Fuzzy Logic and Neural Networks
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Lecture – 42
A Few Applications (Contd.)

Now, let me summarize the content of this particular course. Now we started with actually a concept of fuzzy sets, that is a set with wake boundaries there is no well defined boundary and using this particular fuzzy sets, we discuss like how to model the uncertainty and imprecision.

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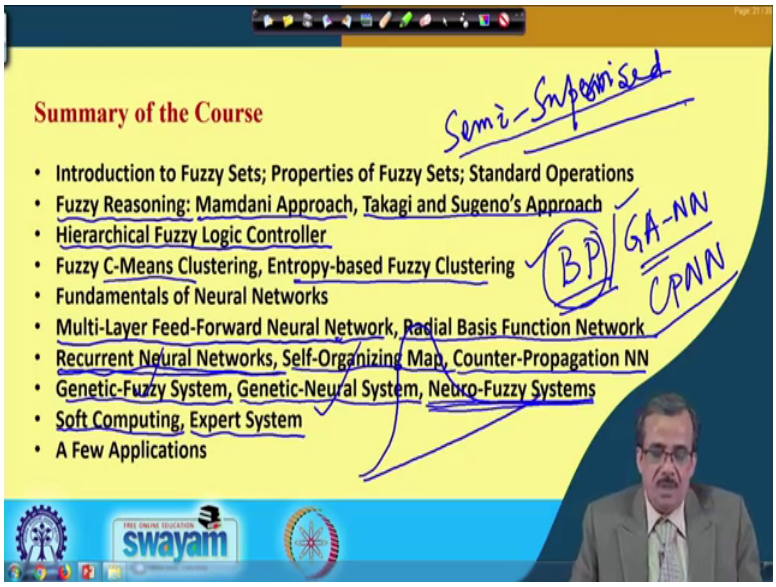

Now we started with in fact, the concept of classical set or the crisp set and we discuss that, that this particular classical set or the crisp set can handle only one type of uncertainties using the principle of the probability theory. But there are many other uncertainties in the world which cannot could not be modeled using the classical set or the probability theory and that is why the concept of fuzzy set came into the picture.

Now, we have defined the concept of fuzzy sets, we got the difference between the fuzzy set and the classical set. The classical set is a set with fixed boundary on the other hand the fuzzy set is a set with wake boundaries. Now we discuss the different properties of classical set and in fact, we discussed about 10 properties followed by the classical set. Now out of these 10 properties, the first 8 will also be followed by fuzzy set, but the last

two that is your law of contradiction and law of excluded middle which not be followed by the concept of your the fuzzy sets.

Now, in fuzzy sets we use the concept of the membership we consider different types of membership function distribution. For example, we consider the triangular membership function distribution, the trapezoidal membership function distribution, Gaussian membership function distribution, Sigmoidal membership function distribution and so on. We started with a few definitions related to fuzzy sets for example, we defined alpha cut of a fuzzy set, we defined what should be how to define the core of a fuzzy set, the height of a fuzzy set and all such things. Then we concentrated on some standard operations used in fuzzy sets for example, say the intersection of a fuzzy set, union of a fuzzy set, then comes your the bounded sum of a fuzzy set, the bounded difference of a fuzzy set, algebraic sum of a fuzzy set, algebraic difference of a fuzzy set and so on.

So, we discussed the grammar of fuzzy sets in detail. Then we concentrate on the different applications of your the fuzzy sets. The fuzzy sets have been used to solve a variety of problems and out of all the applications the most popular one is the fuzzy reasoning tool and the purpose of fuzzy reasoning tool is how to establish the input output relationship. Now if you see the literature we have got two types of fuzzy reasoning tool one is called the precise fuzzy reasoning tool another is called your; another is called linguistic fuzzy reasoning tool.

Now, in precise fuzzy reasoning tool we get more accuracy, but less interpretability that is nothing, but Takagi and Sugenos Approach. Now, in the linguistic fuzzy model so that is the Mamdani approach we may not get so much accuracy, but its interpretability or the readability is high. Now while discussing the fuzzy reasoning tool, we have discussed that the complexity of a fuzzy reasoning tool depends on the number of the linguistic terms we used to represent each of the variables, it also depends on definitely the number of variables. So, for a large number of variables and if I use more number of linguistic terms, the complexity of the fuzzy reasoning tool is going to increase and to overcome that the concept of hierarchical fuzzy logic controller has come and we discuss its principle by using the hierarchical fuzzy logic controller we can reduce the number of rules and then comes your the clustering algorithm, we discussed the different clustering algorithms, clustering is done based on similarity. So, the similarity data points should belong to the same cluster and dissimilar data point should go to two different clusters

we used the different clustering algorithms like fuzzy c means clustering, entropy based fuzzy clustering and so on. Now if we compare the fuzzy c means clustering and your entropy based clustering based on the quality of the clusters obtained.

Now, in fuzzy c means clustering there is a possibility that we will be getting very compact clusters, but we may not get a very distinct cluster. On the other hand in entropy base fuzzy clustering, we may not get a very compact cluster, but you will be getting very distinct clusters, but what we need is your a very good very compact as well as distinct cluster and that is why sometimes the merits of these two tools we combine and we develop actually entropy based fuzzy c means clustering also.

Now, after discussing the concept of fuzzy sets, fuzzy reasoning tool, fuzzy clustering we started with the fundamentals of neural networks and as I told that in artificial neural networks we copy everything from human brain in the artificial way. We copy actually a biological neuron in the form of artificial neuron and one neural network consist of a large number of layers and each layer there will be a large number of neurons. Now if you see, so this particular the network can be developed using the principal of the unsupervised learning and supervised learning. So, by supervised learning actually what we mean is, it is learning with a teacher.

So, we have got free determine known input output relationship and with the help of this known input output relationship if you just do the training so that is called your the supervised learning or the learning with the teacher, now it has got the concept like if there is any mistake done by the student, the teacher is going to make the correction same is true in supervised learning because we have got the known input output relationship. So, if there is error. So, this particular error will be rectified in your the supervised learning.

On the other hand we also discussed actually the unsupervised learning. So, in unsupervised learning actually we use the concept of your competition, cooperation and updating. Now through this particular the competition so we are just going to declare who is the winner and surrounding that particular winner there will be some excited neuron and there will be some interactions and through this particular interactions actually both the winner as well as his followers. So, they are going to learn, they are

going to update their information and ultimately you will be getting one network that is actually the principal of your unsupervised learning.

Now, one thing if you see the literature, the concept of semi supervised learning is also there. Now the semi supervised learning is such your like we use actually the concept of both supervised as well as unsupervised learning. So, the part of the problem will be solved using the supervised learning and the rest of the problem will be solved using unsupervised and it could be vice versa also. So, we have the concept of semi supervised learning also.

Now if you see how to implement so this particular the supervised learning we have discussed that very famous, very popular the back propagation algorithm and the back propagation algorithm works based on the steepest descent algorithm which is nothing, but the gradient based method. Now here in back propagation algorithm, there is a one problem like the solution may get stuck at the local minima.

Now, we have also design and develop some sort of algorithm that is GA neural network, now there we see that we could replace this back propagation by the genetic algorithm and we can also develop the combined genetic algorithm and neural network just to remove the demerits of this particular your the back propagation algorithm.

Now, in this course, actually we discussed a number of networks and we have solved a number of numerical examples. For example, we started with the multilayer feed forward network and we have seen like how to carry out the forward calculations, how to compare the output of the forward calculation with the target value just to find out the error and how to propagate so this particular error in the backward direction, so that we can minimize the error in prediction. Now this multilayer feed forward network has been widely used to determine the input output relationship of different types of processes.

Now, here the performance of this particular the multilayered feed forward network depends on the connecting weights, the bias values, the coefficient of transfer functions and of course, it depends on your the architecture or the topology of this particular the network. Now, supposing that I am just modeling a process having say 5 inputs and 4 outputs. So, if there are 5 inputs some of the input layer, we are going to use 5 neurons and on the output layer we are going to use 4 neutrons.

Now, the architecture or the topology of these particular network depends on how many hidden layers we are going to use and how many neurons we are going to use in each of these particular the hidden layer. So, once I have got these particular the architecture now you can update the values of the connecting weights, the values of the coefficient of transfer function and bias show that this particular network can predict the input output relationship in a very accurate way.

Now here, one merit for this particular network I should mention that using these particular network we can also carry out the reverse mapping. So, both the forward mapping as well as reverse mapping can be carried out with the help of this multilayered feed forward network. Then we started with the working principle of a radial basis function network. The purpose of using the radial basis function network is once again to establish the input output relationship and here we use a special type of transfer function and that particular transfer function is nothing, but the radial basis transfer function.

Now, here by radial basis transfer function we mean that particular transfer function where the value of y either increases or decreases monotonically with the value of x for example, say if I consider so these type of Gaussian distribution, this is an example of your the radial basis function. Now this type of radial basis function or the Gaussian distribution we generally use as transfer function in radial basis function network. Now in neural network, we use some other type of transfer function also for example, say we use hard limit transfer function, we use linear transform function, we use some other type of non-linear like log sigmoid transfer function or tan sigmoid transfer function.

So using this radial basis function network as we mentioned that we can find out the input output relationship. Now supposing that the process is highly dynamic and for a highly dynamic process so your multilayer feed forward network may not have the purpose just to capture the input output relationship and there we will have to go for some sort of recurrent neural networks and this particular recurrent neural network has got both feed forward and feedback circuit and with the help of this feed forward and feedback circuit so it is able to capture the non-linearity or the dynamics of that particular the process.

So, we have discussed in detail the working principle of these particular the recurrent neural networks and as we have mention the moment we pass some external inputs, some

of the internal inputs will be created by the process and those things have been mentioned here that that consider here in recurrent neural network. Then comes your the self organizing map and we have already mention that these particular network works based on unsupervised learning and we have discussed in detail the working principle of the self organizing map, how can it map from higher dimension to lower dimension and this is a very accurate mapping because we use some sort of topology mapping here so which is very accurate and using the self organizing map, so we can carry out that particular the mapping.

Now, using the concept of the self organizing map, we also discuss how to develop the counter propagation network that is your CPNN. Now, using the counter propagation network. So, once again we can model the input output relationship, here we take the help of both unsupervised self organizing map and supervised gross back learning. So, which we have already discuss in details and so after discussing the different types of networks we actually started with some combined tools. The reason behind going for the combined tools is your each of the tools is having its own merits and demerits, but in combined tools we wanted to consider the merits of those tools and we wanted to delete their demerits.

So, we discuss the working principle of genetic fuzzy system, genetic neural system where the aim was to evolve a fuzzy reasoning tool or to evolve a neural network test tool with the help of the genetic algorithm, their working principle we have discussed in detail some numerical examples we have solved, then we concentrate on the neuro fuzzy system.

Now, this neuro fuzzy system has been developed in two different ways based on the Mamdani approach and based on Takagi and Sugenos approach and we have seen how to develop this neuro fuzzy system using the principle of genetic algorithm and we in fact, discussed about genetic neuro fuzzy system. So, after discussing this combined tools we started with the definition of soft computing. So, as I told that by soft computing we mean the combined tools like the combination of genetic algorithm and fuzzy logic that is genetic fuzzy system, combination of genetic algorithm and neural networks that is genetic neural system, combination of neural network and fuzzy logic that is neuro fuzzy system or genetic neuro fuzzy system those are going to constitute actually what you mean by the soft computing and in soft computing as I told that we are not so much

interested in precession or accuracy. So, it is different from the hard computing, hard computing works based on the mathematics the differential equation and solution, but in soft computing we take the help of some nature inspired techniques like fuzzy logic, neural networks, then comes genetic algorithms and other nature inspired optimization tools. Then we concentrated on the expert system like what do you mean by an expert system, why do you need an expert system and we in fact, give the example of a very a few very popular expert system available.

Then we concentrate on actually a few applications of fuzzy logic and neural networks. Now as I mentioned that a huge literature is available on the applications of fuzzy logic and neural networks not only in general science, but also in engineering science different fields of engineering science and your the commerce ok. So, there are so many such applications of these fuzzy logic and neural networks. Now here in this particular course, we discussed about two applications in details one is how to design and develop intelligent and autonomous robots and to design and develop this intelligent and autonomous robot, we discussed about how to develop adaptive motion planner, adaptive controller, how to carry out the vision analysis like how to carry out the problem of computed vision or the robot vision, we also discuss how to generate the adaptive gaits and after that we also discuss the principle of your intelligent data mining.

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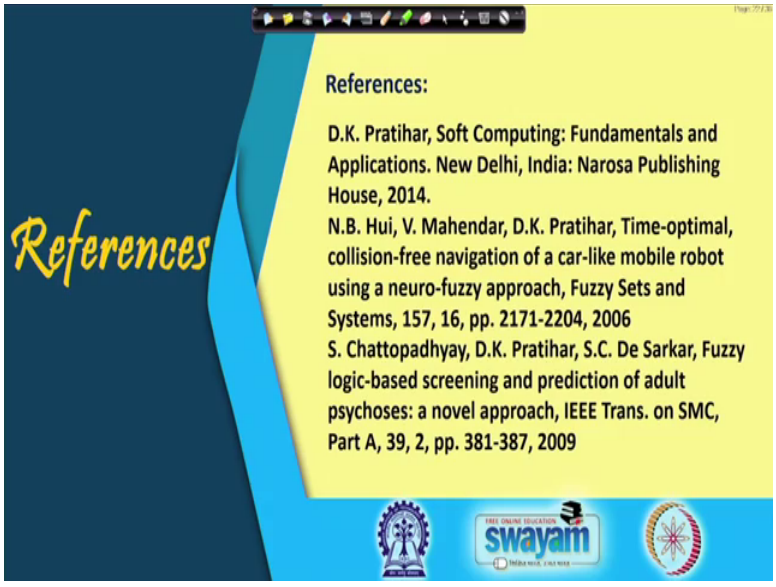

Now, actually these are the things which we have discussed in these particular course and we have solved a large number of numerical examples and just to clear the ideas of each of the algorithms, so what I have done is, I have taken one numerical examples. Now if you see the references, if you want to get more information regarding the course. So, you can you can see the textbook soft computing fundamentals and applications written by me or regarding the problem related to the intelligent and autonomous robot.

So, this particular paper actually carries a lot of information. So, you can have a look of this particular the paper that is written by V Mahendar and me published in fuzzy sets and systems, then for this your the medical diagnosis for the psychosis if you want to get more clear picture you should read this paper S Chattopadhyay, D K Pratihar and S C De Sarkar and this particular paper was published in IEEE transaction SMC Systems Man and Cybernetics part A and you can find out more detailed information regarding the topics which we have discussed here.

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Now, to conclude actually so this particular the lecture, that is the lecture 9. So, what I did is your I started with the definition of soft computing, I define the terms hard computing, I took the example of hybrid computing and I tried to find out what is the reason behind going for your the soft computing tools, we have also defined what do you mean by expert system and we have; we have seen that by expert system we mean it is not simply one computer program and there is something extra; that means, we try to

copy the behavior of a human being the way he solves that particular problem that we are going to model in expert system or the knowledge based system a few applications we discussed in discussed in details and the total the content of the course has been summarized. I think you will enjoy this particular course and you will be learning a lot through this particular course I wish you all the best.

Thank you.