Machine Learning for Soil and Crop Management
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Lecture 33
ML and DL for Soil and Crop Image Processing

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Welcome friends to this NPETL Online Certification Course of Machine Learning for Soil and Crop Management, and we are currently in Week 7, and in this week, we are talking about machine learning and deep learning model for soil and crop image processing. And today, we are going to discuss the lecture number 33 or third lecture of this week.

So, in the previous two lectures, we have already discussed about the different machine learning algorithms. Like we have talked about two regularization algorithms, actually three regularization algorithm, one is ridge regression, then we have discussed Lasso regression and also, we have discussed elastic net regression.

So, we have seen what are their importance, and also we have discussed how they can compensate the overfitting problem which we generally encounter in case of linear model or also they can, how they can address this multicollinearity problem in case of this linear model we have discussed. Also, side by side we have discussed what are the different strategies for calibration and validation. Random holdout K-fold cross validation as well as leave-one cross validation, leave-one-out cross validation we have discussed.

So, today we are going to start in details about artificial neural network. In the previous lecture I have told you what is artificial neural network, and what is the basic functionalities of artificial neural network, and why what is the what is the history of artificial neural

network and then we have discussed about the best why it is called neural network, what is based on its similarity with the biological neuron system and nervous system, we can we define this as an artificial neural network.

So, today also we have seen what are the basic construction of this artificial neural network that means, how a node is constructed. A node is constructed using different inputs and these inputs are having different weights and they are these the multiplication of these inputs along with their weights are calculated and then they, then if they are higher than a threshold value, then they will active there will be an activation function which will be activated and an activation function will activate and that will pass the signal from one node to another node. Here node means the whole neuron.

So, the signal or the information will be transformed from these inputs to outputs within a single node and these outputs of a single node will be taken as an input with the next node or neuron, and that is why, the information will pass from one node to another node or subsequent nodes. So, this is why it is called artificial neural network. And today, we are going to discuss in details about the artificial neural network their features and basic mathematical representation.

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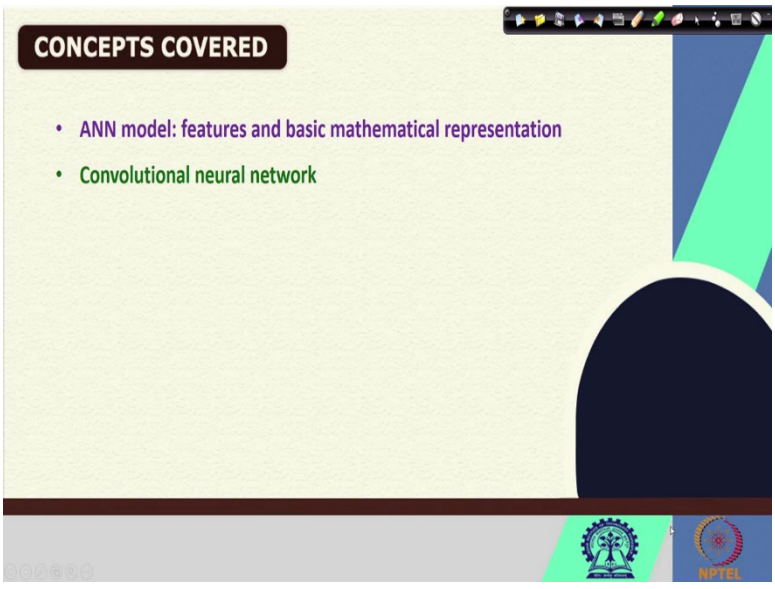

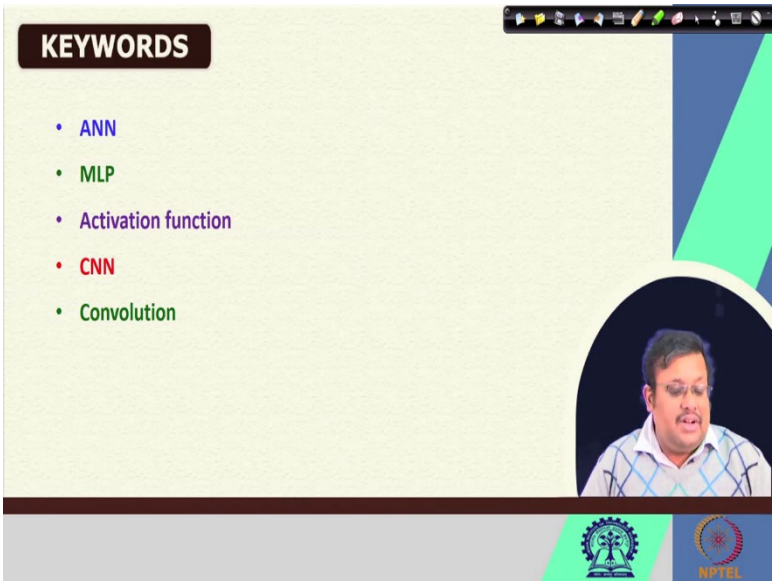

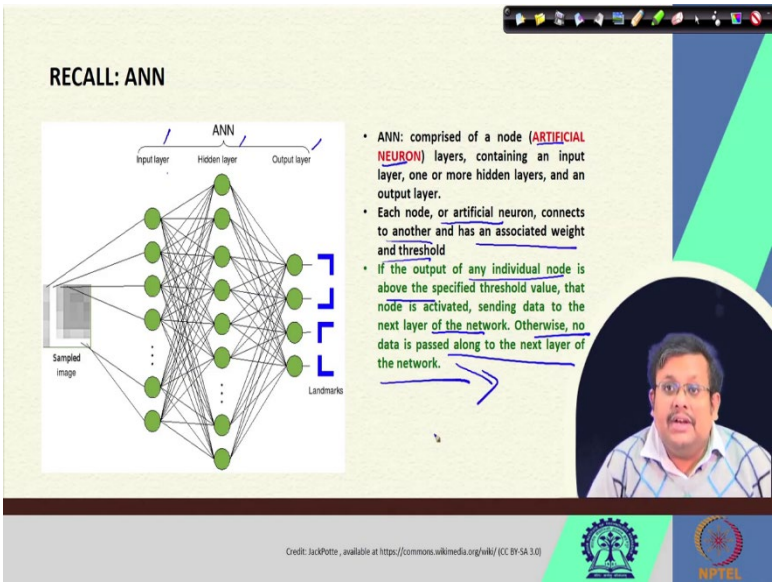

These will be the two concepts we actually are going to cover today. And then secondly, we are going to cover the convolutional neural network which is a modification of the convolution of the artificial neural network. So, these artificial neural networks, and then multilayer perceptron or MLP then activation function, then convolutional neural network and then convolution these are the important keywords for this lecture.

So, if we start by recalling the basic concept of artificial neural networks, remember, these artificial neural networks is basically composed of an input layer it will be basically composed of an input layer and then there will be hidden layer and finally, there will be an output layer. So, the information will pass from this input layer to the hidden layer to the output layer and these information sorry, inputs are connected to the subsequent layer by giving some of the weights. And so, these artificial neural network or ANN basically composed of a node, which is also known as the artificial neuron.

You can see this forms an artificial neuron, which transform, which transmits the signal from the or inputs from its input points to the output point. And you remember in our previous lecture, I have showed you the biological neural network system biological neuron. In the biological neuron there are dendrites, which are the receptor of signals and then they pass these signals through the cell body to the axon to the axon end where they will be transmitted to the next neuron through the synaptic to the synapses, where the dendrites of the next node or neuron will again will receive this information from the tail of this axon.

So, this is how this information passes. So, similarly, here in artificial neural network also it consists of input layers one or more hidden layers and an output layer. So, in reality you will see they are having one or more output layer, so, each node or artificial neuron connects to another and has an associate weight and threshold, we have also seen.

Now, if the output of any individual node is above the specified threshold value, then node is activated by this activation function and this sending data to the next layer of the network, otherwise, if that value will is less than the threshold predefined threshold, then there will be no data will which will pass to the next layer of the network. So, this is how, this is why, this is how this information passes from one layer to another layer in artificial neural network.

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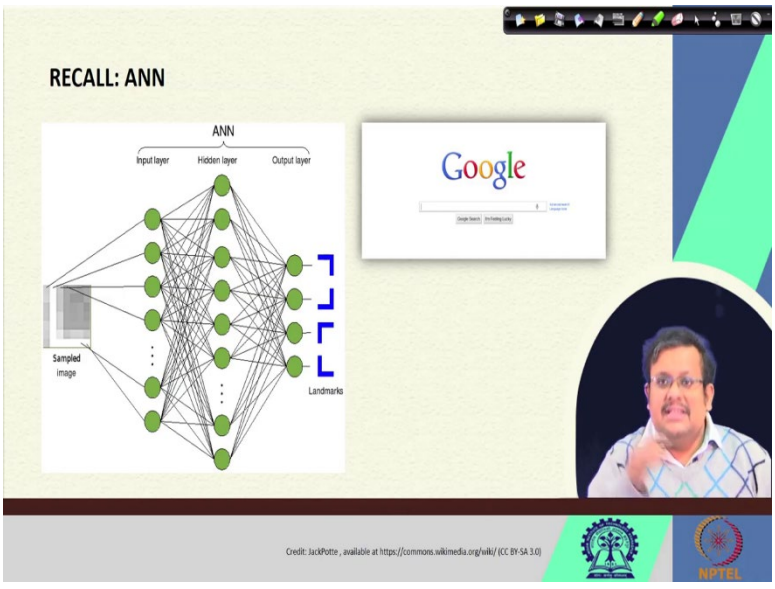

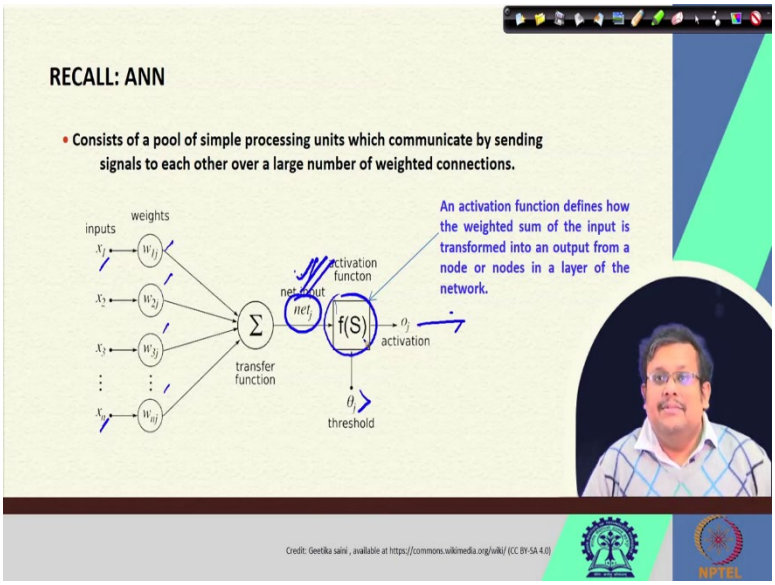

Now, let us move ahead and see some practical example. So, the most widely used the practical application of this artificial neural network is the Google search engine. We all use this thing and this is based on the artificial neural network concept.

Now, if we see the basic structure of an of a node, then you will see that there are several inputs. We have already discussed this in our previous lecture, so we have x1, x2 up to xn, and these inputs are having different weights based on their importance. So, those inputs which are more important, will be having more weightage than those inputs which are less important.

And ultimately, there will be a transfer function which will sum up the multiplication of these inputs with their weight, and ultimately these summation if it, if this net input which is denoted by these net j is higher than a predefined threshold value then these activation function will be active these activation function will be activated and then the based on this activation function, the final output will be passed to the next node.

Now, remember, there is no verbatim signal passing. Of course, the if this next input is higher than a specified threshold, then this activation function will be on and obviously based on this activation function an output will be transmitted. So, the output may not be same with this net inputs, so output is different. So, this is how these artificial neural networks works.

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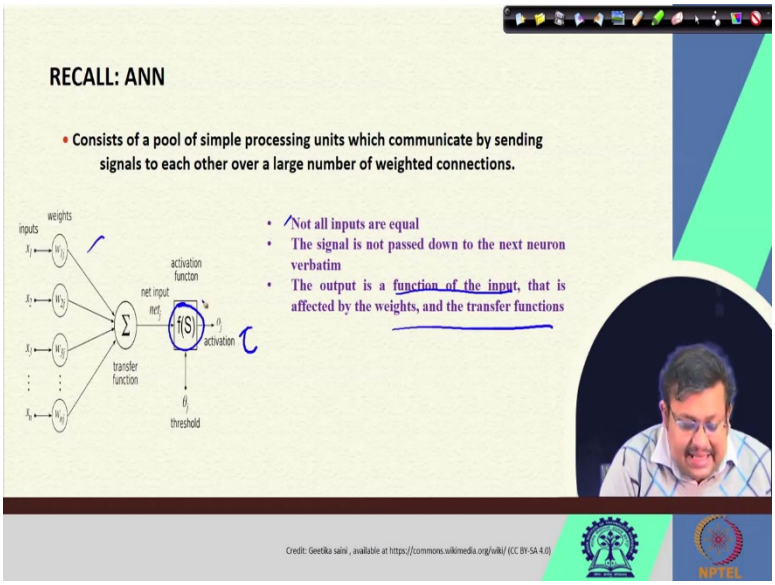

Now, if we see that some of the features of this artificial neural network I have mentioned it that not all inputs are equal. Of course, some inputs are having more and more impact, so those, so that is why their weights are also different. So, remember that the signal is not passed down to the next neuron verbatim, because that depends on this activation function. And if this activation function is on based on this activation function, the output will be determined otherwise the information will not pass.

So, the output is a function of the input that is affected by the weights and the transfer function. So, here these the final output which is denoted by O, will be based on these inputs and their weights as well as these activation function or transfer function they will calculate based on that these final output will be calculated.

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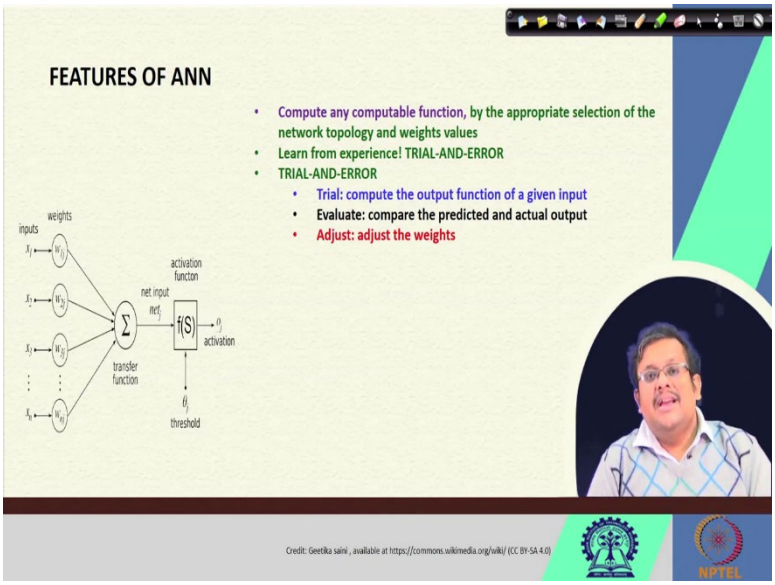

Now, so, what are the roles or features of an artificial neural network, why do we prefer artificial neural network? Now, the best feature of artificial neural network or in other words, why we prefer artificial neural network in solving a complex problem is because it can compute any computable function by the appropriate selection of the network topology and weighted values. And these weights are based on their experience and also these experience is nothing but trial and error.

This is a very important term trial and error. It tries evaluate and adjust their weight. So, based on these process, based on these repetitive process it learns from the data. And from this just like our brain. We go to a new place we explore the new, new things and these are being stored in our brain. And then we give it, we know based on those information which are stored in our brain we take a decision. And if you see that decision is not working, then we adjust our, we rethink and adjust our decision, so that that decision can be helpful for achieving an objective.

So, similarly, just resembling our brain, just mimicking our brain, these artificial neural networks also goes for trial and error to adjust their weight. Because adjusting this weight will only you know can change this net input and this net input will have a drastic effect of whether they will activate that activation function or not.

So, if we give these weights based on our experience then it will be a true learning experience and it will be through trial and error. So, these, this is the best feature of artificial neural network because it can adjust these weights based on trial and error, so it can learn from the experience.

So, what are the three features of this trial and error? First, it will give the trial that means it will come to the output function of the given unit input. Second, it will evaluate these output with the original value. So, the actual output and the predicted output will be compared. And if you see there is mismatch then these artificial neural network will adjust their weight so that the outputs can be as close to the actual output.

So, this is the trial and error, and this is a very important feature of artificial neural network and that is why artificial neural network can compute or can learn from any complex relationship, because it can adjust by trial and error and it can learn from this experience.

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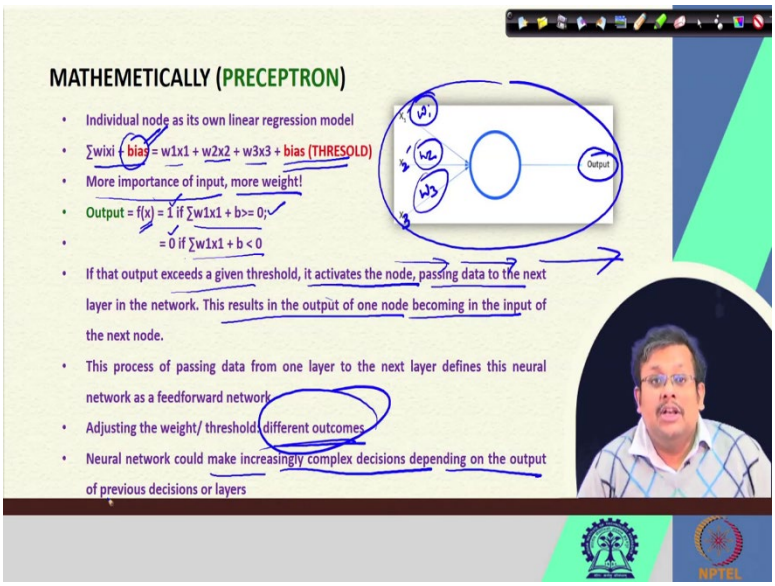

So, let us see the mathematically. So, the mathematically the simplest design of this node will be this one, and we call it a perceptron. So, this is the first and simplest of all the node, which we can in the neural network. So, here you can obviously see there are x1 and then there are three inputs. Let us consider these as x2 and then let us consider this x3 and this will be computed and finally, activation function based on will be getting the output.

So, we can see that individual nodes can be considered as its own linear regression model. So, if we considered these individual node, so, the final output. So, we can consider, we can express this node as this summation of weights. Suppose, there are w1, w2 and w3. So, x1 multiplied by w1, x2, w2, x3. w3 and then we add some bias or threshold. So, the threshold is defined by the threshold can be automatically given or it can be well defined. So, remember that here we are giving here w1, w2, w3, so more importance of an input they will imply more weight.

So, suppose our activation function says which is denoted by these fx, if it is 1, then it will be of no. If according to our activation function the condition is if this term that is wy, xi plus threshold will be greater than 0, then the activation function will give the output of 1otherwise, if it is less than 0, then the activation function will produce the output of 0.

So, you can see here based on these weights, this final term will be calculated and then we will be getting these, based on these condition this activation function will be activated and then they will produce the final output. So, if that output exceeds that given threshold, as we have seen in this case, so, this threshold then it activates the node and passing the data to the next layer in the network, and these results in the output of one node become the input of the next node which I have already told you.

Now, this process of passing data from one layer to the next layer defines these neural network as a feed forward network. So, you can see the information is going from the inputs to the activation function and then it will go to the output, so it is a feed forward network. So, you can obviously understand by adjusting these weights or adjusting these threshold we can change the outcome.

So, when we change the weights, when we change this threshold, we can produce different types of outcomes. So, that is why, during the trial and error process it changes. It changes weights and so, producing different types of outcomes. So, neural network could make increasingly complex decision, because of these features a neural network can produce increasingly complex decision depending on the output of previous decision on layer.

So, you can see these layers are interconnected these nodes are interconnected. Since these nodes are interconnected and the output of one node is dependent not only the inputs but their weights and also the bias and subsequently the activation function. So, you can see that how influencing this could be for learning from a complex data set. So, from a complex data set, if we want to learn by trial and error, we have to have this kind of complex setup, so that we can learn from the experience by trial and error.

So, neural network that is why could make increasingly complex decision depending on the output of the previous decision layers. So, this is an example of the simplest model that is called perceptron.

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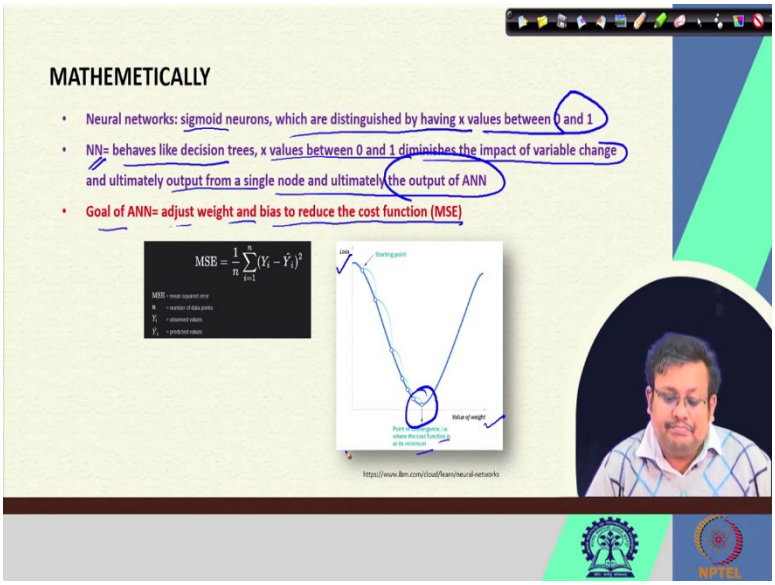

Now, let us see mathematically remember that, although we are getting these neural networks which we are having the, it is a linear function we can see, and we are getting binary output like 0,1 or something like that. But in actual neural network they follow these sigmoid neurons, which are distinguished by having x values between 0 and 1.

So, these x values between 0, 1, 1, so that is why. So, you can take any values between 0, 1, 1, so fraction values of 0 and 1 so the neural network they can behave like the decision trees. Remember the decision tree I have already discussed? So, in the decision tree what happens based on these decision rules, there will be hierarchically segregation of the data. So, similarly in the neural network also just like decision trees, the x values.

So, since they are being distributed in the next layer based on these rules, hierarchically, so, the values between 0 to 1 can diminishes the impact of the variable change. So, and ultimately output from a single node and ultimately the output of the artificial neural network. So, that is why artificial neural network is very helpful for predicting any complex relationship from the data.

So, what is the goal of an artificial neural network? The goal of an artificial neural network will be always to adjust the weights and bias to reduce the cost function. So, in this case, the cost function is the mean square error. So, you can see when you plot the value of the weight and loss of information or so, you can see at a point. So, point of convergence, where the cost function is at its minimum.

So, here the MSE will be at minimum mean square error will be at minimum, so, this will be the optimum value of the weight. So, this value of the weight is considered based on the point where these error term is or the cost function is minimum. So, this is how these error term is being this is how these values the weights are being calculated.

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Now, most deep neural networks are feedforward meaning they flow in one direction only. So, that means from input to output. However, there are some backpropagation network also which moves from the opposite, which moves in the opposite direction, that means, from output to input.

So, basically these backpropagation network, they calculate the attribute the error associated with each neuron and subsequently adjust and feed the parameter of the model. So, this is a

backpropagation network. You will see these terms vary frequently when you go for these artificial neural network-based application.

So, what are the advantages and disadvantages of artificial neural network? Now, there are several advantages. First of all, it can adapt to unknown situation.

It is very powerful. It can model complex functions, and it is easy to use, it can learn by examples, and it is very little user domain-specific expertise is needed. So, anybody can try to feed their data by using the ANN model, but there is a disadvantage also that means, there will be a large complexity of the network structure. So, sometimes the interpretation may not be very straightforward.

So, these are some of the advantages and disadvantages. But irrespective of these advantages and disadvantages, I would say, that these artificial neural network is one of the most widely used deep learning method in current, in modern artificial intelligence and machine learning domain.

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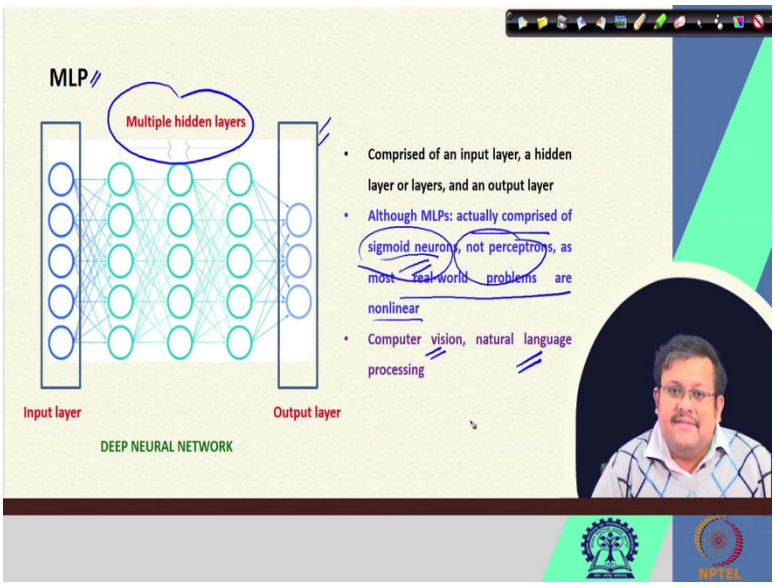

So, we have seen the single layer perceptron but of course, in real life situation, there will be a number of perceptrons, which are also connected between each other. So, of course they are called the multilayered perceptron. So, of course, here you will see that these input layer is connected to the next layer, and this next layer are subsequently connected to the numerous multiple hidden layers and these finally, there will be an output layer.

So, this is called the multilayer perceptron. Earlier, we have seen a single layer where the inputs are coming and output is generated. So, this is called the simple perceptron. However, here you are seeing the multilayer perceptron.

So, although, these multilayer perceptron actually comprised of sigmoid neurons, not perceptrons as most real world problems are nonlinear. So, these multilayer perceptrons are actually comprised of these sigmoid neurons non-perceptrons, because the sigmoid neurons are nonlinear and remember that most of the features in the real world situation are having the nonlinear relationship. And that is why these multilayer perceptron are basically composed of the sigmoid neurons.

Now, what are the application of these multilayer perceptron? The multilayer perceptron are being used for computer vision, natural language processing and so on, they are a different types of application and nowadays these artificial neural network has a wide application in different domains of agriculture and including soil and crop, which we are going to discuss in our coming lectures.

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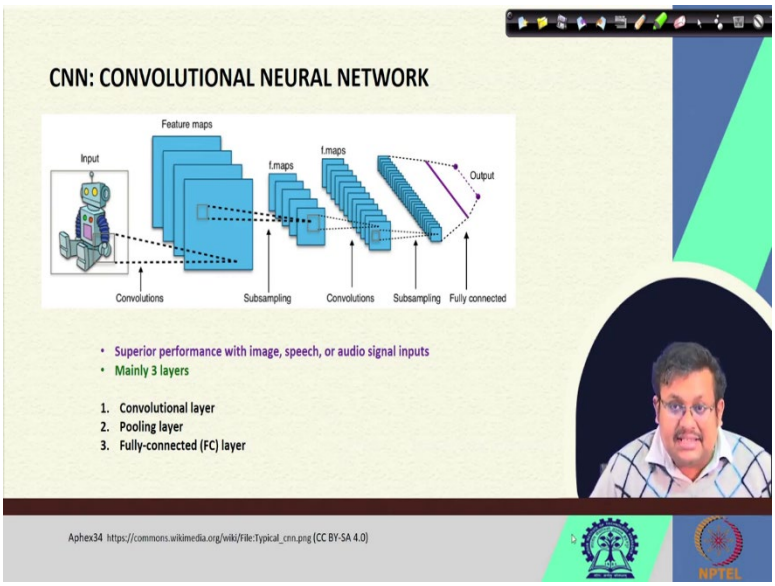

So, what is convolutional neural network? So, convolutional neural network or CNN is an advanced method, which specifically deals with the images speech and audio signal inputs. So, when there is a the image is a special file, that means, it has some width it has some length. So, when we have at this image is divided into millions and millions of picture elements or pixels. We know this time pixel very much. Multi, megapixel and all these things we know.

So, an image is divided into millions and millions of pixels. And to get the information from these millions and millions of pixels, we generally use the convolutional neural network. So, it basically consists of three layers, one is called the convolutional layer, another is called the pooling layer. And the third one is called up fully connected or a fully connected layer.

So, basically this construction of these convolutional neural network basically we input. Suppose we input the image and there will be convolutions. Convolutions we will discuss. It is basically the selection of the feature based on some filters, and we are going to discuss this in our upcoming lecture.

So, after this convolution, we will get the feature maps, which are derived from these images. And subsequently, we will go from the subsampling and feature maps. Ultimately, we will be getting the fully connected layers and then will be based on this final output will be based on these fully connected layers.

So, what are the filters? What are the pooling layer? What are the fully connected layers? We will be discussed in our next lecture. So, let us just go ahead and I would just like to give you

this reference, which we are going to use. So, let us wrap up our lecture here and we will start from where we stop in our next lecture.

So, remember guys, whatever I have covered is a basic overview, but there are plenty of literature available for these deep learning models. Specifically, if you are interested to go and explore these artificial neural network or the application of artificial neural network in different domains. Please go and search some of the available literature. There are plenty of available literature, so that you can have a more in depth understanding of artificial neural network.

So, we have a basic overview. We have seen the basic overview of convolutional neural network, but in the next lecture, we will see details of their working and then I will, we will be discussing what are the benefits of using the convolutional neural network. Thank you guys. Let us meet in our next lecture.