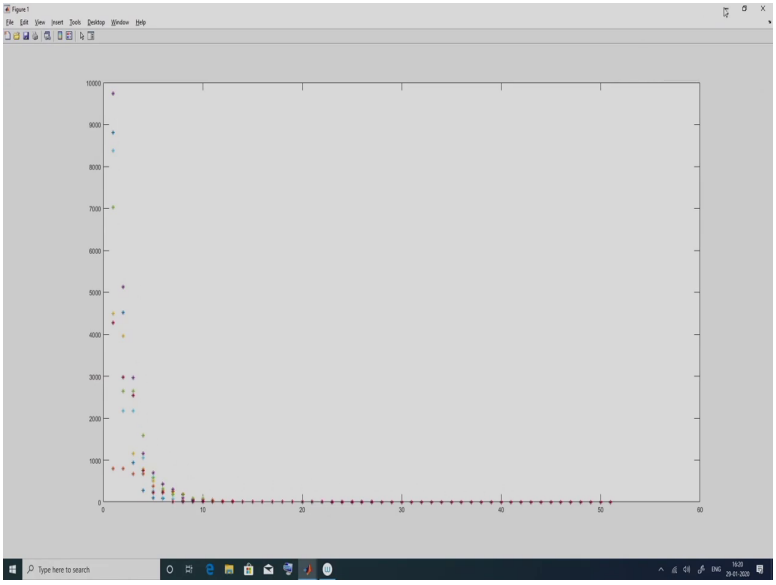

So, Step. So, this is the plot of the first run right. So, the x axis is again iteration, the y axis is the best fitness function value and this shows the convergence of the first run right. So, similarly we can proceed for the second run right. So, the second run we want to plot on the same plot that is why we have hold on right. I want the values of the first one to remain and I want to plot the values of the second run right. So, if we do this Step. So, now, it is i is equal to 2 right.

So, when we when this line is executed 22 second line is executed it will reset the random number generator with a seed of 2 right. So, again if you do Step right.

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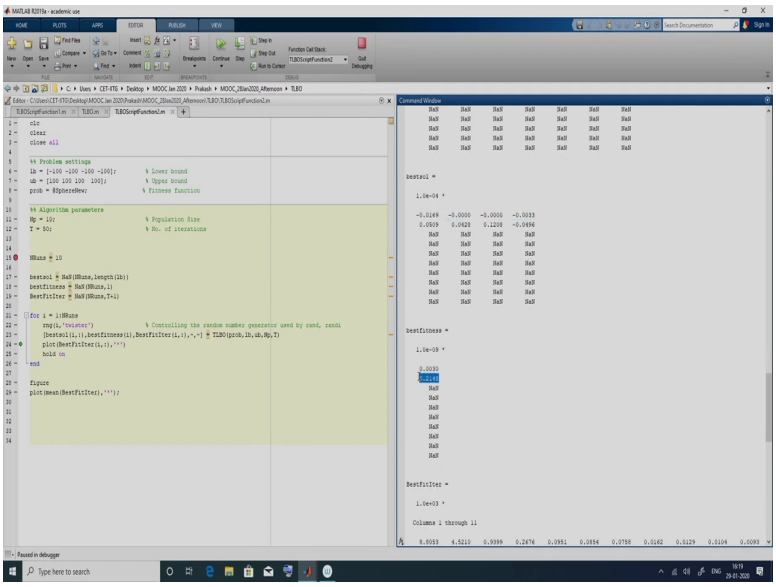

So, now if you see. So, second time when we executed the algorithm this is the set of decision variables at the end of 50 iterations this is the fitness function right 0.2148 into 10 power minus 9 right and this is the values for the convergence curve right and if we plot this..

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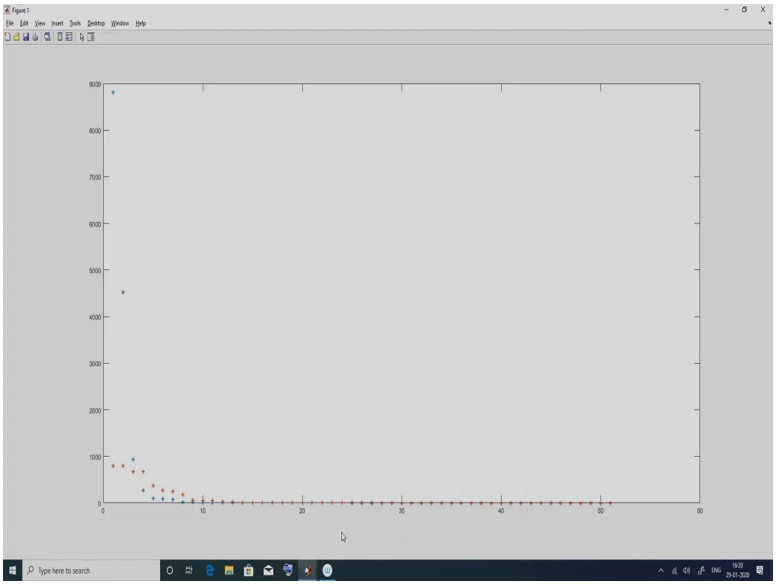

So, now, we will see we will have 2 colours right. So, previously we had this blue colour right. So, now, we have another curve over here right.

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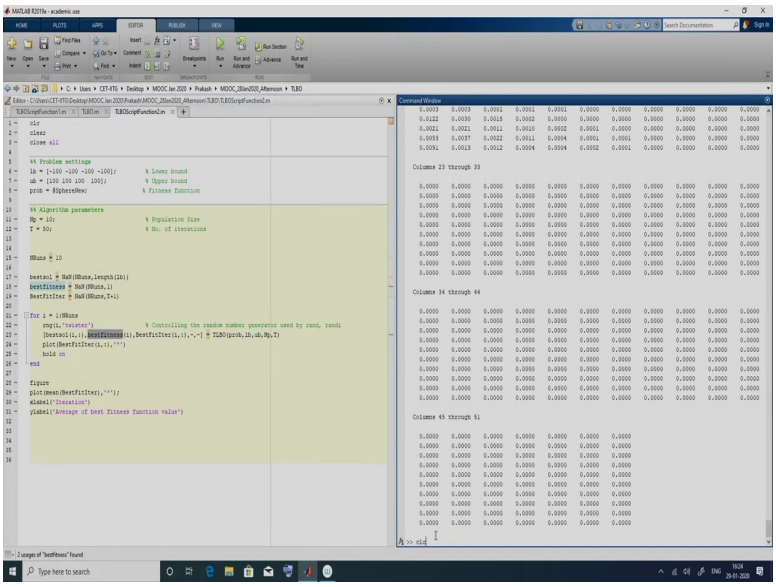

So, this now we can execute for 10 times right. So, every time row would get populated right and the figure will also have one more curve. So, as you see for every run we get a curve over here right. So, right now we have completed 8 runs, we are in the eighth run right. So, it has completed all the 10 runs right. So, at the end of 10 runs this is what we have.

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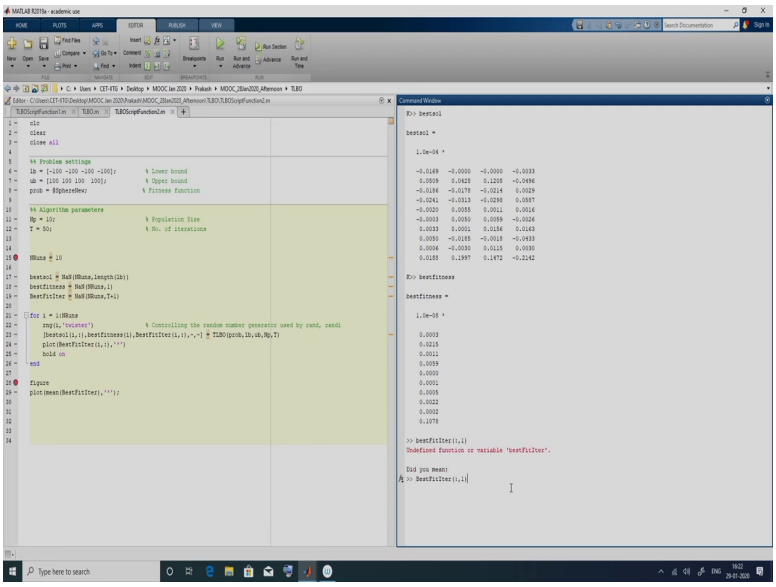

If we see the best solution right and the best fitness, so, for every time the fitness function value that was obtained at the end of 50 iterations is given over here right. So, this is the result of the 10 runs right. So, now, what we can do is if you look into this BestFitIter the rows indicate the run, the column indicates the fitness function value. So, we can find out the mean right. So, we will get.

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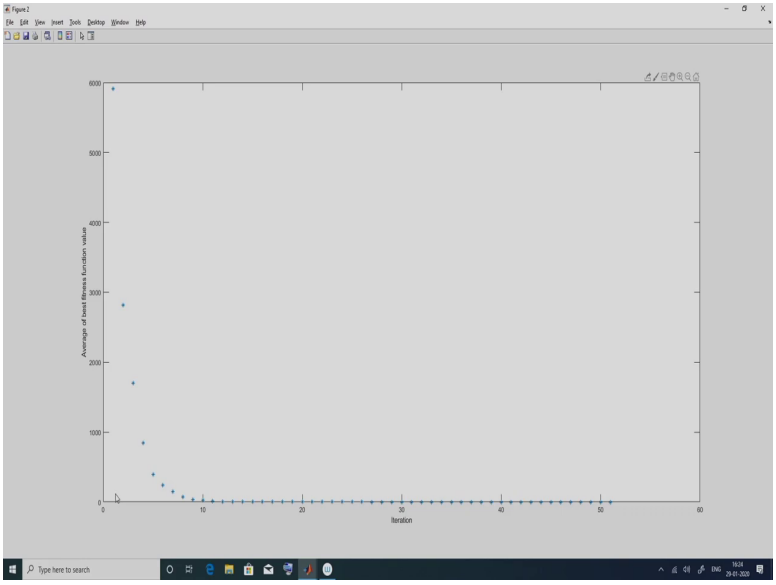

So, we can plot the mean over right. So, this is the mean. So, remember we had 51 convergence curves right. So, at the end of first iteration right the average of all the 10 runs. So, for example, let us say best Fit Iter right. So, I am looking for the all the runs the first column right.

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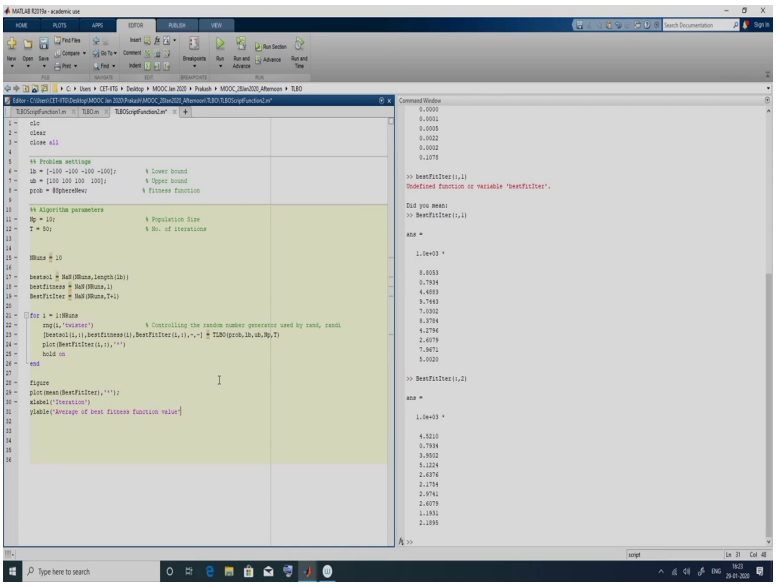

So, the first column the first column will correspond to the zeroth iteration right and the second column will correspond to the first iteration at the end of first iteration. So, at the end of first iteration this is what we had the mean of that column is this particular point right. So, at the end of first iteration what is the average fitness function value obtained across all the 10 runs right.

So, this is again best fitness function value average of the 10 runs, the y axis is average of the 10 runs where as the x axis is iteration right. So, this is how we can we can have a single convergence curve which reflects all the 10 runs that we have executed. So, we can add the x label and y label. So, x label is Iteration and y label is right. So, Average of best fitness function value. So, this is the iteration and this is average of the best fitness function value at

the end of first iteration we had 10 values right corresponding to each run right. So, the average of that is plotted over here.

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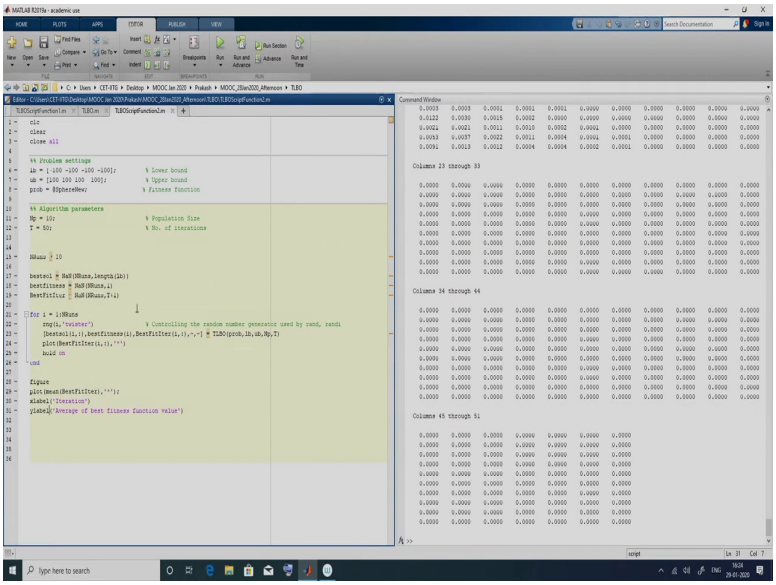

Now, that we have plotted the mean convergence curve right. So, we will now we can also do a statistical analysis of this bestfitness right.

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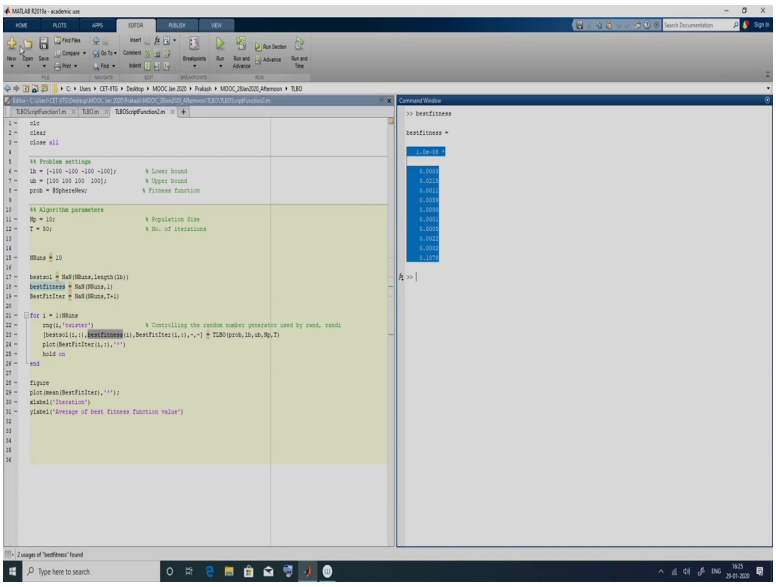

So, this bestfitness has 10 values. So, now, we have this bestfitness function value right. So, now, we can perform a statistical analysis of this right as to what was the best value we obtain in the 10 runs? What is the worst value we obtained in the 10 runs? What is the mean of the 10 runs? What is the standard deviation among the 10 runs?

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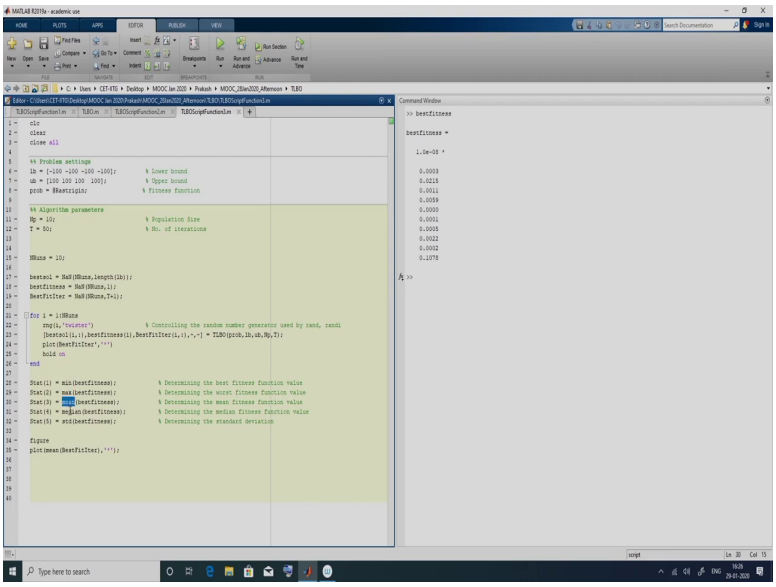

So, that is what is done in this file right. So, here if you see we have discussed all these 3 rights. So, similarly whatever we have discussed previously all this we have discussed previously. So, we are defining a variable called as Stat right it is going to have 5 values right the first value is going to be the best of the fitness. So, we have this 10 runs right what is the best among; What is the best among this run? right. So, that is what will be bestfitness right the worst is the maximum value. So, max of bestfitness is going to be the second column right, mean of the bestfitness is going to be the third column of Stat, a median of bestfitness is going to be the fourth column of the variable Stat and the fifth column of the variable Stat is going to be the standard deviation.

So, we have assigned that the first value is minimum the or the best, the second value is the maximum among the 10 runs or the worst mean, median and standard deviation right. So, all this 5 are in built functions right. So, to find out the minimum value maximum value the

mean value the median value and the standard deviation right. So, if we now execute this right.

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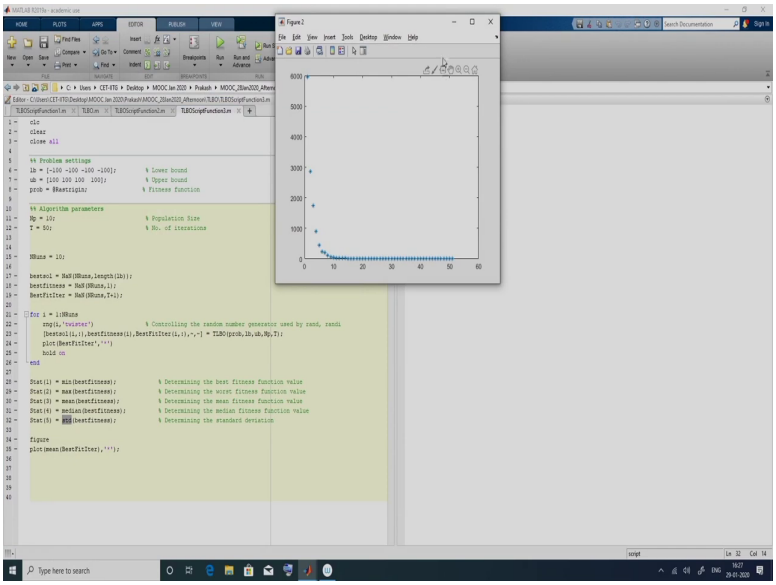

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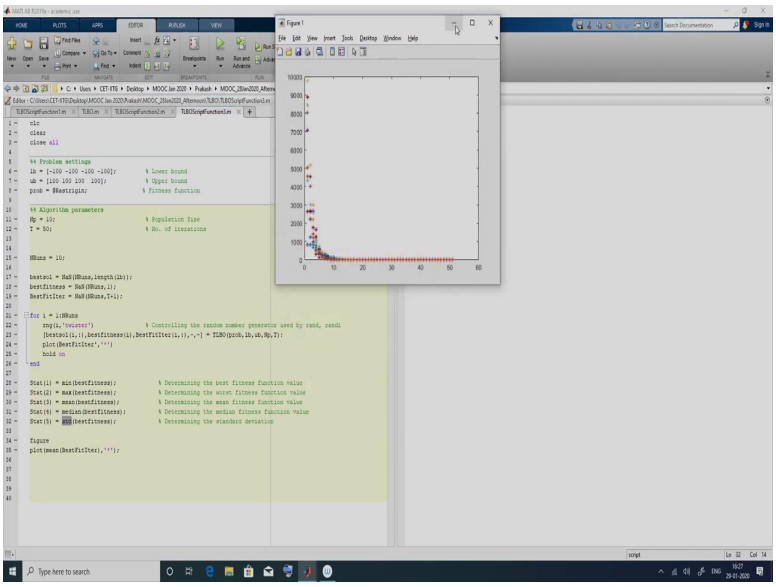

So, this is the mean fitness curve which you know this is a convergence curve of each run right. So, here if we say Stat right.

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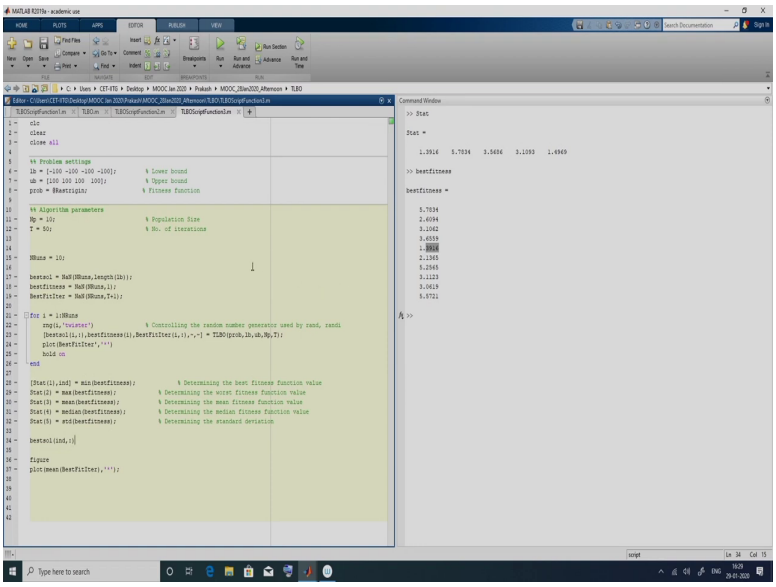

So, the 10 times we run this problem the Rastrigin function problem right the best that we could get was 1.3916 the worst that we got was in the 10 runs 5.7834 right the average of the 10 runs is 3.5686 the median of the 10 runs is 3.0193 and the and the standard deviation is 1.4969 right. So, this is nothing, but the statistical analysis of this vector bestfitness right. So, here if we see the best value is 1.396 the worst value is the first run 5.7834 the mean if you calculate the mean of this it will work out to be 3.5687 the median is 3.1093 and the standard deviation is 1.496. So, if we are interested in the decision variable corresponding to this 1.3916 let us say we are interested what is what is a set of decision variable that will give us this 1.3916. So, over here we can modify this as in addition to the value we can also get the location right.

So, ind will be the location. So, in this case it will return 3 4 5 because its located in the fifth one and best solution we have saved in over here bestsolve right. So, bestsolve right. So, we are interested in the this row and all the columns right.

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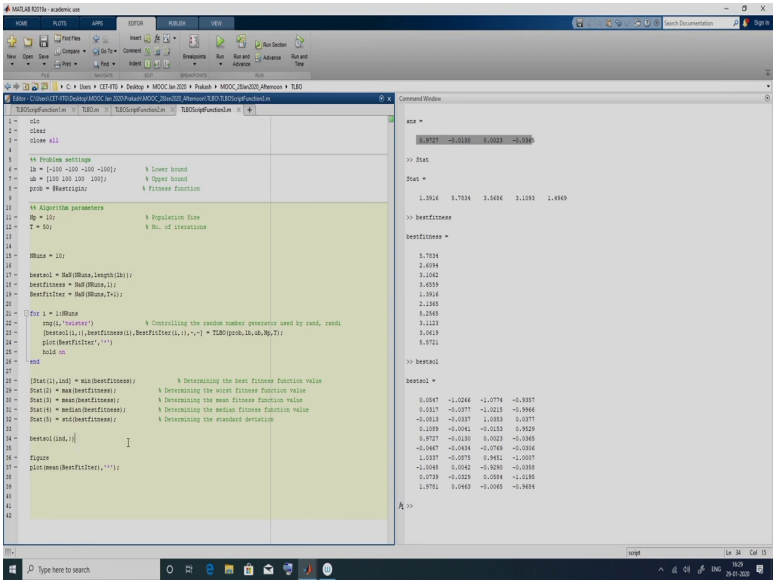

So, this will give us the best solution right. So, this is the Stat right. So, the bestfitness function value is 1.3916 right. So, if we see bestfitness it is 1.3916 and the corresponding solution is this one or we can look at bestsol.

So, bestsol remember it will be a 10 cross 4 matrix right. So, the fourth the fifth one right. So, the fifth one is 1 2 3 4 fifth one is this one. So, which is what was given over here. So, that is how we extracted the best solution.

So, this is how we can perform statistical analysis we take an algorithm right run it multiple times on the same problem and then we find out among the number of runs which we have executed. What is the best value? What is the worst value? What is the mean standard deviation and median? That is the end of this session.