Introduction to Soft Computing
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Lecture - 14
Concept of Genetic Algorithm

So, there are three computing paradigms, which is followed in sub computing one is fuzzy logic, another is genetic algorithm and the third is artificial neural network. So, today, we will introduce the genetic algorithm the computing paradigm for soft computing. Now genetic algorithm is basically used for solving optimization problem, now you know exactly, what is an optimization problem?

So, the optimization problem essentially solving the to find the optimum value; that means, find the minimum or maximum value as an example say suppose, this is the value for which the different.

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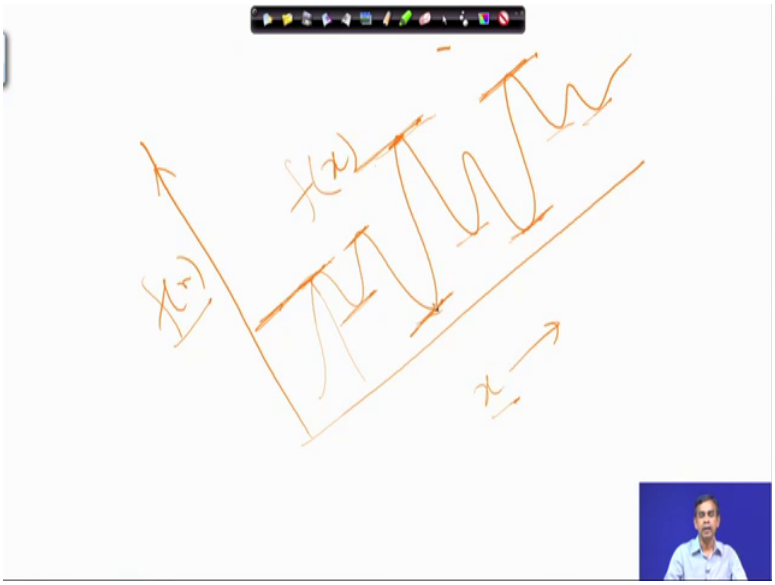

So, suppose f x, f x is a function which varies with x. So, if it is x in this direction then f x this is the f x.Now, so this concept say suppose the value of f x varies with the x, using this form, it is like this now. So, this means the value of funk f x varies with x and it takes the form like this and you can say that x as it varies then it has many values.

So, here basically the for some x, the value f x is highest, it is the maximum, it is the another maximum or so on. Similarly, minimum these are minimum this one. So, it basically says that how the f x varies with x and if it is like this and if you have to find which is the maximum value for which or what is the maximum value of f x or for which values of x, it is the maximum.

So, that can be obtained and if you have to search it then it is called the searching for an optimum result and. So, far the searching for an optimum result is concerned, it has many what is called the values actually, here these are the value is a highest value is a peak. All peaks are basically, some values they are called maxima similarly, all this is the lowest values the valley it is called the minima.

Now, out of this so many maxima's there are some values it is called the global maxima, if we say that this is the maximum of all the maxima values. Similarly, it is a local maxima local minima if it is minimum of all the minima values there. So, the concept is local maxima or local minima and then global maxima or global minima. So, finding an optimum value; that means, a minimum which is global maxima or global minima is called the solving for optimization problem.

Now, we will discuss about the GA. The genetic algorithm, which basically gives us a unique and fantastic way to search for all optimum values; that means, either minima or maxima before going to discuss about the genetic algorithm, we will just discuss about, how mathematically the optimization problem is defined, if suppose x 1.

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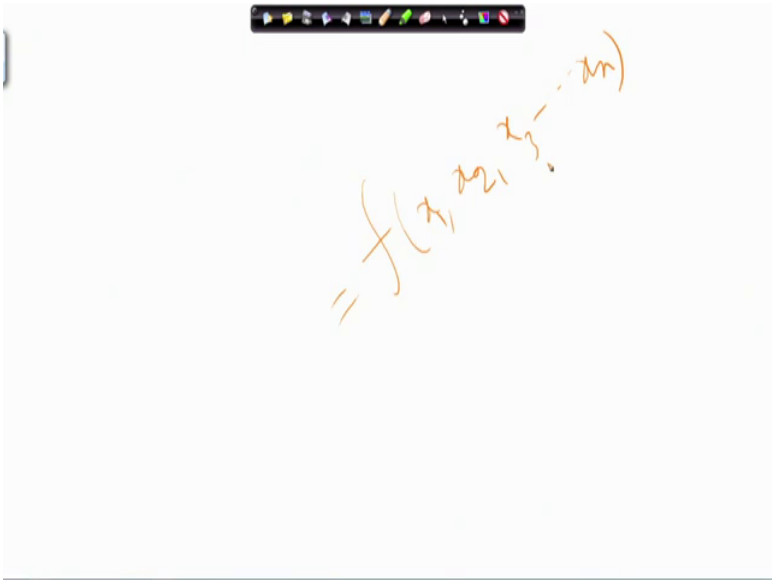

x 2 dot, dot x n, are the input parameter is given to us and we have to find, the function which is defined by f and which is discussed with this in terms of these are the input parameters; that means, the value of f is decided by the value of all these parameters x 1, x 2, dot, dot x n. So, this is a function we call this function as a objective function. So, this function is called objective function.

Now, we have to find either say optimum value, optimum means either minimum value or maximum value, for a given set of values of this x 1, x 2, dot, dot x n. Then this is called the optimise value. So, this optimise value can be either minimize, if we have to find the minimum values or we have to either find maximize if we have to value the maximum maximization value.

So, objective function always in terms of either minimization or maximization and this basically define by means of an objective function, which takes like this x n, now this functions this optimization. In fact, subject to certain constants. So, if it is minimize and constant may be another function g i x 1, x 2 dot, dot same set of parameters.

Now, this may be equals to 0, where they are may be one or more constant. So, this i, i equals to 1 to m, so if m constants are there. So, these basically this is the objective function it is like this and this is basically the constant usually we denote as subject 2. So, there may be g 1, g 2, and dot, dot g m constant. So, here the finding an optimum value; that means, finding some

values of the input parameter. So, that this function returns the optimum value and it should satisfy all these constant.

Now, this problem is no more TBL problem. In fact, and this problem cannot be solved in normal time, that is why we need some pragmatic approach like say soft computing to solve the optimization problem; that means, we have to find the values of input parameters for which a function f should return on optimum value minimum value or maximum value and at the same time, it should satisfy the search constants number of constants. So, this program is no more a simple program.

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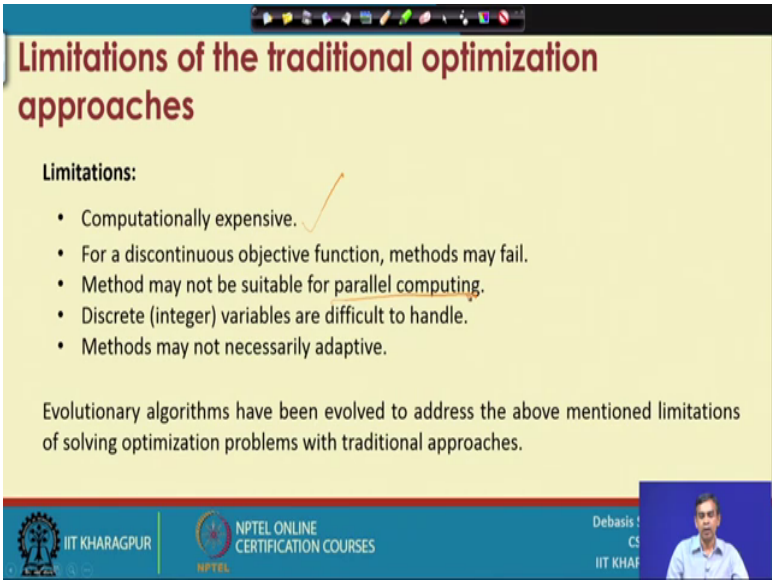

So, traditionally there are many methods are available and run to solve this kind of optimization problem, but they have their own limitation actually the traditional optimization methods are. In fact, computationally expensive that mean they cannot be applied to solve some optimization problem in real time, it may take 1 month to solve some problem like and all the traditional optimization methods usually not suitable for a discrete objective function and.

So, they are not suitable for discontinuous objective function there are some functions which have some value in some ranges. So, is a discontinuity they are in the objective function those method fails and as it is the time consuming, what is called the task finding an optimum value. So, usually we advise to follow parallel computing, but the parallel computing may not be implementable may not be realise using traditional optimization.

So, we need something which basically suitable for parallel computing and it is observed that traditional optimization approaches are not good enough to deal with the discrete values of the input parameters. So, if the input parameters are having discrete values then the existing optimization technique cannot solve them, and another limitation of the existing approaches is that they are not necessarily adaptive.

Adaptive in the sense that the same algorithm that you have developed, if you have to apply to m number of parameters instead of n, where n maybe greater than m or less than m; that means, if the input parameter increases then you have to rewrite the method the program totally differently if the say input parameter type is different a earlier it was for integer.

Now, you have to see it real type so, then it cannot be. So, they are actually they are not adaptive; adaptive means if the environment changes input changes that input parameter type changes then the traditional approach is not easy to adapt them.

So, we need some new method, which basically address all these limitations and we will see the evolutionary algorithm, it is an alternative approaches to the traditional optimization approaches that can solve and then address all these problem. So, genetic algorithm is basically one special type of evolutionary algorithms.

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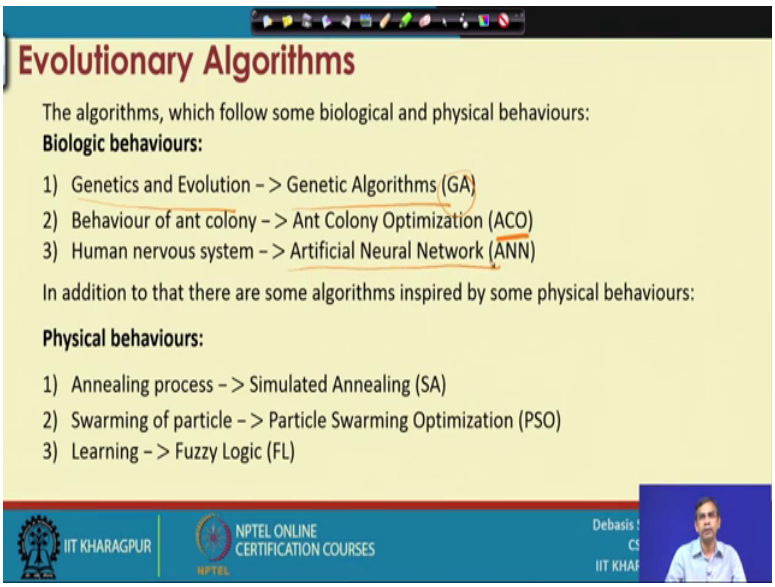

Now, so far the evolutionary algorithms are concerned how they are different than the traditional approach. So, they are different in terms of their the way they solve the problem.

In fact, the evolutionary algorithms they follow few concepts and the concept is called the, they follow certain biological and physical behaviours, which is around our globe in our world.

So, genetic algorithm which we are going to discuss is basically follow, the concept of genetics and evolution. Genetics is a well known concept in biology and evolution is also an well known concept in biology. So, these are biological concepts, so genetics and evolution is followed to solve the optimization problem then this is called the genetic algorithm and popularly it is abbreviated as GA.

Now, the way the ant they collect the food or they invite others fellows to a particular food source. It has been, followed to solve optimization problem and this is called ant colony optimization. So, it is also some sort of behaviour of ant, which has been followed and their behaviour is basically adapted into solve optimization problem it is called the ant colony optimization called ACO.

Now like there are how our nervous system work, if we follow the concept then and if you apply it then you can solve any problem this is called the artificial neural network or ANN. So, these are the classes belong to the biological behaviours there are some physical behaviours, the matters how they work. Now annealing process is the one process which is used to prepare the metals and if we follow the annealing process to solve a type of optimization problem or optimization problem, then it is called the simulated annealing, it is abbreviated SA.

Now particle how this swarm in a stream or flow the same concept can be followed to solve another optimization type of problem is called the particle swarming optimization problem or PSO. We have learned about fuzzy logic, how fuzzy logic can be used to learn. So, this is also another physical behaviour so all this concept are basically the concept, which is followed in evolutionary algorithms.

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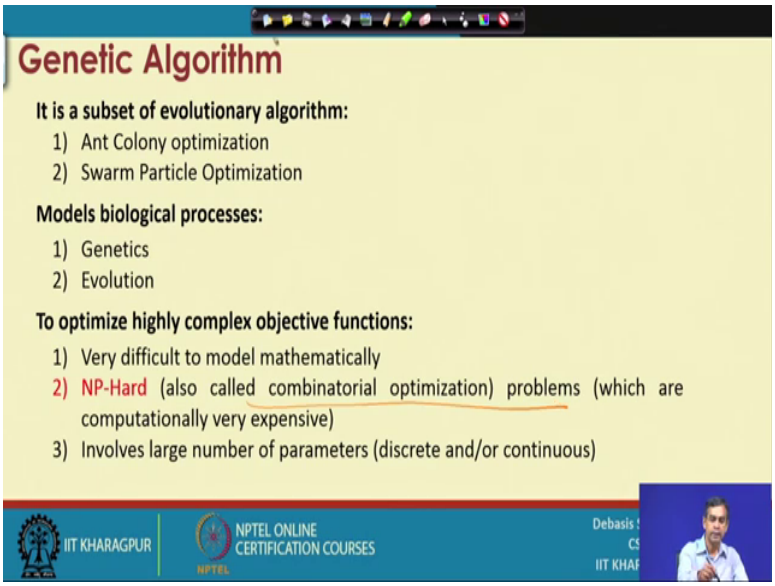

Now, in this lecture we will basically focus on specific evolutionary algorithm, it is called the genetic algorithm, As I told you genetic algorithm like ant colony optimization, particle swarm optimization is another type of evolution algorithm and it follows the two important biological processes called the genetics and evolution and particularly it has been observed that genetic algorithm is tremendous successful, in case of solving the problem which are basically called combinatorial optimization problem; that means, the problems which cannot be solve in real time.

It is also called NP-Hard problem, or you can say that additional methods if we apply to solve this kind of problem; that means, NP-Hard problems it is computationally very expensive and cannot be computed in real time. So, it is the problem and then genetic algorithm have been applied to solve this kind of problem and we can see the result in real time. And more significantly, the genetic algorithm is best suitable for those kind of problem for which any specific mathematical model or a suitable algorithm is possible to define how to solve the problem. If we are not have that specific algorithm are steps to solve the problem, when we can apply the genetic algorithm to solve this kind of problem.

So, the problem which is very difficult to module mathematically or specific algorithm is available then we can apply the genetic algorithm to solve this kind of problem. And if a problem involves a large number of parameters, the parameters maybe discrete or maybe

continuous or anything then the traditional approach is very difficult to use it, but genetic algorithm can be used to solve this kind of problem efficiently and effectively.

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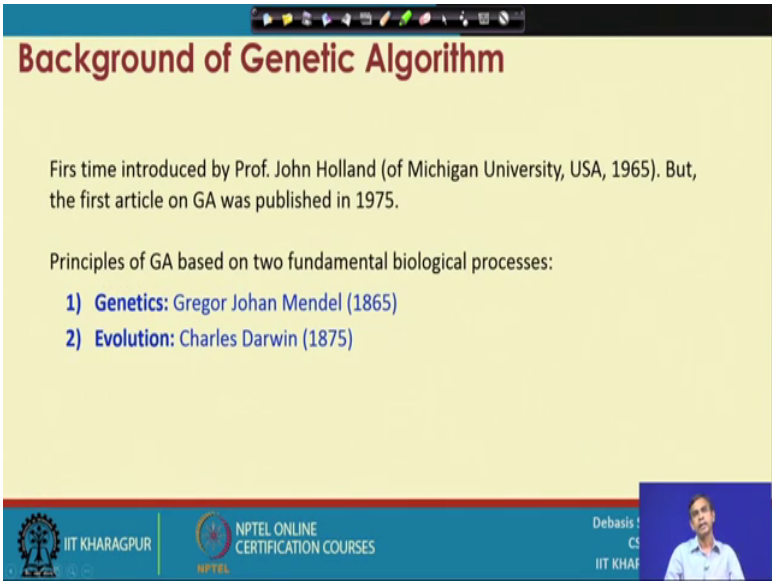

So, this is the idea, this is the history behind the genetic algorithm and which we can follow it. Now I just want to start with a little background about genetic algorithm. So, it is as early as in 1965, Professor John Holland, from Michigan university. He first proposed the concept, concept of genetic algorithm in 1965, although he has proposed the idea, but ultimately it was acceptable to the research community much later in around 1975.

In fact, the two pioneer who work to make the GA, most successful they are the two revolutionary people one is called the Gregor Johan Mendel and Charles Darwin, Gregor Johan Mendel in 1865, he proposed one revolutionary concept called the genetics and around 10 years later, Charles Darwin who proposed the concept it is called the evolution and that these two concept are merged together to solve the optimization problem which become the true I mean origin of the genetic algorithms.

So, in order to learn the genetic algorithm, it is better that we should learn about the two things the genetics and evolution first.

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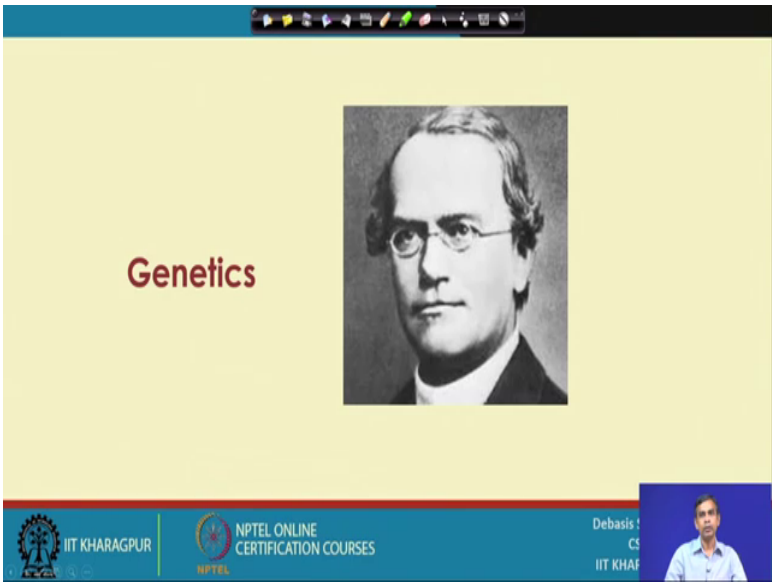

Now, as I told you Gregor Johan Mendel is the forefather of the concept of genetics.

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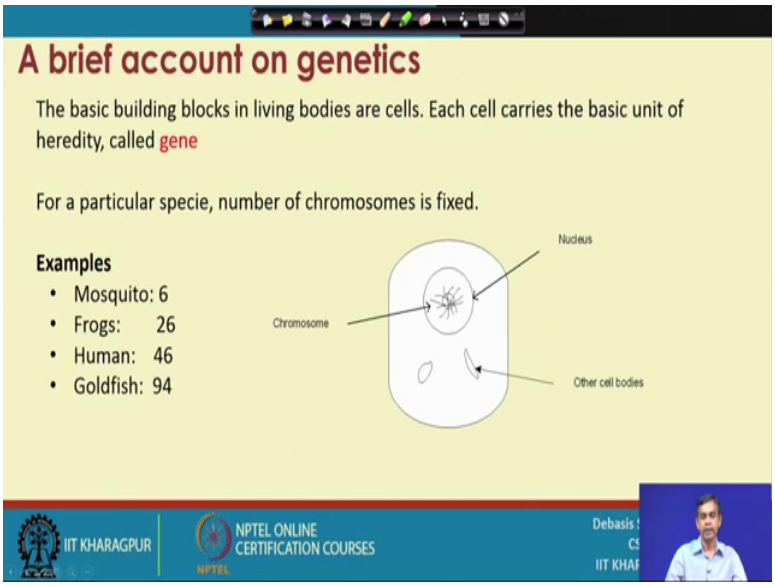

And genetics is an well-known things, and you know genetics came from the concept called gene and gene is basically is a fundamental things in our life, and it basically say that our body is consist of a large number of cells, living cells and each cell is basically a consists of what is called the one essential part in the cell it is called the chromosome, and if we go into details about the chromosome.

In fact, there is a spiral helix form and they are called the genes and these genes are basically the characteristics of a particular cell. So, are in other words a chromosome decides a particular type whether it belongs to monkey or it belongs to man or it belongs to cow.

So, it is also observed that chromosome in terms of number the different species that we are having had the unique number of chromosome for example, mosquito has number of chromosome 6, human has 46, 23 pairs and goldfish 94 out of is goldfish is the one element which is having the largest chromosome.

Now, so chromosome is one important be things that is there and. In fact, this chromosome also plays an important role in our genetic algorithm, we will learn it exactly how the chromosome is synonymous to genetic algorithms, first let us see exactly how the chromosome actually works it.

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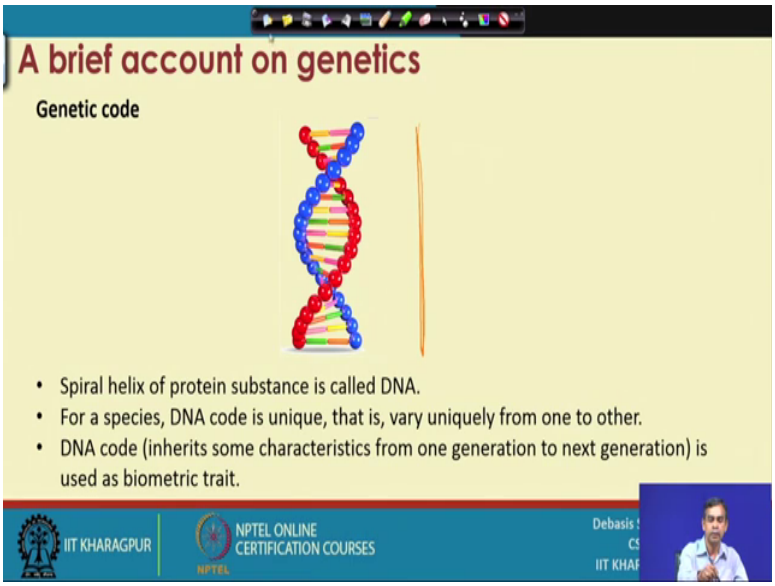

Now see chromosome basically is a code it is called the genetic code also and we know that every individual has its own characteristics, own features, own specification this is because he genetic code is unique and it is differ it is complete different from any other individuals around.

So, a genetic code is basically looks like a spiral helix, it is basically a protein substance and this protein is called DNA, deoxyribonucleic acid and a typical look of the protein DNA is look like this so this is a DNA structure and this DNA, has its own unique structure for a

particular individual and that is why you say that it is unique, and if we can represent this DNA code then we can basically identify the person. In fact, so that is why this DNA code is used as a biometric trait that mean by this DNA, we can identify a person uniquely.

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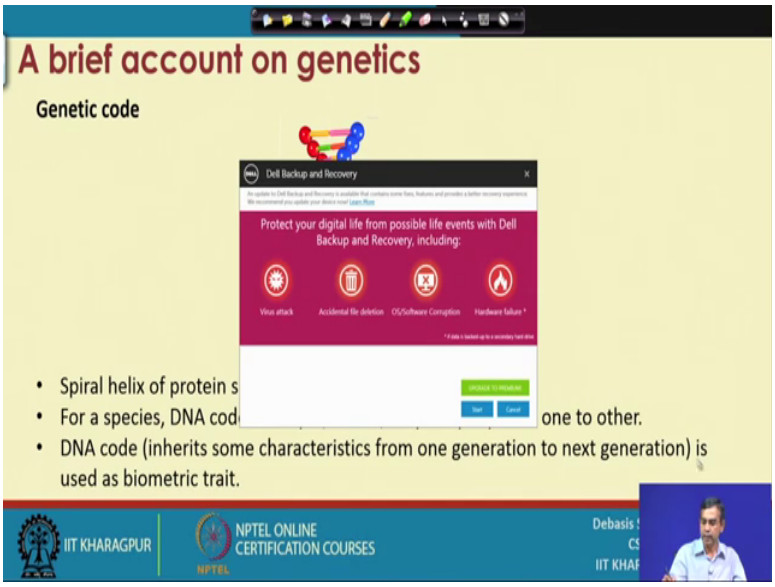

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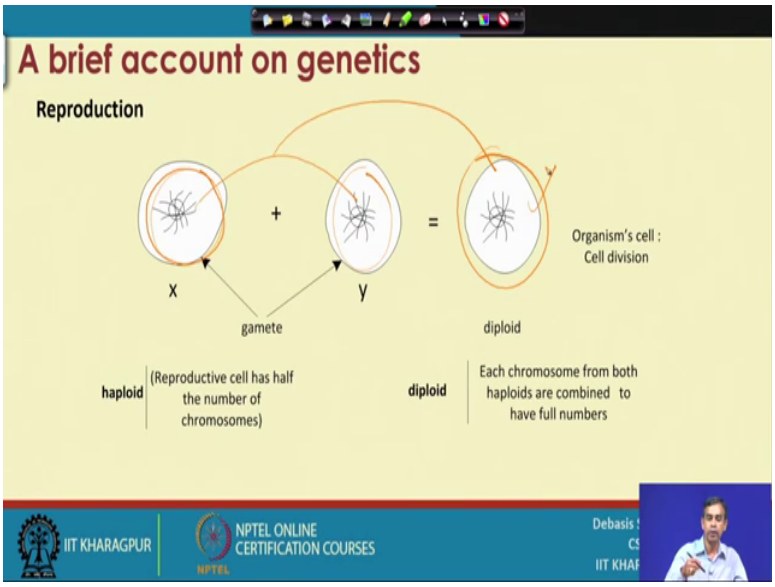

Now, so this is a concept of DNA and then the, this concept is basically, is also important in the reproduction the reproduction as you know. So, that two what is called a half cells they are called haploid, to half cells from the two opposite sex male and female obtained and then when they merged they form the diploid and then there this diploid is basically form a cell.

So, here very important thing is that haploid is basically one part which has the half number of chromosomes and this another half number of chromosomes, and when they merge together they form the diploid which basically form the full number of chromosomes. So, here is basically the division after that unification and then it produced another unique. What is called the unique identity or unique elements?

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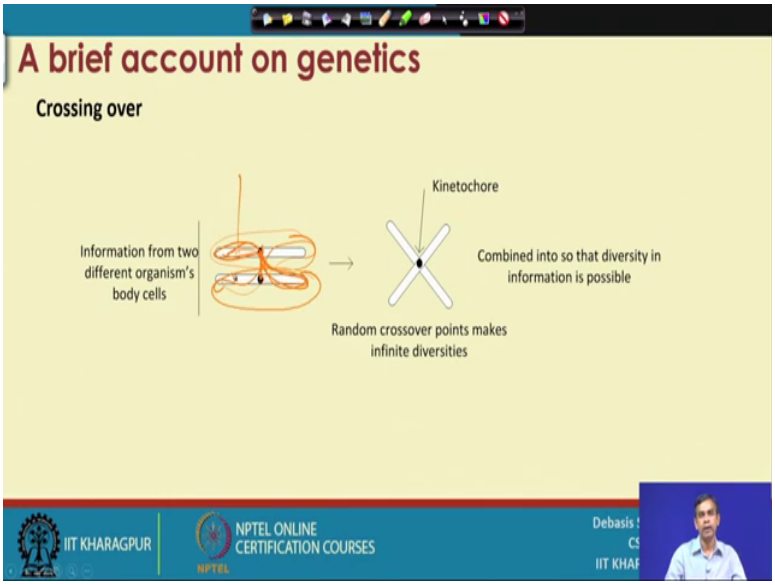

So, this is the concept that is followed in reproduction and so this is a part of the life and we just follow the reproduction, but behind this reproduction there is one important thing that we have learnt about that from two haploid we got a diploid and here is the idea about. So, this is the one chromosome from one haploid another chromosome from another haploid and there is one point, it is called the kinetochore point.

Now, they basically combine this kinetochore point and then. So, from one element here and another element here and then if we consider another element which is basically one part of here and another part here. So, basically it, basically gives the one chromosome to diploid. Similarly, another chromosome to diploid, now here one thing you can note if we take one part here and one part here.

So, the new chromosome that we get, so it has the two call a mixture of chromosomes and that mixture of chromosomes basically if produce is able to produce a new elements or new identity.

Now, so this is the fundamental thing that is followed there, if we follow these kinetochore points in different position. Then we can have the infinite number of different possibilities of having the differ unique identity. So, in this sense the reproduction allows or reproduction produces a unique element, every time it reproduces from two chromosomes to another chromosome or two haploids to another diploid.

So, this is idea that is follows there and this concept in genetics is called the crossing over and we will follow it exactly the concept of chromosome as it is there in genetics. Similarly, the crossing over or simply it is called the crossover is also an important what is called the philosophy that is followed in optimization technique.

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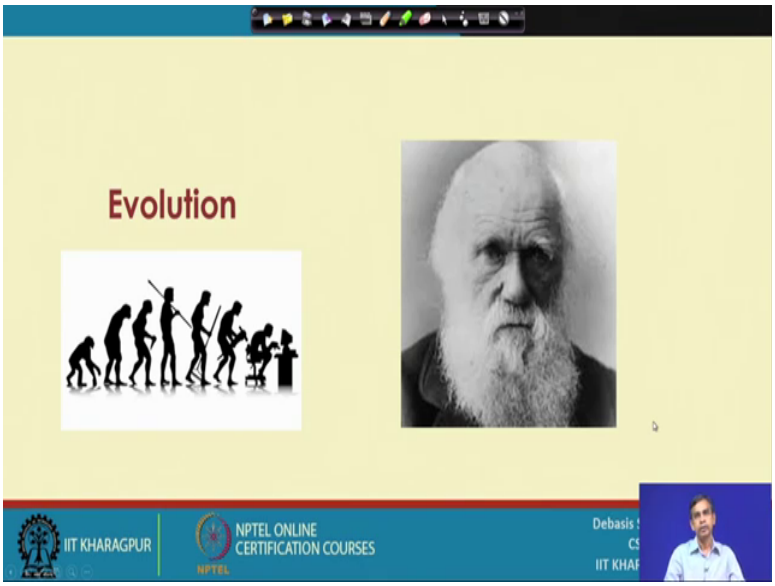

Now, so this is the genetical genetics, which basically Gregor Johan Mendel proposed first then how reproduces and every reproduction produce the unique element, next evolution is basically improvement from one level to another. So, regarding this in evolution the Charles Darwin is the forefather of this what he proposes four concepts. So, far the evolution is concerned the four concepts.

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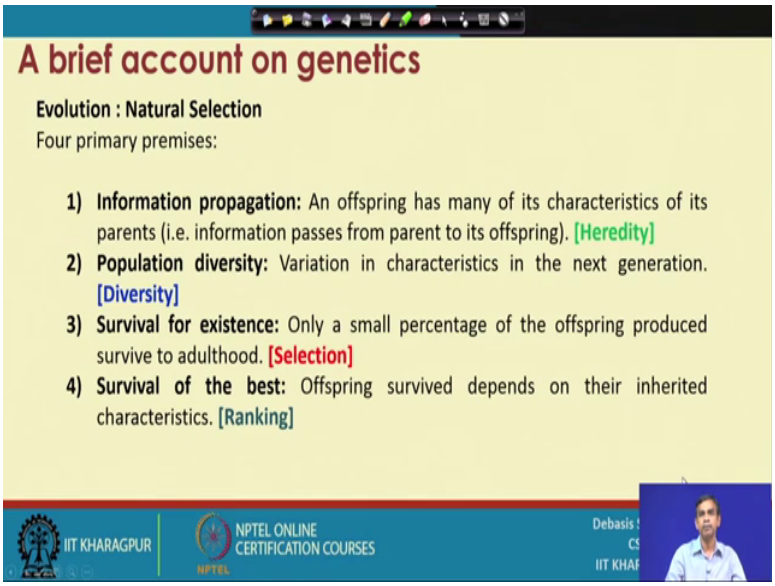

Are basically heredity, diversity, selection and ranking, so according to the Charles Darwin heredity? It is basically called information propagation, information propagation means that an offspring has many of its characteristics of its parents and therefore, the property or characteristics from its parent is basically passes through its offspring; offspring means children.

So, this is called the heredity; that means we inherit something from our parents. So, that is the concept heredity and population diversity. So, Charles Darwin termed it as diversity only so it is basically called the variation in characteristics in the next generation.

So, if we see the different generation no two generation we can obtain which have the same identity always it have at least some minor difference maybe, but differences are there next premises is called the selection, that is very important and this selection Charles Darwin termed is at survival for existence. So, basically out of many offspring only a small percentage of the offspring is basically able to survive in to adulthood and other basically go to I mean dies to exist, there they cannot sustain much more.

So, that is the selection and our world is basically followed, this selection procedure and that selection is basically called the survival of the best. So, Darwin call is a survival of the best; that means, only those offspring they survive depends on their inherited characteristics. So, it is based on the ranking, so these are the four things, four premises rather which is followed they are in so far the evolution is concerned.

So, evolution will be carried forward and Charles Darwin shows that these are the four primary things by which the evolution can takes place and evolution is followed there and this evolution also Charleston called the natural selection initially so, but will termed is a evolution and we will see exactly.

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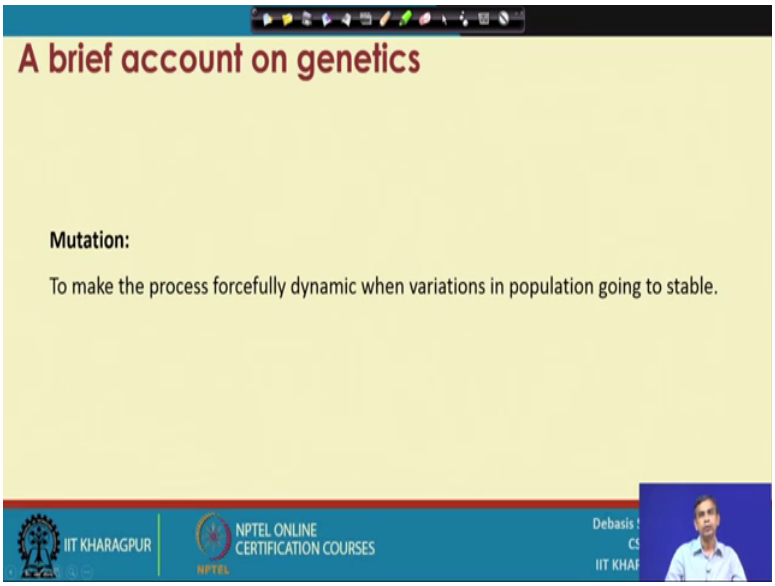

How these two concepts are followed in genetic algorithm and then genetic algorithm has been proposed. Now, other than this genetic algorithm concept, there is another is called the mutation will discuss about the mutation a mutation means all of a sudden there are some changes. So, two parents those are the fair skin all of sudden their offspring may be black also.

So, it is the due to the mutation all of a sudden there are some changes; that means, there are certain drastic differences in their chromosome property and that is the mutation. So, mutation is also one part of our natural what is called the process and natural generation production or genetics.

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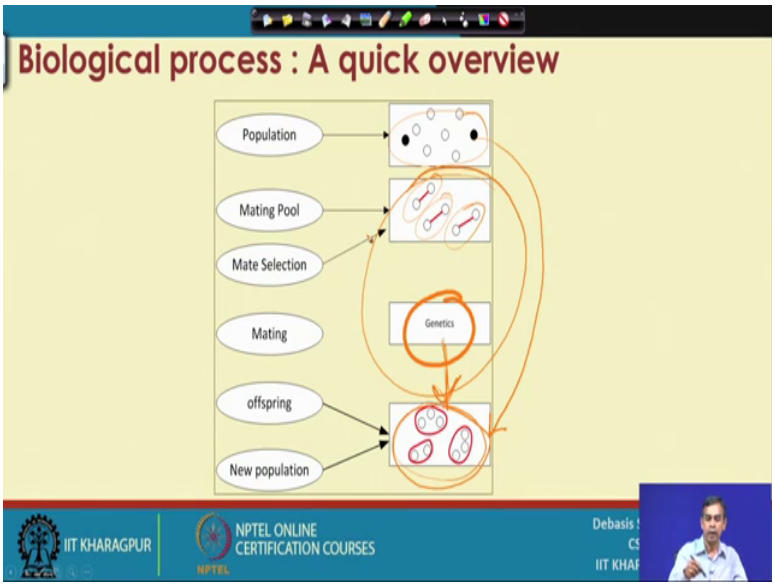

Now, so this concept is basically followed there and will learn about that how the concept of biological process namely genetics and evolution is followed there I just briefly summarise the concept that we have learned so far. So, if we have a population which is the population initially and then from this population, we follow the mating pool, mating pool means we just simply see that, who can be that can be fitted for mating another's.

So, there is a mating selection like marriage or whatever it is there. So, after the mating selection is there then it starts a mating and is basically. So, genetics is followed there. So, that is a mating and then from the mating, we have we follow whatever the crossover mechanism or cross crossing over that then and they produce there they produce the reproduction.

So, this reproduction produce, the new offspring and new offspring all together produce the new generation. So eventually the idea is that from the current population following the reproduction procedure we obtain the new population and here in between there are genetics and evolution involved. Now these are the concept that is followed there and in genetic algorithm. So, we are basically using the same concept.

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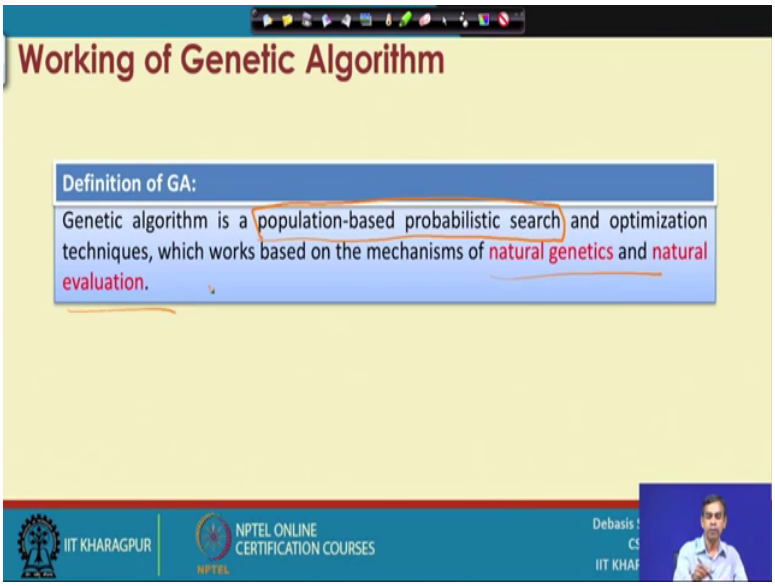

So, I can start with the genetic algorithm concept, it is basically the is an algorithm and this algorithm is a population based and is a probabilistic search, probabilistic search means the mating and the reproduction is a probabilistic random and then optimization. It is basically selecting the best candidate, from there and which works based on the concept of genetics and then evolution.

So, this is a concept of genetic algorithm so the fundamental thing it is there the genetic algorithm is basically, is a population based probabilistic search that is important. Now we will learn about how the population based, probabilistic search can be achieved and using the genetics and then the concept of evolution. So, this is the our objective study objective and we will see exactly how this can be done.

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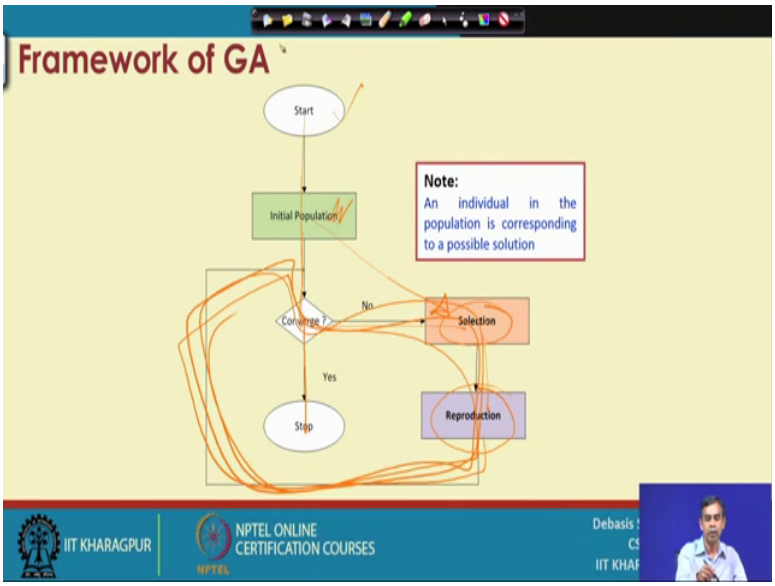

Now, quickly I will start with first the architecture genetic algorithm. So, this is basically the flow chart of genetic algorithm. So, we start with any population so we can say that initial population randomly we select some population actually and then there is a concept call the converge; that means, if we say there is no improvement in the next population then we can say that stop it here no more progress, but if we say there is some possibility of progressing.

So, then we can go and then selection it basically out of these populations select the best and those best basically responsive for reproduction if generates the next population. So, it will go there and again start there with the next population is converge, converge mean we can achieve our goal or not that mean complete or not. So, this way this algorithm is basically is a process you continuous or it process which run for long until we can come to the converge, so converge means in the sense that we can search the optimum result. So, that is the converge now here many things are hidden.

So, how this population is related to our problem solving, and how the selection and reproduction can be realised. So, that from one population the another population can we obtained. So, the another population means it is basically towards the better solution and these are the process selection and reproduction is basically is a fundamental block for probabilistic searching. So, we will discuss about this concept in details in the next class so fine.

So, this is the basic framework of the genetic algorithm and based on this basic framework there are many other framework also have been proposed, all this things we will discuss in the next class.

Thank you.