Introduction to Soft Computing
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Lecture – 34
Introduction to Artificial Neural Network

In soft computing one another important paradigm of computing is artificial neural network. So, in this lecture we will introduce the concept of artificial neural network and it is uses to solve many problems in different applications.

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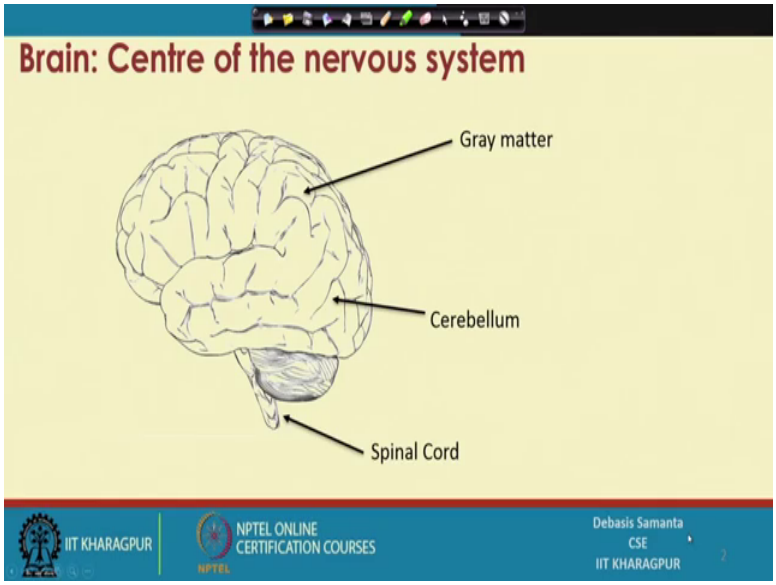

So, we know the human is the best creature in this universe and the main things, that is intrinsic in the human is basically it is brain. Brain is also called central nervous system due to this very unique characteristics of the brain human can do many thing human can remember human can reason out human can prove theorem human can solve many problems human can see the world recognize those things and many more. So, behind all these the all performance compared to the other living things in this world the human play the brain plays an important role.

Now, as the brain it is also central nervous system ok; biologically it looks like a gray matter. So, that is it why sometimes in medical science brain is called the gray matters. Now, in this gray matters there are a lot of other brain cells are there and any things from

any part of the brain is basically controlled by this central nervous system. So, this is this how this brain is also called the head office of our body.

Now, today we will see exactly how this brain is composed of and how this brain works and then how the same thing can be mimicked to solve our problem in an artificial manner so, the artificial neural network.

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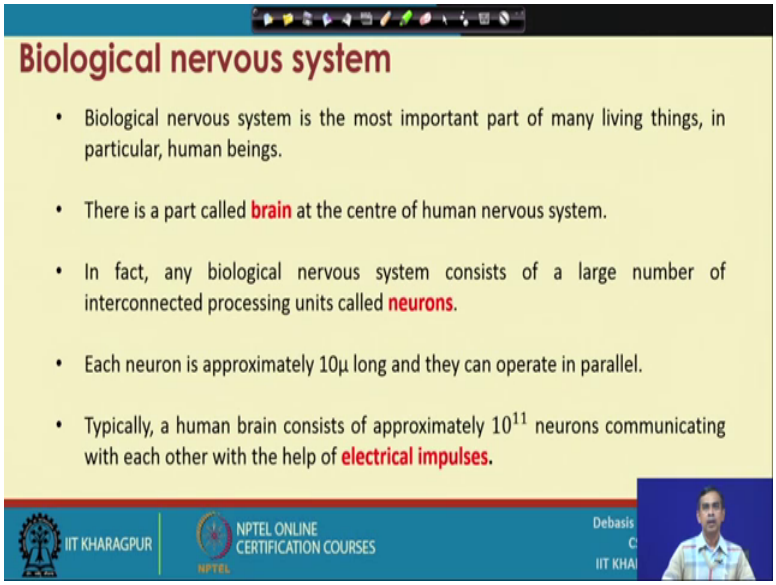

Now, so in the brain in fact, there is a large collection of brain cells as I told you this brain cells is, basically the atomic level the processing units and more precisely this atomic units is called neuron each neuron is approximately in micron in length and these are the unique neurons which basically are the fundamental things of any what is called a sense processing.

Typically, within a human brain there is; around 10 to the power 11 number of neurons. And these neurons are basically stay there in a connected manner or you can say in a network manner and in this network all these neurons are the units which basically carry certain pulses. This pulse is basically same as the electrical pulses. So, it is also in many ways similar the way how the current flows from one source to another destination. So, these neurons are the cells which basically propagate the electrical pulses from any part of our body to the central nervous system and vice versa. So, these neurons are the important things and we will see exactly how a neuron looked like.

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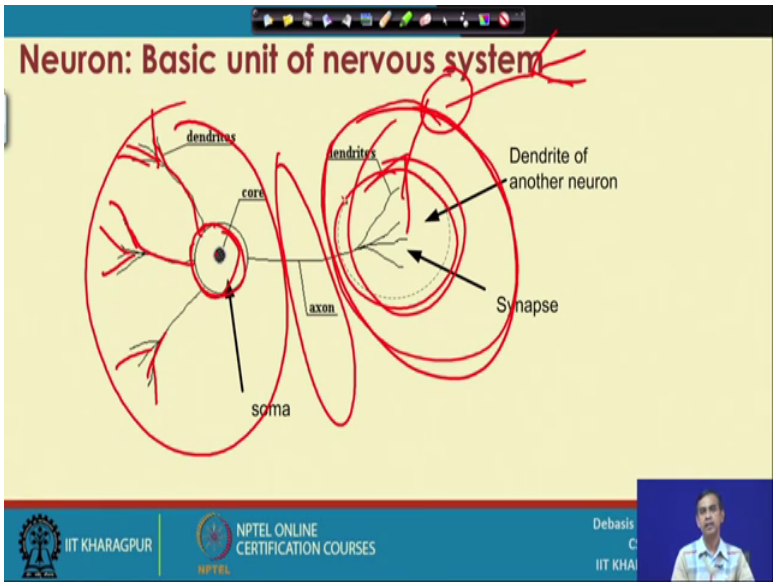

So, in this slides we see one neuron and if we see these slides then you can understand it has three different parts. So, this is the first part this is the second and this is the third part; now this part is called the head of the neuron now so, in this part one is a elongated or is a soiled portion is called a cell body of the neuron and it is called the soma and in the soma there is a core this core is not exactly the nucleus as it is there in the body cell. And, now in the soma there will be here a like connection these are called dendrite dendrite is very small thin here like organs parts.

And, then the next part it is basically end or tail of the neuron it is called the it is called the synapses. So, basically the synapses; is one part where it basically meets with other dendrites of other neuron. So, it is basically a junction point of meeting other neuron. So, other neuron. So, this is a junction point. So, there is a synapse is also called junction point. Now, between these soma and synapse; there is a connectivity this connectivity is called the action. So, this way the neuron are constructed.

Now, this neuron just like a body cell it is also a cell it is a living cell and the important difference between the other body cell. Then this nerve cell is that the other body cell can go cell division whereas, the neuron cannot go cell division this means that at the time of birth a person having number of neurons can never be increased. And also if some neurons are damaged or destroyed it cannot be reproduced like unlike the body cell, if there is a cart or wound it will be healed and then some new cells will grow to fill the

wound or heal. So, this is the difference between these cells and functionally there are many differences between these neurons and the simple body cells ok.

So, we will learn about the neuron. So, neuron is look like this.

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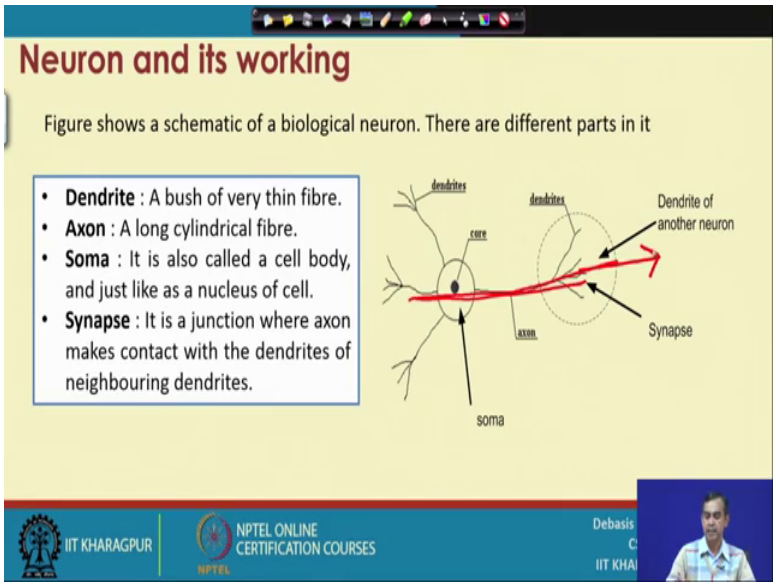

And now let us see how this neuron is basically what there now and this is a very very schematic of a biological neuron and the different parts that does know we have discussed about. So, different part means the dendrite the axon soma and synapse and here the signal, signal will flow from dendrite to axon; that means, from one neuron to the next neuron. So, this way the signal can propagate it in a one direction. So, if; so, there is a basically connection from every points in our body to the brain and that is the network is there and for building such a network the basic unit is basically this neuron ok.

So, this is the neuron there now here one question that arises is that; how the signals flow from one cell to another cell.

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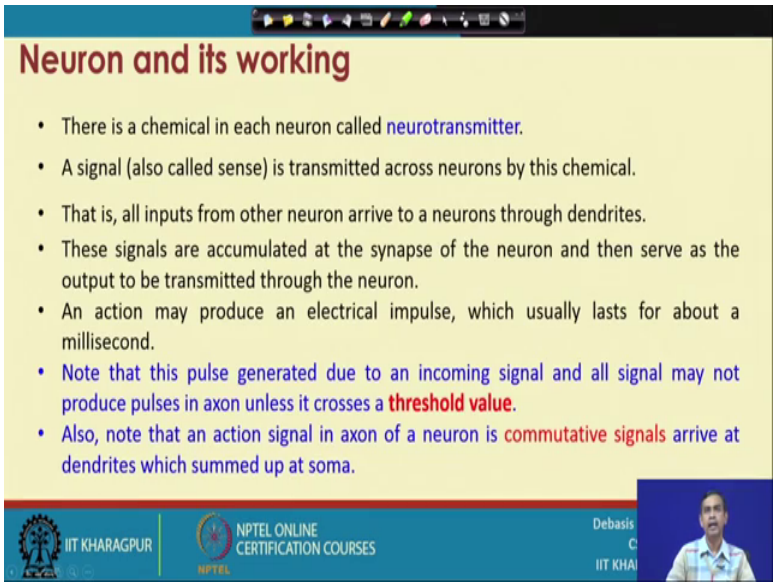

Now, in every neuron there is one sort of fluid is there those fluids are called neurotransmitter; that means, the body of a neuron is filled with this liquid it is a neurotransmitter now a signal whenever it is created this causes some what is called a different level of concentration. So, far this liquid neurotransmitter is concerned for example, if a mosquito bites then the at the point where the mosquito bites at that point a signal is created the signal is basically is it created means it basically creates a different level of what is called an neurotransmission.

Now, this neurotransmitter is basically is a solution sort of thing we can sim in a simple manner we can say is a some concentration of some cation like any sodium calcium magnesium all these things are there. So, these are the basically is ion concentration. So, whenever a signal or some event occurs then there is chain in this concentration level of these ions as a result some voltage will be developed and due to this voltage this signal will propagate from one neuron to next neuron.

So, this is nothing, but an in just like is an electrical impulse and this electrical impulse, whenever it is created in a neuron lasts only for few seconds it is not few seconds rather it is for a few milliseconds; that means, whenever that ion concentration difference occurs it will persist only for a few milliseconds after that again concentration will be balanced and there will be no signal or no pulses and so, so this way the signals are

created and once the signals are created signals will be propagated from one neuron to another neuron.

Now, in this context one thing we should note that all signals cannot be propagated from one neuron to another neuron a signals which have certain, what is called the strength more than a threshold value only can be transmitted from one neuron to another neuron? If the signal strength is less than this threshold value, the signal will not be transmitted from one signal to another signal and another from one neuron to another neuron and another important thing is that to a neuron the signal can arrives through the different dendrites and.

So, many signals whenever coming from the different neurons to a particular neuron are summed up summed up at the soma and then summed up signal is basically propagated via axon through the synapse to other neuron. So, these are the things that happens in our; biological neurons.

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And this idea is enough to understand how these things can be considered to solve many problems.

Now, see these pictures here how the signals can be. So, here basically one, here basically some event occurs. So, these basically produce some, what is called electrical pulses will be flow there come here and then go there this way it will flow and the signal

which is produced here right. Because I told you once point here, but in this point the number of neurons are n fact, located..

So, so the point where the neurons are located they will receive this pulse and then pass through this what is called a neuron and then summed up here and when this signal strength is greater than a threshold value will be passed through these synapse and then from there it will go to the other neuron. So, this way the signal propagation takes place in our neuron.

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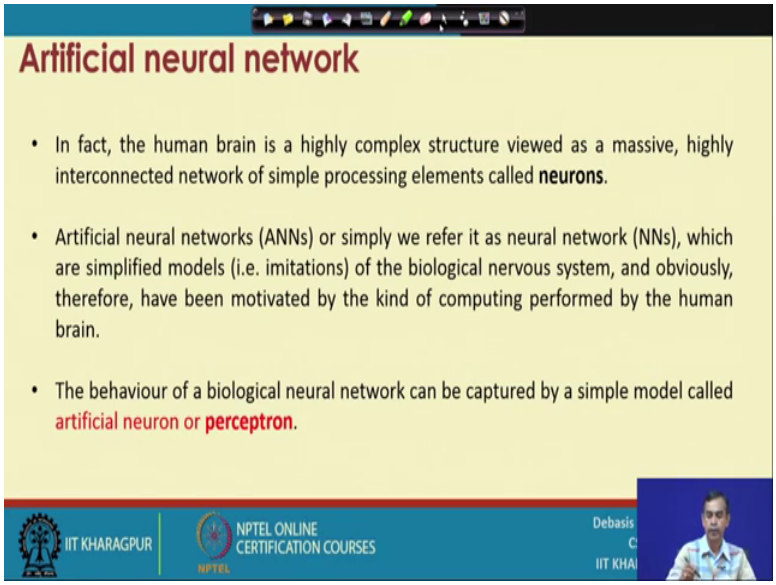

Now so, this is the idea that is what is called the biology biological neuron. In fact, the human brain is basically the very complex structures and it can be viewed as a massive, highly interconnected network of these neurons. So, gray matter that we just have now learn about it is basically nothing, but a collection of neurons, as I told you it is around 10 to the power 11 neurons, the people who are having more neurons they have the more processing or computing capabilities thinking capability they are great scientists like Albert Einstein.

Now these artificial neural networks is basically the mimic is a simulation of the biological neural network which is there and the artificial neuron is called perceptron. So, in many book you can see it is call it is termed as perceptron. So, neuron or artificial neural.

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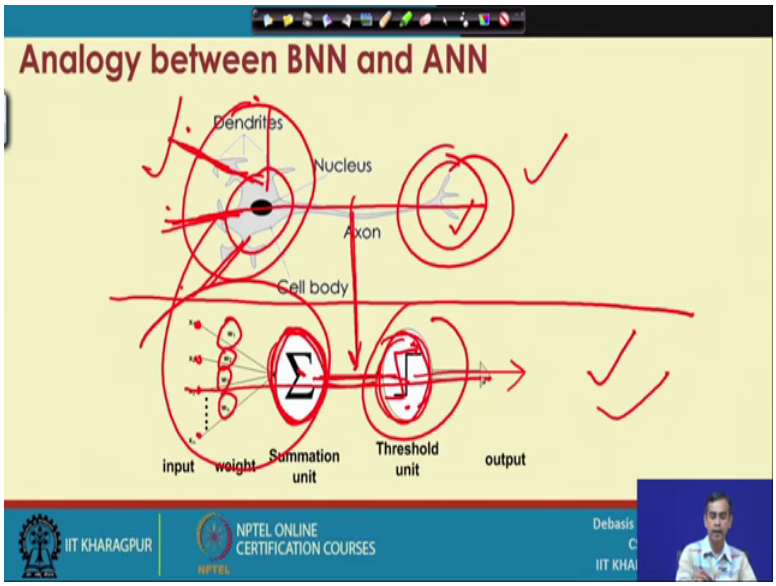

Network is basically is the basic units which can solve many problems.

Now, let us see how we can mimic this biological neuron to our artificial neural neuron or it is called a perceptron. Now, here we can see that to this figure can be considering the two parts: in this first part we can see it is basically the figure of a biological neuron and the second part of this figure is basically.

So, the artificial neuron that is a perceptron now, here if we can see the input here in this artificial neural network X 1, X 2 dot dot X n are the input to the perceptron and all the input come to this part it is called the summation unit; it is basically same as the input from the different part it is coming like X 1, X 2, X 3 X 4 and coming to this part and this is the summation unit.

And another important thing that we can note it here is that; whenever the signal is coming here it, basically come with some weight W 1, W 2, W 3, W 4 it is like this. So, similarly it is here also the signal that is coming here with certain weights; weights is basically indicates that how the signal is significant to this neuron? So, basically all signals those are coming they are called a weighted signal..

Now, when the weighted signal comes into this summation unit, basically all the signals and multiplied by their weights are summed up here and then total summation of this strength will be passed through this, this is just like axon this is just like a axon, and then

come to this point and this point basically; now the signals which are summed up here comes to this point is basically same as the synapse or junction it basically connection to other neuron.

Now here the signals which are arri which are arrived here right will be check that; whether the signal strength is greater than the threshold value or not; if the signal strength is greater than the threshold value their signal will pass to further , but if it is less than then it will not past. So, so this way we can say this part is same as this part and this part is same as this part and this part is this one.

Now, so, this is the biological neuron and this is artificial neuron, neuron and we can see that; how this biological neuron works it can be considered to work here and basically writing. So, far the program; that means, computation is concerned it has to computation. So, input is there and output is there as you know in every computation the input and output is there and this is a system which basically map given an input to a output and the mapping.

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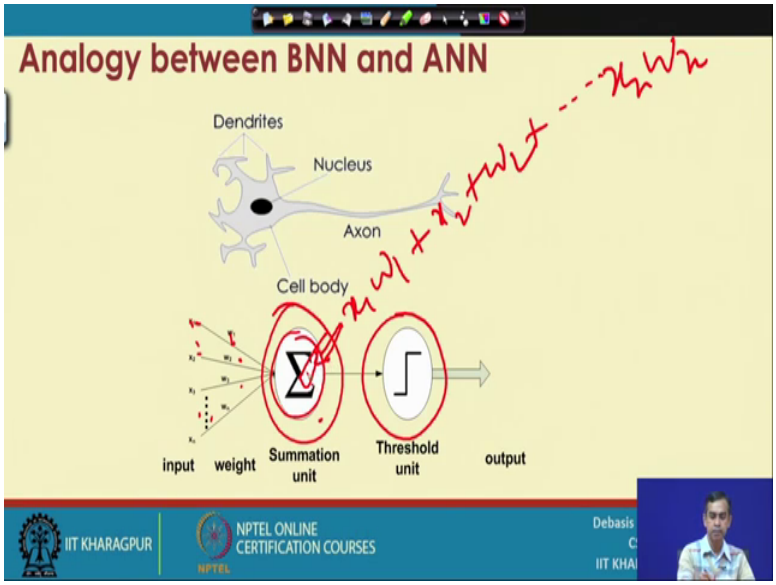

So, there are two mapping functions or simple functions are there, one function is basically; take all these inputs and their weights and the simple function that it will calculate is called the sum summation of products of all weights and their inputs; that means, X 1 W 1 X 2 W 2, X 3 W 3 and then sum of all these values. So, a simple program that can be written which take input X 1 and W 1, X 2 and W 2 and produce X 1

W 1 plus X 2 W 2 plus dot dot dot dot X n W n. So, this kind of so, this is basically computation that can take place here in this part a simple program with a simple loop can be right.

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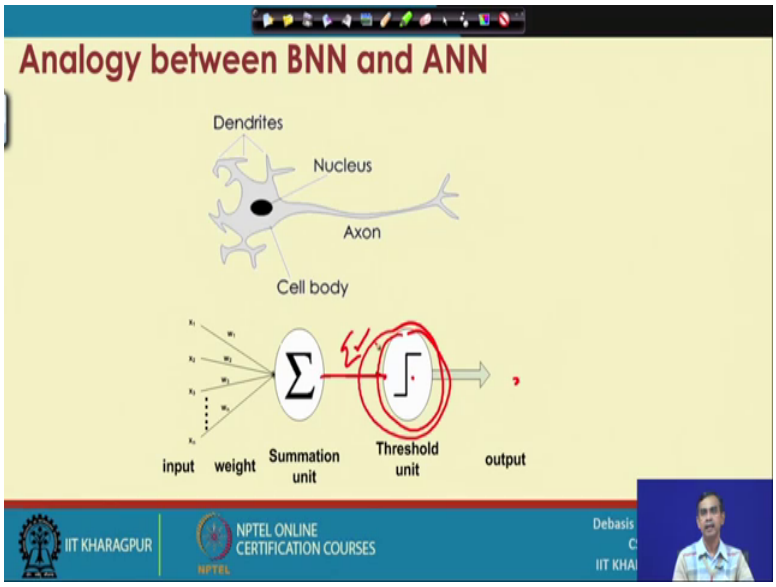

And then here one another program we can think about whenever it receive this input; that means, these are sum of all the inputs it is there it will check with respect to some threshold value if the input this sum is greater than the threshold value then it will pass. So, it is basically what if then command is there a very simple code is there. So, what I can understand is that the way this biological neuron works we can write a simple program to mimic the working of the biological neuron by means of a perceptron.

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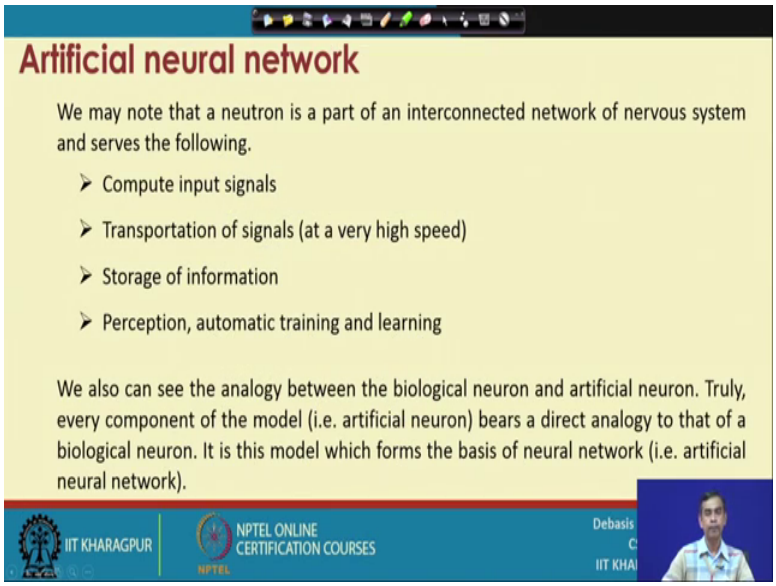

So, this is the idea the way the signal is work. Now few things are very much pertinent. So, far this perceptron and our biological neuron is concerned. So, as I told you a neuron is a basic unit and it works as an interconnected form. So, it is basically network..

So, that is why? It is got a network of neurons and this network of neurons computes the input signals, if you pass any signals as an input to this system it will compute the signal and it can has the characteristic to transport the signals at a very very high speed and in addition to this, what is called the working of the signals few things are very important is that; it can store information it can perceived and also it can learn automatically.

So, these are the concept that is there, and we will see how our artificial neural network the way the biological system works it also can be implemented and it basically give rise to the one important theory in the sub competing artificial neural network. So, this is the idea about.

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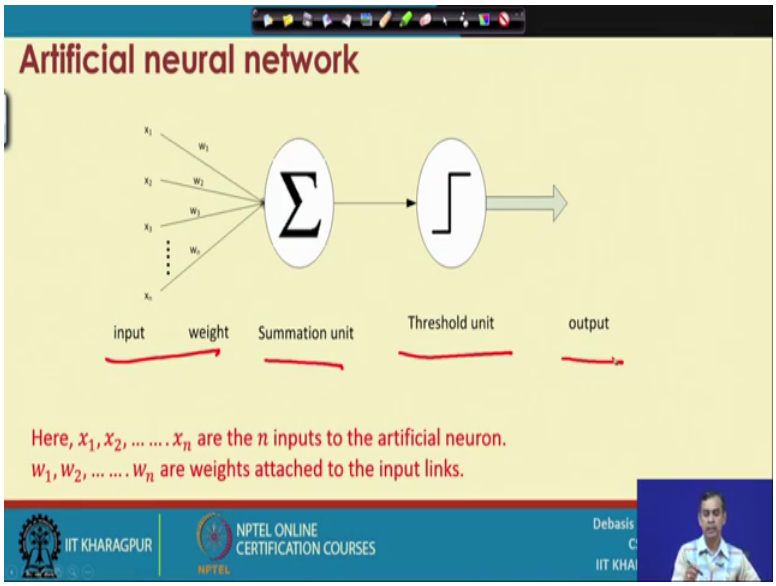

So, far the artificial neural network is concerned and as I told you that this work has certain computation per thing. So, input weight are the input and weight are the input and weight are the input to the things and this is one module or one function. Another function is output is there so, so this way this neurons neuron system will work for us and now let us see.

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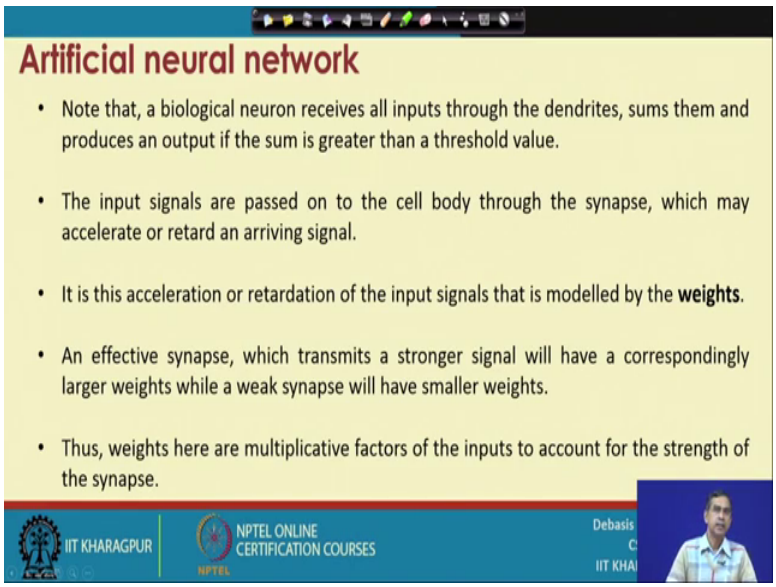

How this neural networks is basically solve many problems right there.

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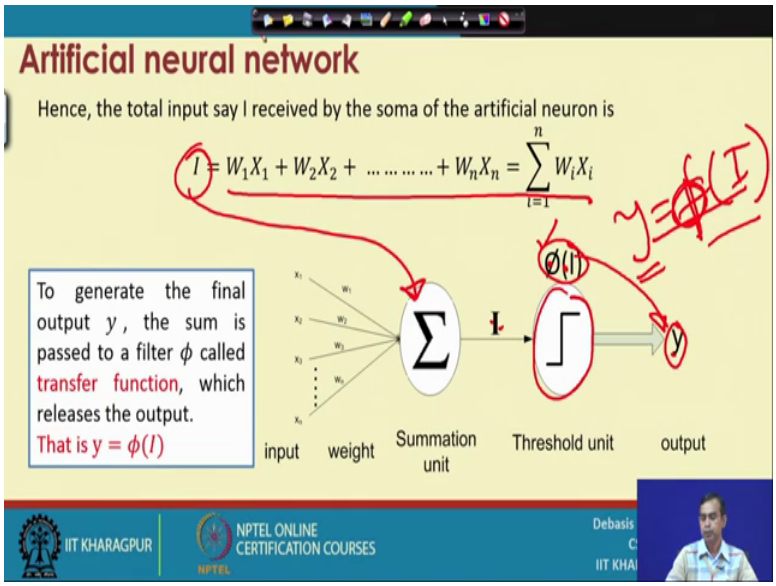

Now here exactly, again I just want to repeat the same thing ah, but in a different way. So, if this is the input like this is the input to the system, then reproduces the output by means of this program. So, I is that here this I passing there and here, basically function this function we called transferring function or transfer function this function is phi and for this function I is the input and y is the output. So, this is the transfer function right. So, the this I. So, this function transfer function takes this I as an input and then produce the output.

Now, again so, this actually we can write y is a function of I or it is phi of I like as you know we have mentioned at the very beginning of this course any system has the antecedent and then consequence. So, it is antecedence and conjugate it basically maps input to output. So, mapping so, this way we can understand that this neuron or is a perceptron rather; how map an input to an output?

Now, again in this processing one important thing that is there is called the transfer function. Now, we have to learn about the transfer functions and what is the meaning of this?

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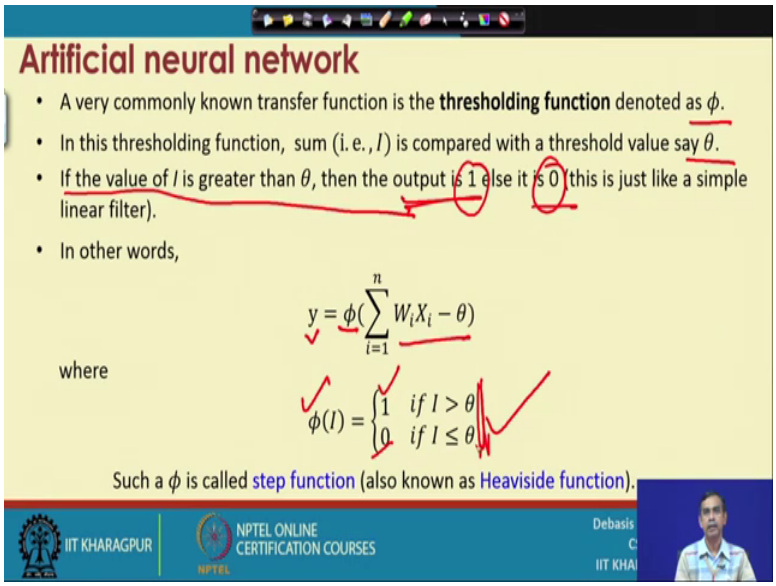

One here now there are in fact, many many transfer function known sometimes all these transfer function is also called thresholding function. We usually denote this transfer function as phi. Now all these transfer functions is basically compared the input I with respect to some threshold value we denote this threshold value as theta.

Now the way this transfer function works is basically is a rule; that means, if the value of I greater than theta, then the output is 1 else the output is 0. Now, we will learn that the output of a neuron is either 1 or 0; it is not necessarily that always 1 or 0. Sometimes some other value also can be considered for, but for the sake of simplicity in calculation usually these two outputs are there. So, 1 and 0 so; that means, y has the value either 1 and 0. So, this phi returns either 1 and 0 and this is the rule that it follows if I greater than theta, then the function phi I returns 1; if less than or equals to theta is 0.

So, this is one transfer function that we have discussed and it follows the rule like this; and if a transfer function follows this kind of simple concept, then it is called a step function also alternatively this function is called heavy side function. Now so, we have learned about the basic or simple transfer function that is there in the theory of.

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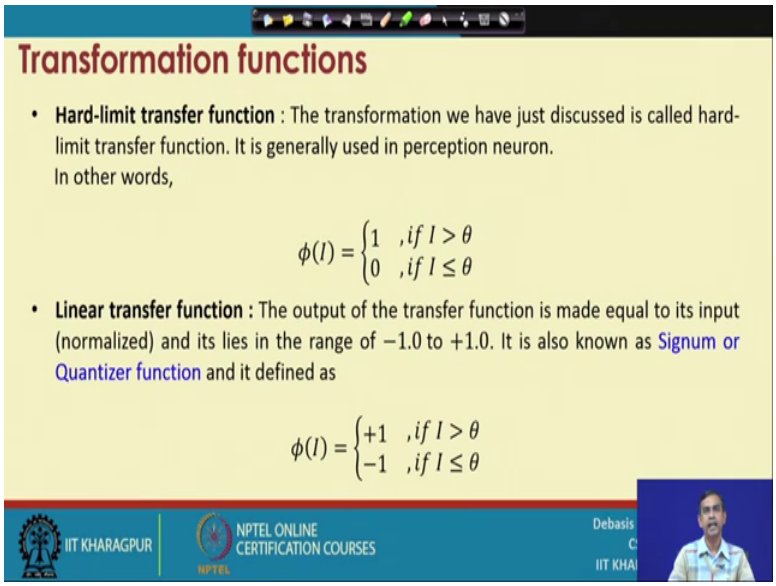

Artificial neural network sometimes this the step function is also called hard limit transfer function v, other than this hard limit transfer function there is another function also known it is called the linear transfer function.

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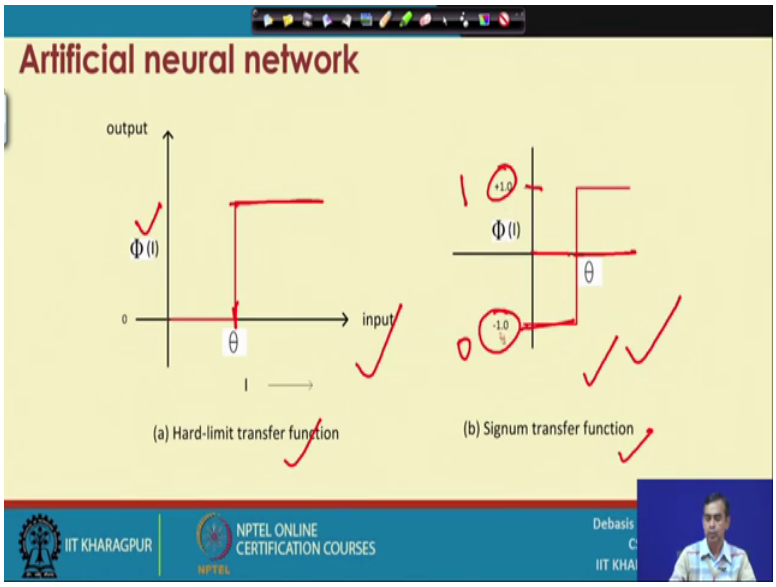

Now, here is the picture basically shows how the hard limit transfer function works and here is the Signum transfer function or linear transfer function. Now, in this case I can see that we see that if the input is within this rang, then this function phi I written 0, and if the input is beyond this range then output that the function that returns is 1.

Now, this is the hard limit transfer function on the other hand Signum transfer function. So, it is basically if the input within these range it return minus 1 and beyond this range it will return 1. So, here in this case the output is minus 1 or plus 1. So, this is another one so, minus 1 also can be considered as 0, and this plus 1 also can be considered one if it is normalized to that one. So, anyway so, so Signum transfer function usually minus 1 and 1 hard limit transfer function, 1 and 0 although minus 1 to 0 2 levels. So, two levels can be denoted by 0 and 1 also.

So, these are the two functions are there in addition to these two transfer function.

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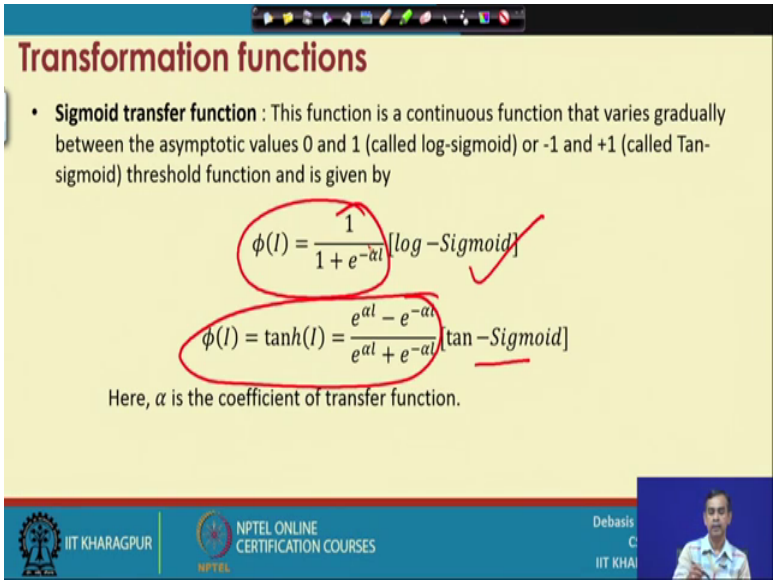

There are few more transfer functions are very important, these transfer functions are called Sigmoid transfer function. The sigma transfer function has two versions: one is called log sigmoid function which basically takes this form and another is tan sigmoid function; who is basically take this form. Now, it apparently seems that these two transfer functions very difficult to compute, but there is a computation tricks by which all this calculation can be computed very efficiently, that we will discuss; when we will consider the application of the neurons to solve problems anyway. So, we have learned few transfer functions which are very popular in the theory of neural network.

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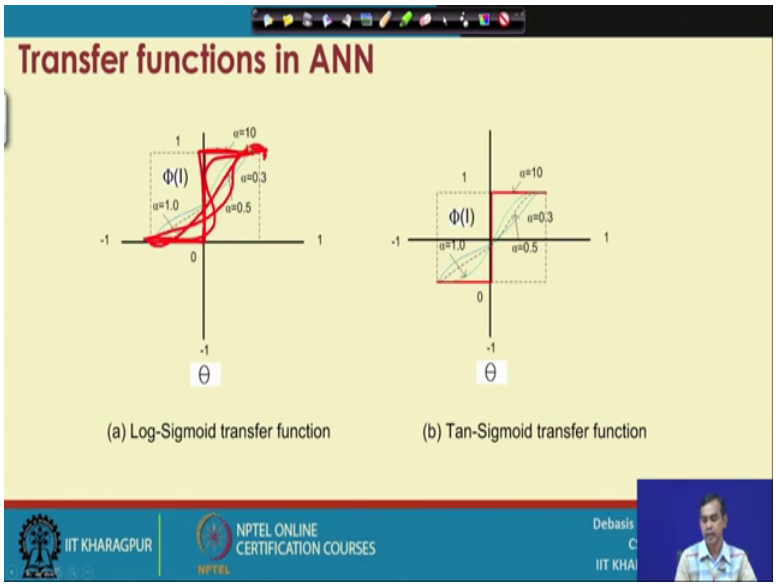

Now, after learning this transfer function so, this is a graph actually. So, this graph basically shows how the transfer function that we have discussed just now; log sigmoid and tan sigmoid works is there. And here the different values alpha can be decided; if alpha equals to 0, these basically same as the sigmoid function that we have discussed if alpha value is 1.0 or 10 the sigmoid function will be like this. So, for the different value of this one the sigmoid function will takes place like that.

Now the same thing is applicable to the tan sigmoid transfer function, here the alpha one important parameters right which basically decides, how the transfer functions will behave. now so, these are the transfer functions.

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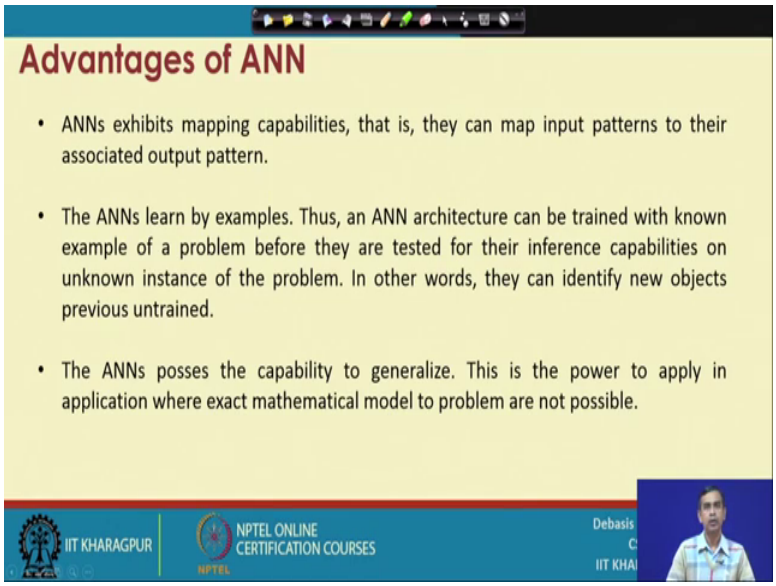

Now so, far the Ann is concerned why we should follow this Ann or the artificial neural network to solve our problem this is, because it has very nice mapping capabilities; that means, any input if it gives to you it can map to any output and that is with a very faster rate. So, that is why any input can be if it is pattern then it can read result the corresponding output patterns very effectively.

And another important thing is that; so, far this neural network is concerned, whatever the different parameters that we have mentioned the different parameters means the transfer function the different parameter means alpha in the transfer function or the number of units or weights in the neuron all these are the parameters basically which characterized a behavior of a neuron.

Now, if we can decide the values of this neuron, then it is enough that the neuron can work for you. Now, again this values the all these weights transfer function the threshold values everything can be learned automatically if you trained the neuron. Now, we will discuss about how all these parameters can be learned automatically. Now, this is the one capability that the neurons are having; that means, automatically it can learn it is value. And therefore, solve the problem. So, learning and everything will be discussed shortly, then we will be able to follow this concept.

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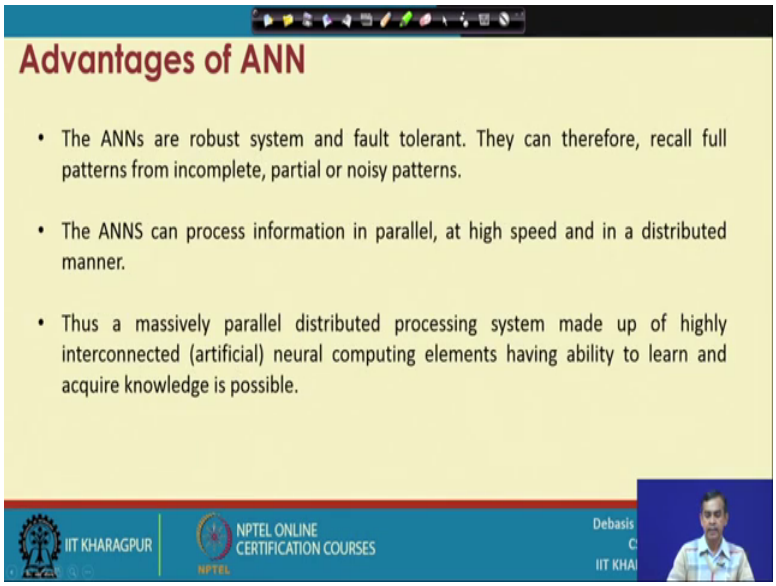

So, this is our advantage and another advantage is a very much robust fault tolerance therefore, it can recall full patterns for incomplete partial or noisy inputs Ann can be used to process the information in parallel at a very high speed and in a distributed manner this is, why this neural systems is effective for parallel distributed processing and we can solve any problems which cannot be solved using the single processing methods.

. So, this is the advantage that the neural artificial neural network is having now so, we have learned about the idea about the basic units which is there in artificial neural network and in the next lecture we will learn about how this neuron can be trained to solve or learn itself for the different values in it.

Thank you.