Introduction to Soft Computing
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Lecture - 28
Non - Pareto based approaches to solve MOOPs (Contd.)

We are discussing non pareto based approaches to solve multi objective optimization problem. In the last few lectures, we have discussed 2 approaches. These are non pareto based approaches namely, lexicographic ordering and simple weighted approach.

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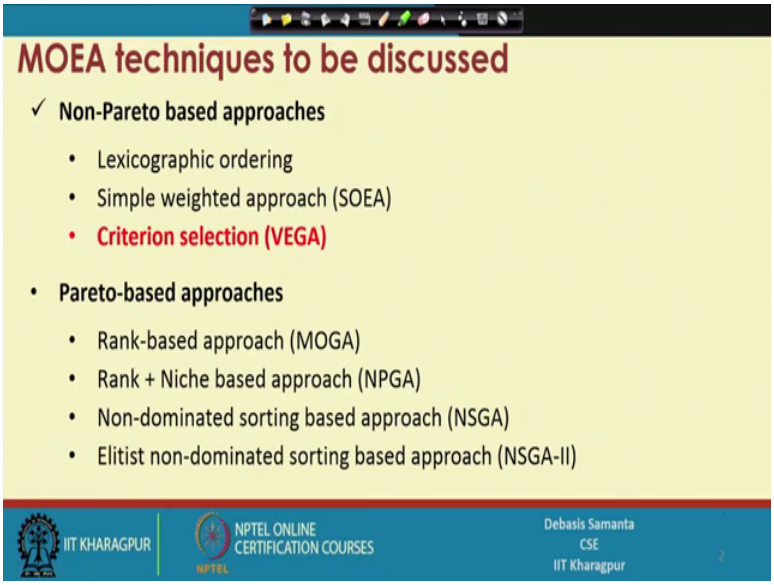

Shortly, it is termed as SOEA. Another approach in this line is called vector evaluated genetic algorithm. Short term is called VEGA. This approach is totally different than the previous 2 approaches. So, this approach is basically called the based-on criterion selection. So, that is why, it is a criterion selection-based approach. So, in this lecture, we will learn about the VEGA approach to solve multi objective optimization problem.

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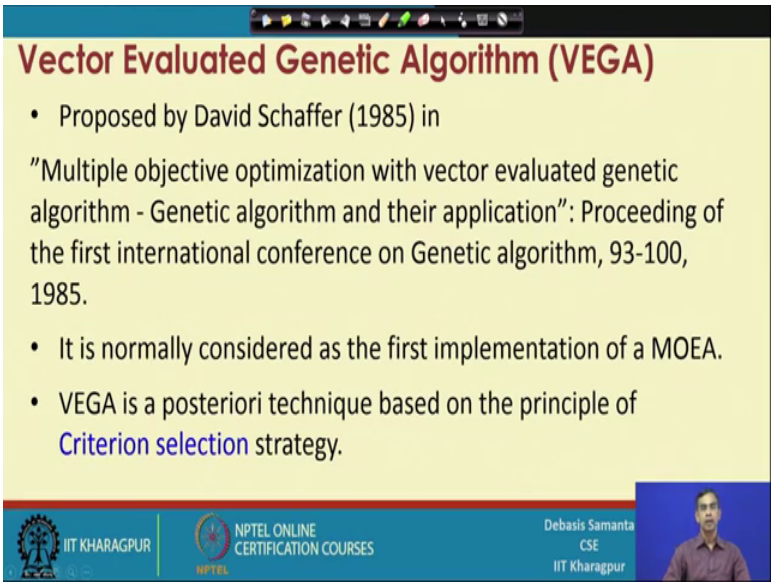

Now, this approach, first time proposed by David Schaffer in 1985. He reported the approach; the title of his approach is called multi objective optimization with vector evaluated genetic algorithm- Genetic algorithm and their application.

It is published in the proceedings of the first international conference on genetic algorithm in 1985. It is in the same proceedings where, the first approach on the lexicographic ordering was also proposed. Now, so this approach, this VEGA approach is called the fast of it is kind or it is a fast implementation of the MOEA approach.

This approach in fact, unlike the previous 2 approaches, it is a posteriori technique; that mean for this approach, we do not require any prior knowledge. So, this is the one difference among the 3 approaches which are based on non pareto based approaches. And another characteristics of this approach is that, it is the criterion selection-based approach; that means, here selection is different than the selection technique that is follows in a simple genetic algorithm.

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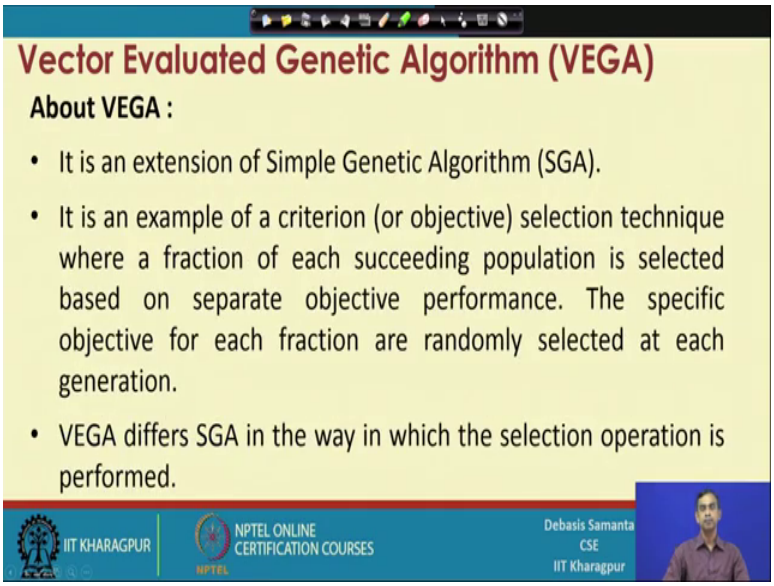

More interestingly, this approach the VEGA approach, in fact, it is an extension of simple genetic algorithm. It is an extension because, it considers a different selection strategy then the selection strategy; that is, there in simple genetic algorithm.

Now, we will discuss exactly what are the selection? What is the selection strategy that it follows in this approach? Now, here basic idea about is that, as you know, in case of multi objective optimization problem, there are multiple objectives. So, VEGA considers one objective at a time out of the several objectives in succession. That mean, it will consider one objective, then next objective and so on and then, it is the selection; selection of a particular solution is based on the performance of the objectives as a whole. That is different; they are with respect to the simple genetic algorithm.

So, here basically, a particular objective out of the several objectives are randomly selected while, we generate the population. Anyway, let us proceed to learn about VEGA and then we will be able to understand how the selection strategy is different in this here.

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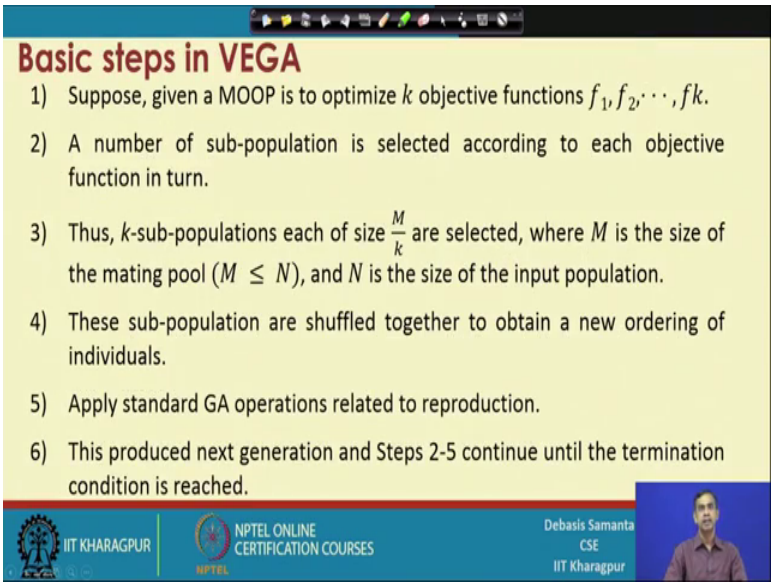

Now, we can start with let us consider, there is a multi-objective optimization problem with k objective function. So, k objective functions we denote them as f 1 f 2 dot dot f k. So, these are the objective function that we will consider here k number of objectives are there. Now, the next step is that, we have to select a number of sub population and the sub population means subset of the populations and this subset of population is selected according to each objective function in succession.

Therefore, if there are k objective functions are there, so, we have to select k sub populations. Now, size of each population is M by k, where M denotes the size of the mating pool and usually M is less than N, where N is the size of the population. So, here basically the idea is that, out of N solutions in the population, current population, we have to select M solutions for the mating pool and from the mating pool we generate the mating pair and therefore, reproduction. Now, so the second step, as I told you, we have to select k number of sub populations; each of size M by k. Once a sub populations are selected, then we have to follow one shuffling technique. So, here basically shuffling means, we have to shuffle from ith sub population to j th sub population, so that some mixing is possible.

Once this is done, these are mating pool is ready and then, we use this mating pool to produce the next generation. So, this is the idea about it and then we will continue the same procedure until we reach the termination condition.

So, these are the simple steps that is there in the VEGA approach. Now, let us explain the VEGA approach how it works.

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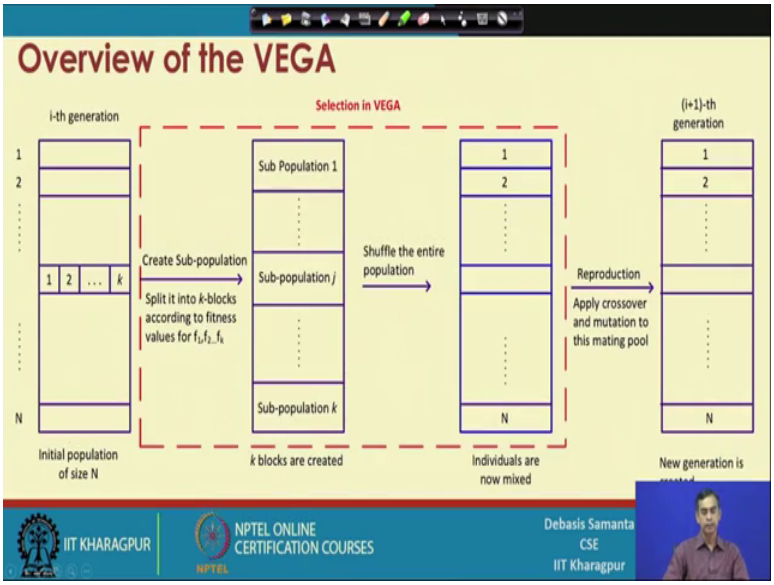

Now, this figure will help us to explain the concept that just now I have mentioned here. So, the idea it is like this. So, suppose, this is the current population at any time of the generation iteration.

So, let us suppose the i th iteration is going on. So, in the i th iteration, the current population, this is the current population and then the size of the current population is N. And as I told you, this is an multi objective optimization problem with k number of objective factors. So, this is the k number of objectives are there now. So, given this is the population at any instant. Our next task is to create sub population. So, create sub population like this. So, here basically, if this is the entire population, then we have to select a block of size M by k.

So, there are these way k number of blocks are there. So, each blocks are there. So, k number of blocks are there. Now, in each block, we have to select the solution which has the highest values with respect to a particular objective function. For example, in block 1, from this solution, we select all the solutions which has the highest value of objective factor f 1. So, it is basically f 1 and in this is f j and this is f k. This means that, in each block, all the solutions are having excellent with respect to one objective vector only.

So, all the solutions here are very good with respect to objective function f 1. In the j th block, all solutions are excellent with respect to the objective vector f j. And in this k th block all solutions are very good with respect to the objective function f k. So, this is the idea here. So, here M by k number of solutions, here m by k number of solutions and m by k number of solutions.

So, these way, we have to create k number of sub populations. Once the sub populations are created, then we have to shuffle. Shuffle means, one solution from here will be shuffled with to one solution in the population block j or one sub population from here to this one or any other solution from here to here. So, from any i th block to any j th block some shuffling was carried out. So, this is the shuffling. After shuffling, it will give a mating pool.

So, this is the mating pool, where, few are very good with respect to objective function in particular region and then other will inferior. So, it is the idea about it. And then, once this mating pool is created, we follow the same technique of the reproduction that is there in case of genetic algorithm. And from this mating pool, we will be able to create the next generation population for the next generation the i plus 1 th generation.

So, this is the idea about the VEGA. And we can understand that VEGA has the different approach. So, for this technique, selection is considered. Now, we will discuss about how the sub population is created and then how shuffling occurs and then how the VEGA can complete a cycle and all this thing.

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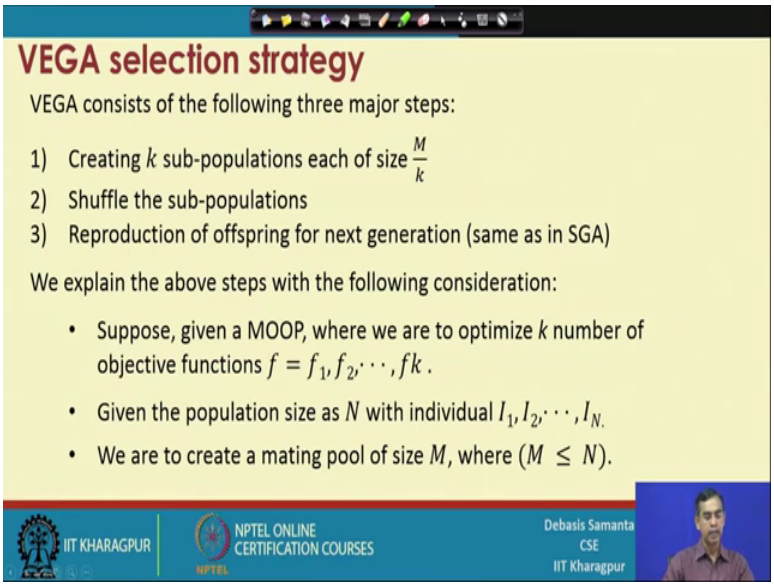

So, here VEGA consist of 3 major steps as we have planned. So, first step is basically creating k number of sub population each of size M by k. The second step is that, shuffling the sub population and then finally, the third step is the reproduction to produce offspring in the next generation. And as we have discussed about that, the first step is different, second step is different and then this third step is the same as the simple genetic algorithm that we have planned.

So, this is the idea about it. Now, let us see how the different things or shuffling or sub population can be created and then, what is the procedures there.

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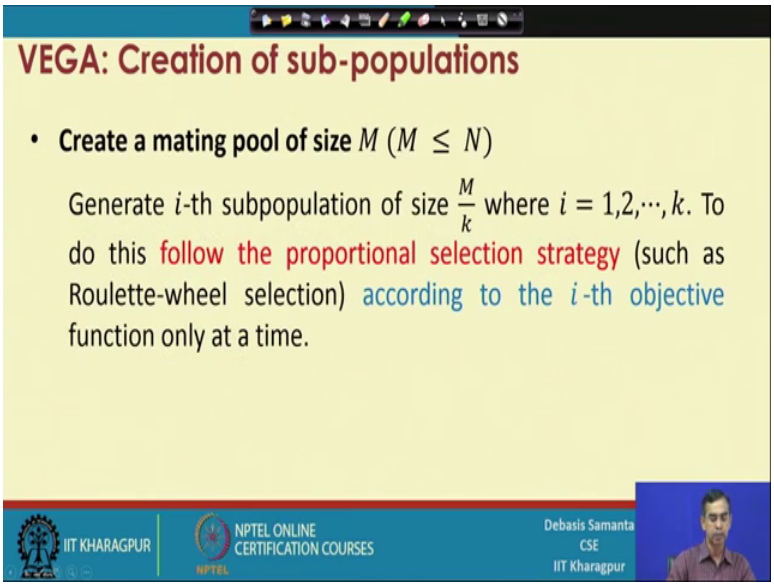

Anyway, so, once the mating pool of size M is created, we have to follow the proportional selection strategy. So, this is basically, the idea about how to create the sub population. So, to create the i th population of size M by k from the entire population, where i is basically 1, 2, k any one numbers, here to select the sub population for the i th block, we follow any selection strategy.

For example, any proportional based selection strategy such as, roulette wheel or hang by selection can be followed. So, here, whenever we follow this roulette-based selection strategy, like this one, basically we will consider only one objective factor, one objective function; that means, so i th objective function should be considered in order to select the proportional selection strategy to fill the i th block or i th sub population. So, this is idea about how to create the sub population any one population like this one.

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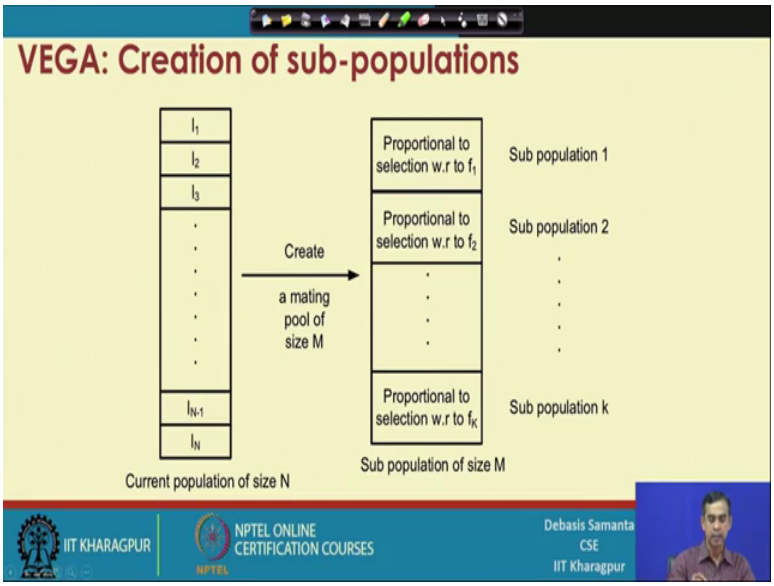

So, this is the pictorial description of the same thing. Here, this is the entire population of size N.

Then, our objective is to create the mating pool of size M. So, what we should do is that, for this for this population, when we have to fill it up, we will follow any proportional based selection strategy to select k. Select N by k number of solutions from here to obtain the sub population 1. Now, here and then, whenever we apply this selection; that means, to select all the solutions for this block, then we can follow any proportional based selection and then with respect to objective functions f 1. So, here with respect to objective function f 1, we apply any proportional based selection and then sub population will be created.

So, this will be continued with respect to f 2 for the sub population 2. Similarly, with respect to f k for the sub population k; this way, we will be able to create the sub population of size M where, the number of solutions belongs to a particular block has the excellent, with respect to one particular objective function f 1 and so on. So, this is the main the main task the major one task that is there in VEGA.

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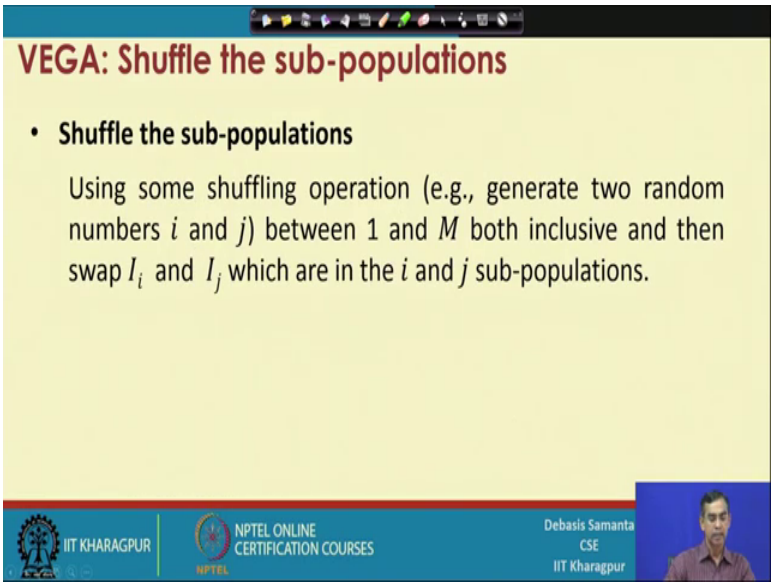

And once this sub population is created, then our next task is to shuffle the sub population. So, the shuffling that can be, we can like shuffling means, shuffling the solution from one block between any 2 block. Now, this shuffling can be done in many ways. I have mentioned one simple approaches here. For example, we first generate any 2 random numbers, say i and j between 1 and M.

Then, swap i i; that means, the solution i i and then solution i j, which are there in i th and j th sub population namely. So, we have to select any 2 solutions at random which belongs to any to sub population and then shuffle them. And this shuffling can be repeated may be some p times, where p is decided by the programmer. P may be 10, p may be 5, that means, how much mixing of the solutions you want to have. So, this is the idea about shuffling. Once the shuffling is done, then our mating pool is created.

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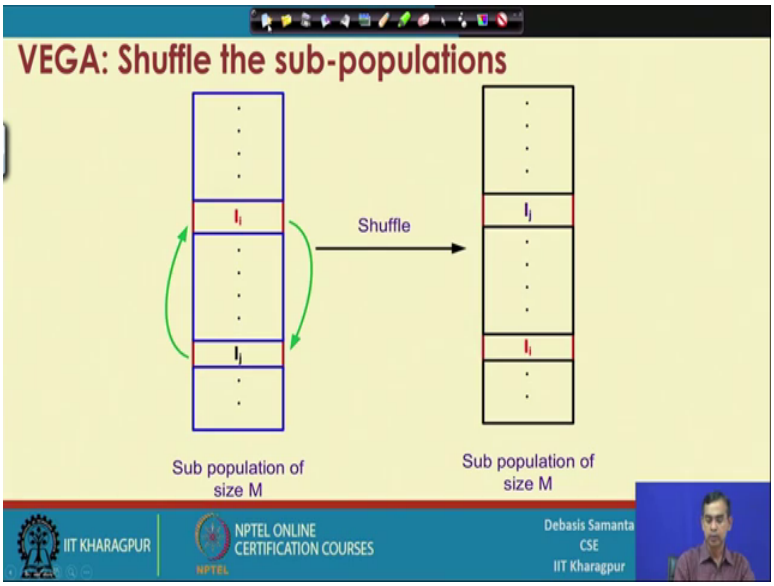

So, here basically the illustration of the shuffling procedure this is the one solution in any i th block. This is another solution in the j th block. Basically, shuffling that mean i 1 will go to the j th population and i j will go the i th population. So, after shuffling this is the mating pool is there. Now, once this mating pool is known to us, we will be able to go for reproduction. Reproduction strategy is same as the reproduction strategy that is there in case of simple genetic algorithm.

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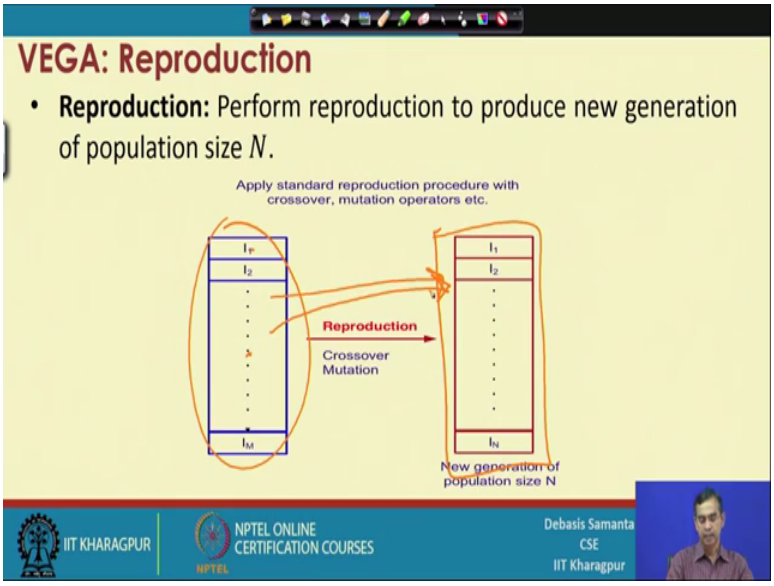

Here, this is the mating pool and from this mating pool, we have to create next generation populations. For the next generation, size will be same; that is, the N is the size of the population.

So, here, we can do again any 2 solutions at random. So, this one and this one any 2 solutions at random at the mating pair and from this mating pair, we will be able to generate offspring depending on the crossover operation; mutation operation that we have already learnt for the simple genetic algorithm. So, this way, from the mating pool of size M, we will be able to create the population of size N. And so, this is the idea about reproduction that is there in case of vector evaluated genetic algorithm.

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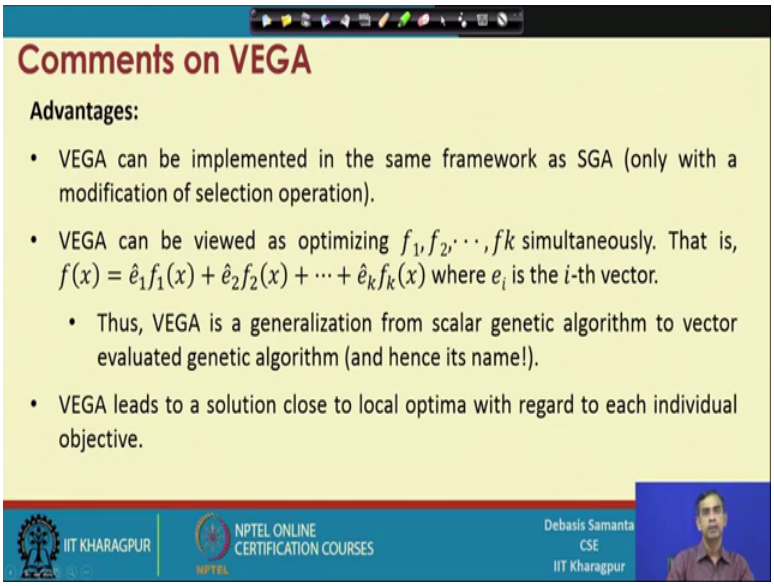

And then, let us see, how this vector evaluated genetic algorithm. We understand that, VEGA can be implemented in the same frame work as SGA; that means, it is basically an SGA, but only the thing is, that the selection strategy that is there, we have to little bit modify.

So, it is basically modified version or extended version of simple genetic algorithm. Now, VEGA can be viewed as optimizing all the objective function in succession and that is why, we can write that, it basically optimizing a function x, which is in the vector form of all the objective functions like f 1 x f 2 x this one. So, this is why, this method is called the vector objective. So, it is basically, we have to find f x such that f x is has one component f 1 x another component f 2 x and then k component f k x. So, we have to

find f x. So, that f 1 x is good, f 2 x is good and then, f k x is good. All objective functions are good.

But, we consider all objective function, whether good, then it is not at the same line rather in a succession line. So, first we say that, whether it is good with f 1 x or it is good with f 2 x or it is good with f k x. Then we can say that f x is good with respect to k objective functions like this one. So, this is the concept that is there and that is why, it is the vector evaluated.

It is called the vector evaluated genetic algorithm. In fact, a generation from the scalar genetic algorithm; scalar means, if we multiplied this f 1 by w 1, this by w 2, this by w k and if we consider w 1 equals to w 2 equals to w k, then it is basically a scalar generation. But, it is not scalar generation. It is basically vector generation and then the each component of the vector is basically excellent with respect to that component only and a thorough research and experiment with different (Refer Time: 20:33) it is observed that, this VEGA approach is comparable to the previous 2 approach; namely, lexicographic ordering and then SOEA approach.

However, and then SOEA approach, it is better compared to the previous 2 approaches and it also leads to a solution very close to local optima with regard to each individual objective vectors are there. So, this approach can be considered as a better approach.

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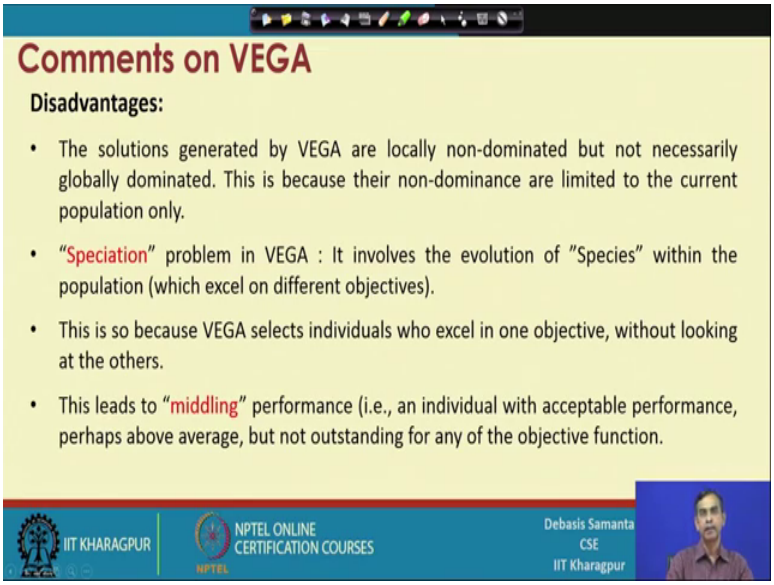

So far, the approaches that we have learnt and so, this is the advantage that, the simple genetic algorithm framework can be easily adapted to implement the VEGA approach and it gives better result compared to the previous 2 approaches. However, it has certain serious limitations and fine like the previous 2 approaches, which are belongs to non pareto based approaches, this approaches also gives only one solution.

That is why, it is called a non pareto based approach. Now, the solutions generated by VEGA are locally non-dominated, but not necessarily globally dominated; that means, all solutions are close to the local solution, but not necessarily close to the global solution. So, it cannot return the global solution. In fact, another 2 problems with this approach; the problem here called as speciation problem and middling problem.

So, this are the 2 drawbacks in this VEGA approach. Now, we say that, it suffers from the speciation problem, if it basically considers or if basically do very good result in terms of a particular objective vectors, but not all objective vectors. This is why, and now, in case of VEGA approach, we see that, whenever we select a solution for the next generation, we basically select with respect to a particular objective vector. Now, so that is why, it suffers from the speciation problem. That means, whenever we select an object we do not consider all objective function at a together, rather all objective function at a time. So, this VEGA approach suffers from this speciation problem.

Now, another problem that the VEGA approach suffers is called the middling performance. Middling performance means, the results that it returns neither very bad nor very good it is a say middle performance; that is, the things is there. So, if we are interested with not. So, accurate result. So, for the objective function optimization is concerned, we can use VEGA approach. In fact, VEGA approach is very fast compared to any other multi objective optimization solving approach. So, this is the pros and cons of the VEGA approach that we have learnt.

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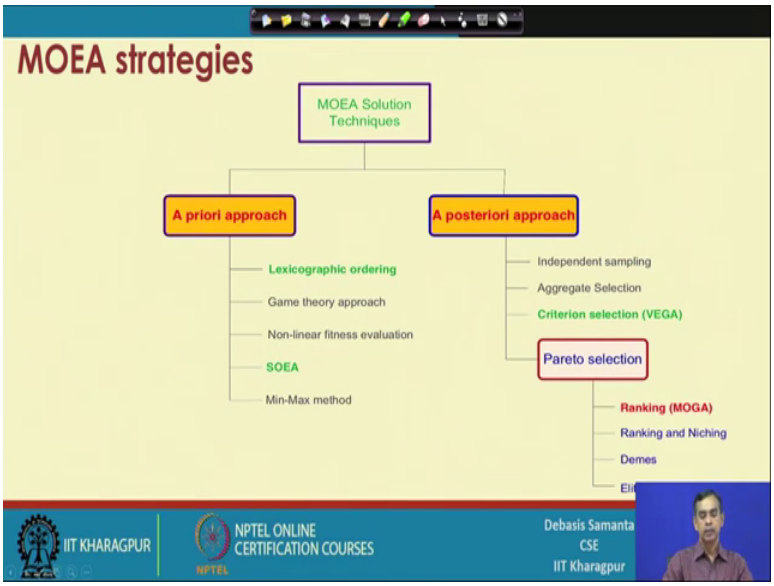

So, we have learnt different techniques to solve multi objective optimization problem. We term all the approaches as the MOEA algorithms or MOEA strategies. And so, for the MOEA strategies are there, we consider non pareto based approach. So, all the solutions are non pareto based approach. And out of these non pareto based approach solution, the solution that we have discussed as A- priori approach. So, we have these are the A-priori based approach.

And so, and then, in this course, we have learnt about two A- priori based approach; namely, SOEA and the lexicographic ordering. They are non pareto and A-priori approach. Another non pareto based approach that we have just now learned it the VEGA approach. The VEGA approach, in fact is A- posteriori approach. So, there are different variations. So, for the non pareto based approach are concerned, we have learned it and then we will we are going to learn about the pareto based approach.

There are many good techniques or good approaches belongs to this group pareto based selection. So, we will discuss about one approach all. So, we will discuss about 4 approaches in this course ranking and then niching the demes and then elites. So, those things will be discussed in the next slides, next class.

Thank you.