Fuzzy Sets, Logic and Systems & Applications
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Lecture - 04
Fuzzy Sets and Fuzzy Logic Toolbox in MATLAB

So, welcome to lecture number 4 of the course on Fuzzy Sets, Logic and Systems and Applications. So, in today's lecture we will be discussing Fuzzy Sets and Fuzzy Logic Toolbox in MATLAB and this will be in continuation to my previous lecture.

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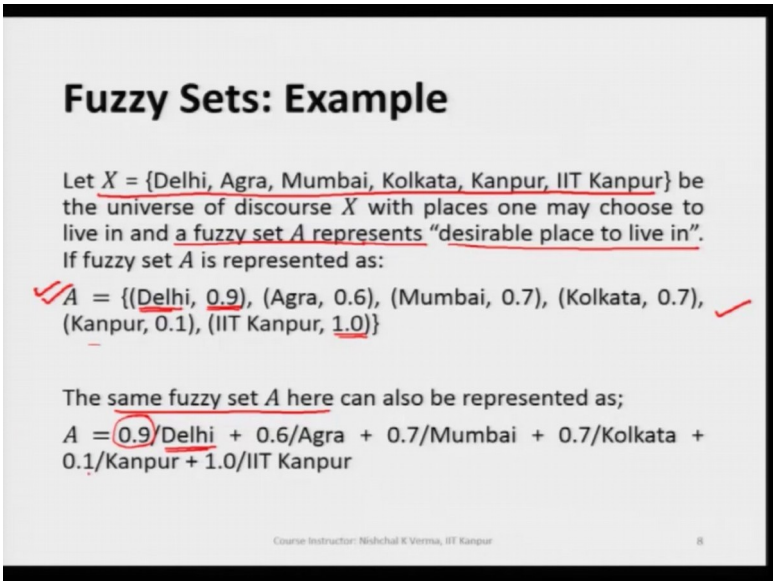

So, let us take some examples and then whatever we have understood so far let us try to understand even further. We have a set of cities and this set is here for this example taken as universe of discourse. So, capital X is the universe of discourse. It means that whatever elements that will be taking or including in our fuzzy set will be taken from this fuzzy set.

So, these are the places the cities which we may choose and then if we want to write a fuzzy set like this that a fuzzy set A that we would like to write. So, a fuzzy set that we would like to write is based on the desirable places to live in.

So if we write this in form of a fuzzy set we will write it like this. So, A if A is a fuzzy set and this will be equal to the collection of all the elements. So, if I take Delhi. So, Delhi is the element which is drawn from the universe of discourse and then since if since this is a fuzzy

set I must have the belongingness or the membership value. So, we will have a pair of city and then corresponding membership value.

So, corresponding membership value can be any value in between 0 plus and 1. Why I am saying 0 plus 1? Because this value must be some value which is more than 0. This value can be 0 plus epsilon. So, if it is 0 we are not we will not be including the corresponding element. So, this value this membership value must be more than 0.

So you see if we are writing like this. So, this membership value will indicate as if it is the desirable place to live in means the it is my liking to live in a particular city. So, Delhi has 0.9 membership value. It means that the I am liking this comparatively you know if we have other places to choose.

So, Delhi with 0.9 means that we are writing we are liking this 90 percent or something like that. So, if one is a 100 one is taken as a 100 percent and then if I take Agra, so I may choose Agra with 0.6 membership value. It means I like Agra less than Delhi and then if I choose Mumbai then I like Mumbai more than Agra and less than Delhi that is with 0.7.

If I take Kolkata, Kolkata is 0.7. So, it means I like Kolkata same as Mumbai and if I take Kanpur. So, Kanpur membership value is 0.1. So, I like Kanpur you know less than all the cities as discuss like Delhi, Agra, Mumbai, Kolkata, and then if I talk off IIT Kanpur, I like 100 percent. So, that is why you know Kanpur IIT Kanpur has the membership value 1, so, 1 means 100 percent here.

So, as I mentioned when I when we write fuzzy set. So, fuzzy set we will have the pair of the elements and the corresponding membership value. So, if you see here in this fuzzy set you see here this fuzzy set includes the city and then corresponding membership value. So, this way this is a this can be called as a fuzzy set.

So the same fuzzy set see this is the crude this is the form which I mentioned above before. So, the same fuzzy set A can be written as

$$A = 0.9/Delhi + 0.6/Agra + 0.7/Mumbai + 0.7/Kolkata + 0.1/Kanpur + 1.0/(IIT\ Kanpur)$$

So, we see that the same fuzzy set will have first membership value and then we separated by the slanted line and then we write the corresponding elements. So, like that all the elements in the fuzzy sets are included.

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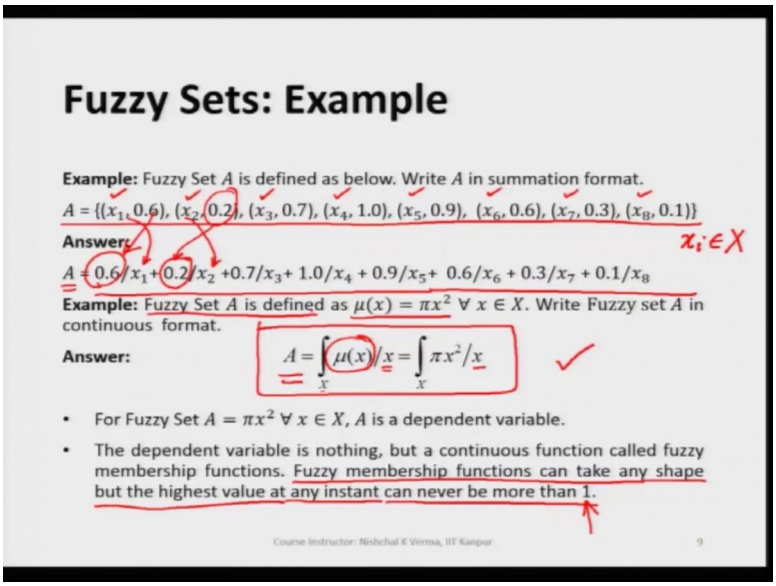

Now, if we take another example here to make it more clear. So, fuzzy set A is defined as below right A in summation format. So, here A is given like this. If this is a fuzzy set that is given to you and please understand that these $x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8$ all these elements must be drawn from the universe of discourse x.

So I am writing here x_i's for all these and this is the capital X which is my universe of discourse. Where i is the first i is equal to 1 to 8. So, i if I change this i is equal to 1 this will become x_1. So, x_1 and then similarly up to x_8 so, all these elements will be drawn from the universe of discourse capital X.

So, how we will be writing in this summation this a fuzzy set in the summation format. We have already seen that how fuzzy set can be written in this summation format. So, let us know quickly write and understand. So, you see here this x in summation format can be written as; can be written as in summation format what do we do we first write the membership value. See the membership value here which is coming from here for the first element. So, membership value and then we separated by a slanted line we can also call this as oblique.

So, $0.6/x_1$ and then $0.2/x_2$ you see here this is the membership value here which is coming here and then this is the corresponding you see here corresponding element. So, this way we first write the, we first write the membership value and then the corresponding elements separated by a slanted line and we also use plus in between just to show the collection of these elements in the fuzzy set.

So, this way we write the same fuzzy set in the summation format. Now let us take another example here if we are interested in writing a fuzzy set in continuous form whose membership function is given as $\mu(x)$ is equal to πx^2. So πx^2 is a continuous function. So, and of course, needless to mention that this x should be coming from, all x′s should be coming from the universe of discourse.

So, if we are interested in writing fuzzy a continuous fuzzy set. So, we will be writing it like this. So, A is the continuous fuzzy set and as I mentioned that when we are writing a continuous fuzzy set we use integration sign of integration. So, here you see the sign of integration and then just below this we write the universe of discourse and which is x and then we write the continuous membership function you see the continuous membership function is given as πx^2.

$$A = \int_X \mu(x)/x = \int_X \pi x^2/x$$

So, we write this here and then we write the corresponding elements and this elements is coming from again the universe of discourse which is a generic variable normally we call generic variable, so we write the generic variable x here and now if you replace this $\mu(x)$ by πx^2. So, in place of $\mu(x)$ we write πx^2 and then we separate by a slanted line the generic variable and then this becomes our, the fuzzy set in continuous format ok.

So, this is how we write of continuous fuzzy set in this format. So, similarly if we have the other continuous functions for $\mu(x)$ we can replace we can write and that will be our continuous fuzzy set, okay. So, and one more thing I would like to tell here is that the fuzzy membership functions can take any shape, but the highest value at any instant can never be more than 1, this is because you know these fuzzy membership functions they provide the membership values and the membership value cannot be more than 100 percent.

So, that is why the 100 percent is actually for is represented as 1. So, that is why any membership function can never go more than the value of 1.

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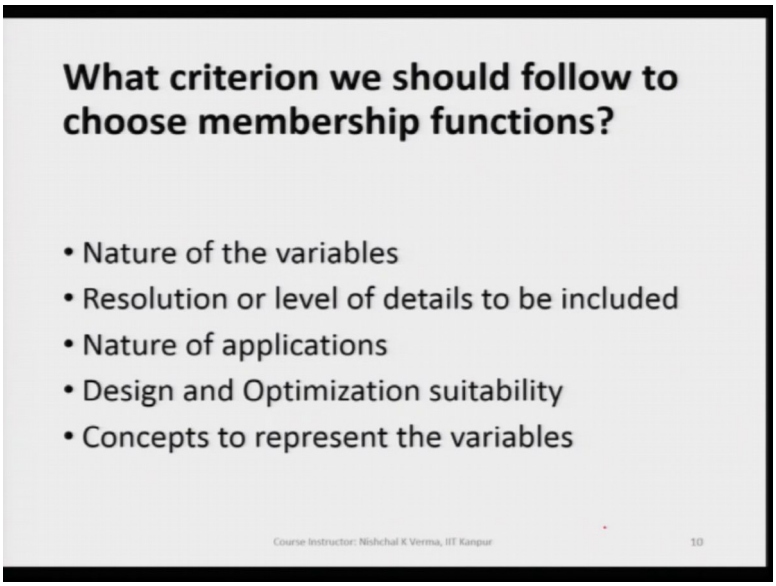

So, this way we understand that how do we write a fuzzy set and we also understood at this point that why it is necessary to include the membership values along with its elements in a fuzzy set. I would like to repeat here that since in fuzzy set all the elements can be either present are partially present. So, all the elements are included that is why the membership values are necessary to be included along with the elements and these membership values from where do we get these membership values these membership values functions.

So, we will discuss this in more detail in coming slides coming lectures and but these membership values are also known as the belonging belongingness our degree you know are these other names. So, membership functions are very important and these membership functions provide us the membership values and there are certain criteria's. Which we normally follow while we choose the membership functions.

So at this point I would just like to tell you that the nature of the variables are very important when we choose the membership functions because these membership functions as I mentioned they are providing us the belongingness they are providing us the membership values. So, we need to be very intelligently choosing these membership functions in order to have the proper fuzzy set. In order to form right fuzzy set.

So, nature of the variable is very important and then resolutions are the level of details to be included and then the nature of applications design and optimization, suitability, concepts to represent the variables. So, all of these the factors which we normally take into account and

based on these we try to choose the membership functions. So, this will be discussed in detail in coming lectures, but at this point I would just like to like you to know that these points are these factors are important for taking choosing the membership functions.

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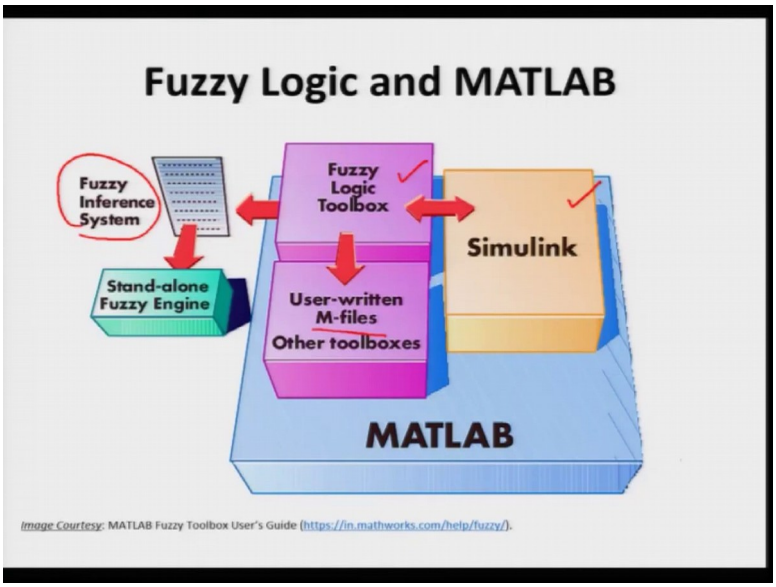

Now, since in fuzzy logic fuzzy in this course we will be doing some exercise we will be doing certain tasks by using MATLAB. So, I would like to briefly introduce the fuzzy logic tool box in MATLAB and with this I would like you to get yourself acquainted that a fuzzy logic toolbox is available in the MATLAB those of you who have not done any prior exercise in MATLAB or do not know anything in mat lab you can start from here.

And this is the this is basically I thought that this will be very helpful while going through the fuzzy logic and the corresponding exercises you can implement using MATLAB, but MATLAB is not the only platform you can use other platforms like R ,you can use you know Java, C whatever you are interested with, but here I will be going through the MATLAB platform.

So, fuzzy logic toolbox is there in the MATLAB and if we see if we have a MATLAB in MATLAB the fuzzy inference system is already there and then we have fuzzy logic toolbox, we have fuzzy simulink and then here if you want we can write the MATLAB files. So, in MATLAB like other tool boxes if fuzzy logic tool boxes also there.

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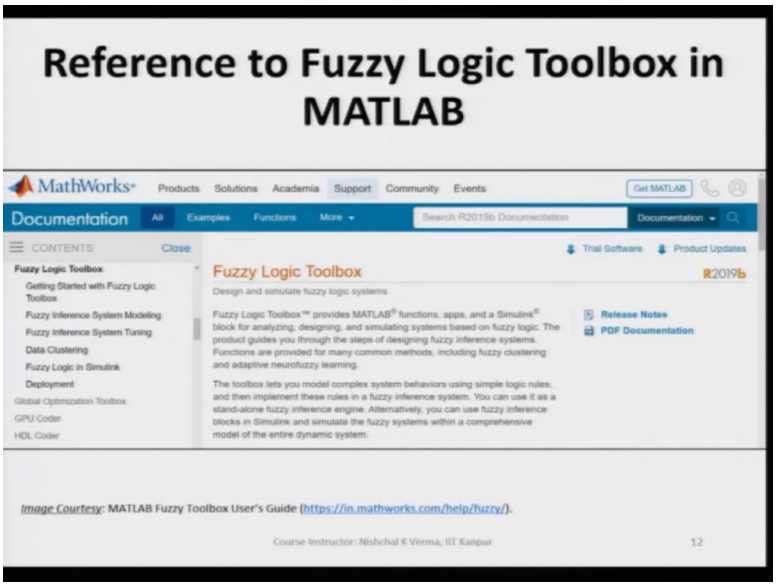

So, I would like to very briefly tell you that if you are interested you can go to this MATLAB fuzzy logic toolbox and this is the snapshot which you see here of that of the fuzzy logic toolbox page.

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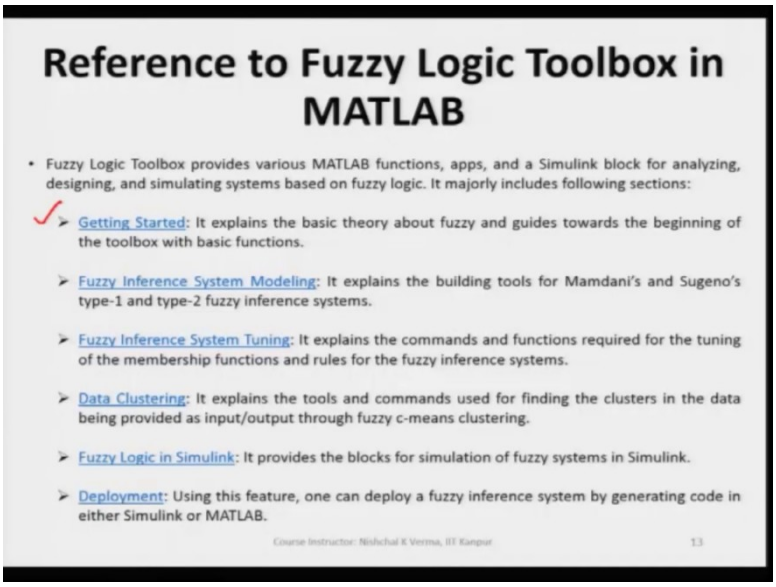

And if we go to that we have these pages available like getting started. So if you do not have any prior idea of a MATLAB either with a reference to the fuzzy logic toolbox or even otherwise you should go to a fuzzy logic toolbox and then go to getting started. So, this

explains the basic theory about fuzzy and guides towards the beginning of the toolbox with basic functions and then fuzzy inference system modeling.

So, this explains the building tools for Mamdanis and Sugenos type 1, type 2 fuzzy inference systems. This also has the fuzzy inference systems tuning. So, it explains the commands and functions required for tuning of the membership functions and rules of the fuzzy inference systems, this also has data clustering.

So, in data clustering we have the tools and commands that are used for finding the clusters in the data being provided as input output through fuzzy c mean clustering and then the fuzzy logic simulink is there where we have graphical user interface and we can you know connect these the blocks and then, so, same thing can we can implement using this and then we have the deployment, so using this feature given in the MATLAB one can deploy a fuzzy inference system by generating code in either simulink or MATLAB.

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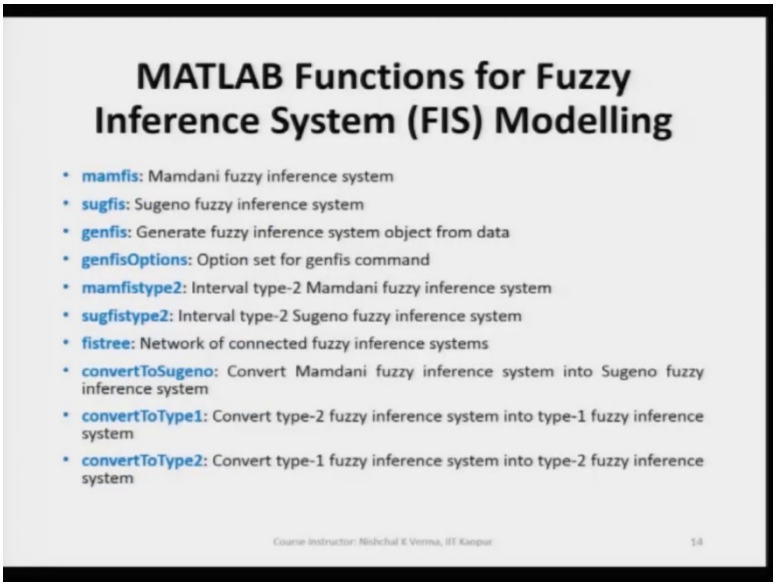

So, here are some functions some inbuilt functions that are provided in the MATLAB. So, you may like to go through. So, like a mamfis which is a nothing, but the inbuilt function for Mamdani fuzzy inference system and then sugfis is the sugeno fuzzy inference system. So, like that we have so many functions you can go through all these are listed in these slides.

So, I will just read these functions like genfis and then genfisoptions, mamfistype 2 sugfistype 2. So, type 2 means the there are the fuzzy system is actually divided into two

types. So, first there is a first is a type 1 and then type 2. Now type 3 is also coming up, but whatever we will be dealing here with we will be with respect to type 1 initially and then fistree convert to sugeno, convert to type 1, convert to type 2.

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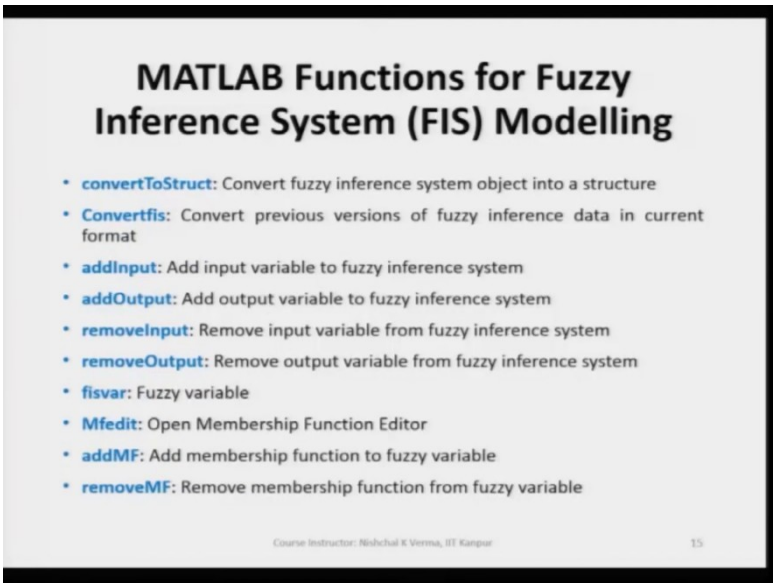

So, all these functions are given and then here we have few more functions that you can go through.

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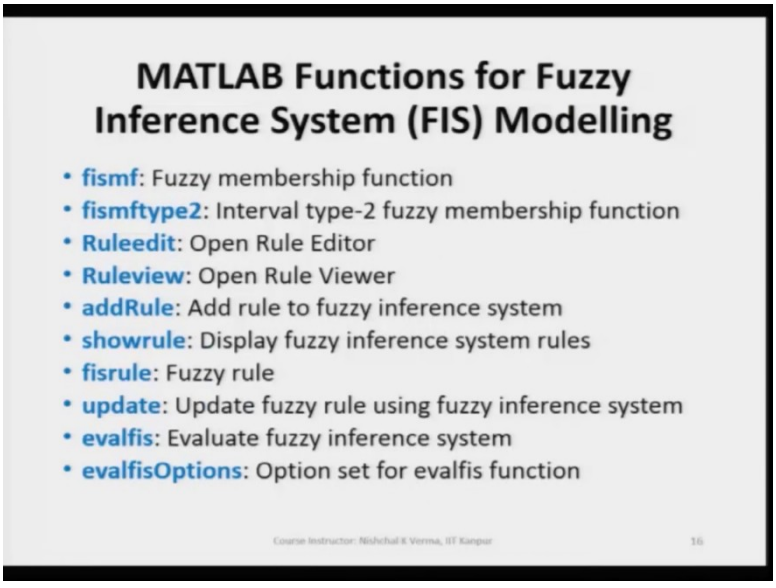

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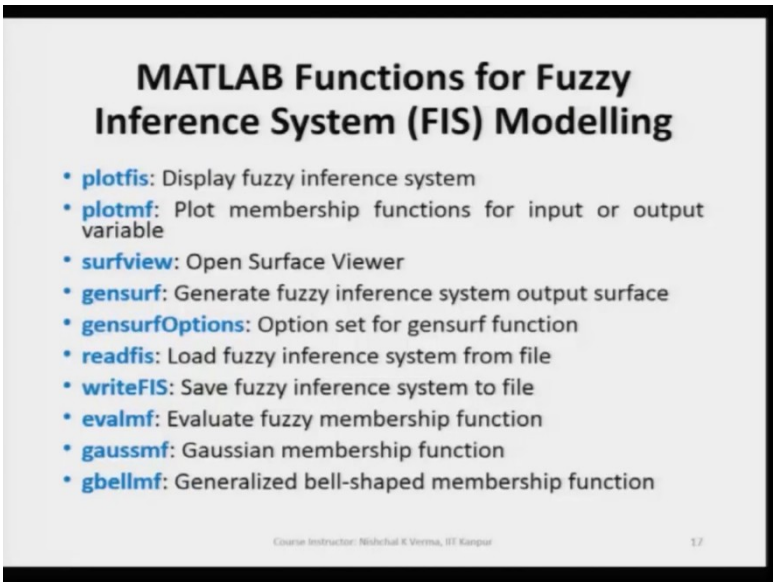

All these functions all these functions are and these functions will be helping you to directly use, give the input and get the output.

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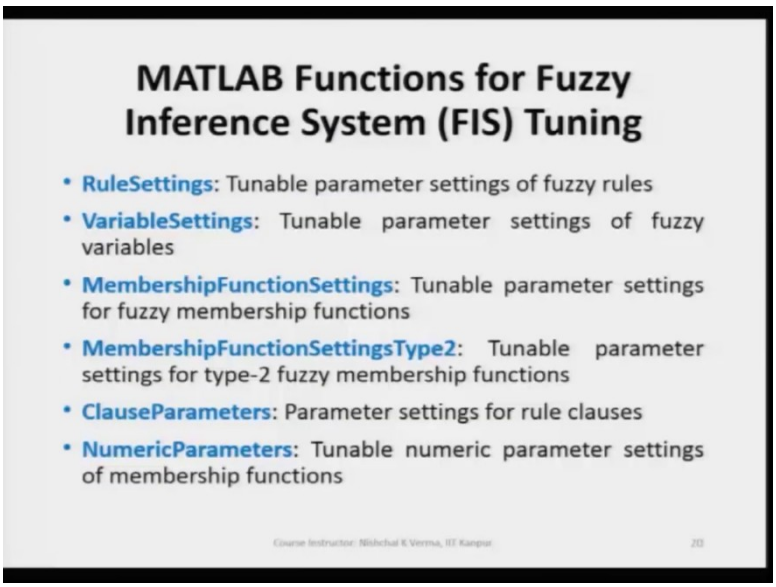

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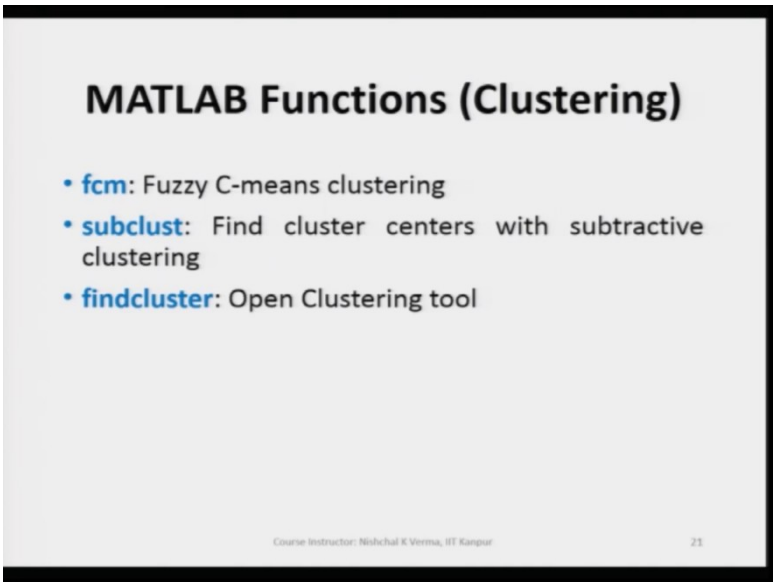

So, these are the functions that are included in the MATLAB.

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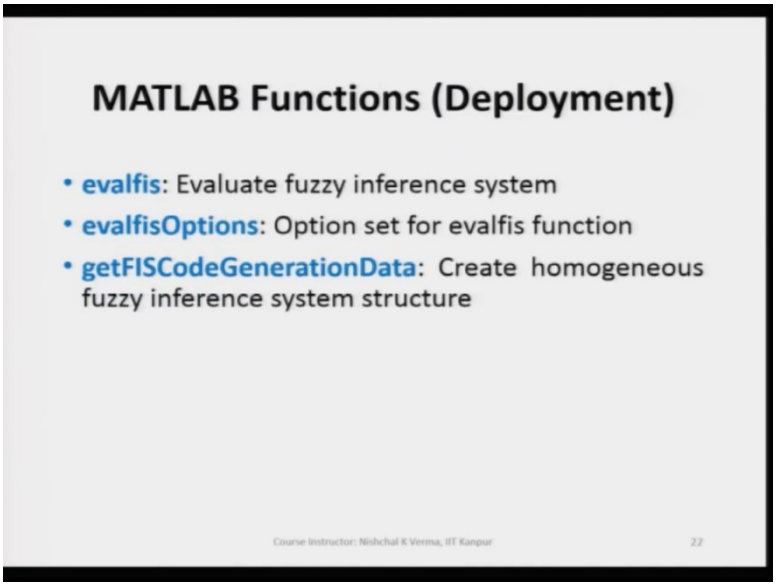

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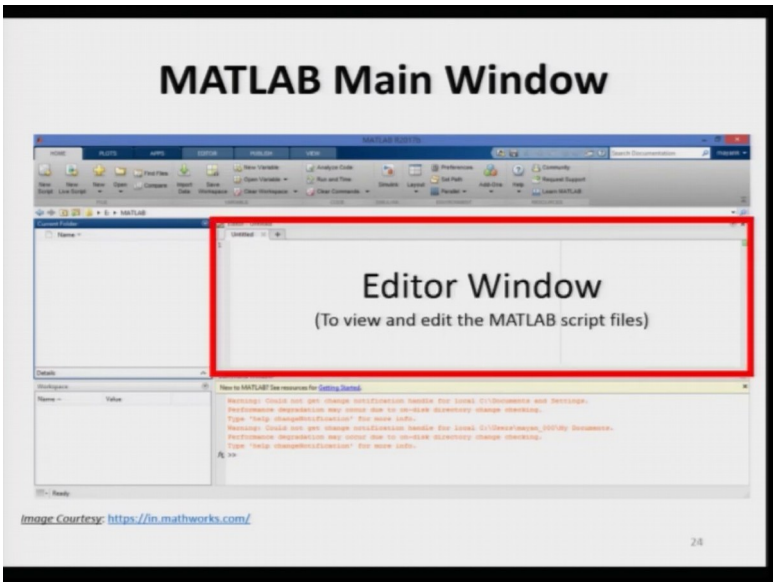

So, please go through these functions and uh try to use these functions and get yourself acquainted. So, further for those of you who do not have any idea of MATLAB before? So, when you open the MATLAB you basically you get to see this slide and in this slide you get to see this page and in this page you will have the four boxes.

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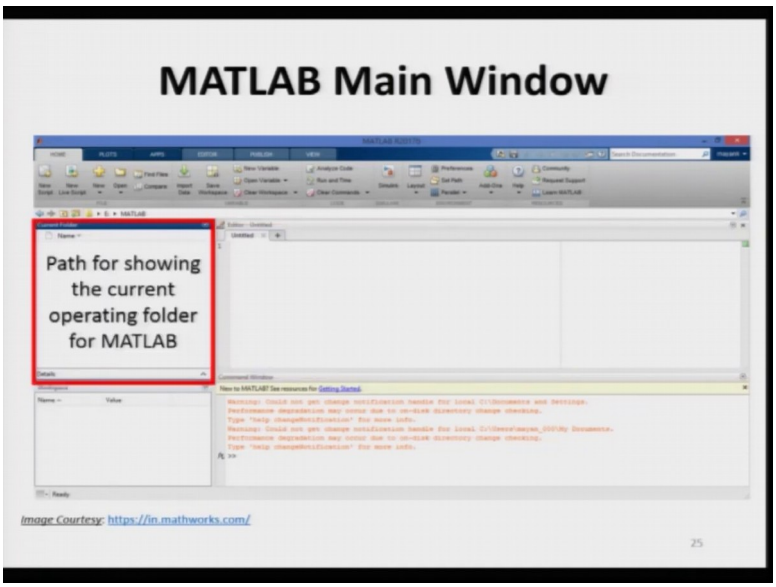

If you see here the first box is the editor and then the current folder.

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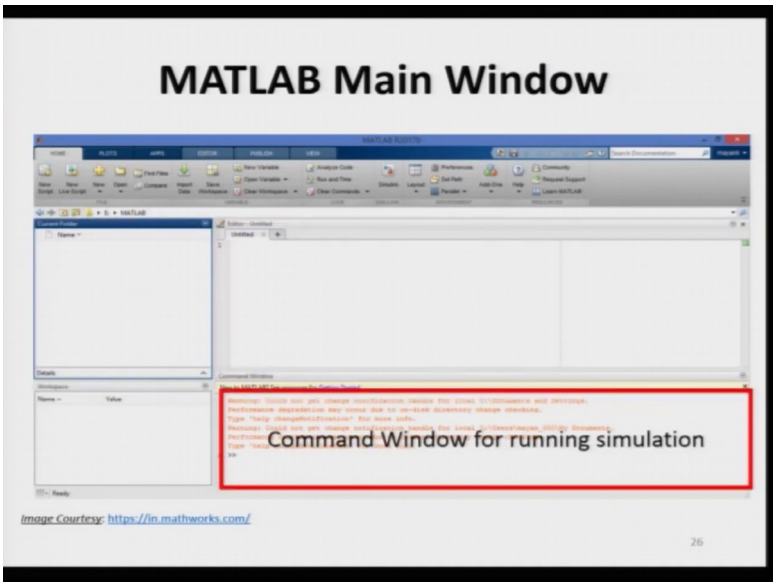

And then the work command window.

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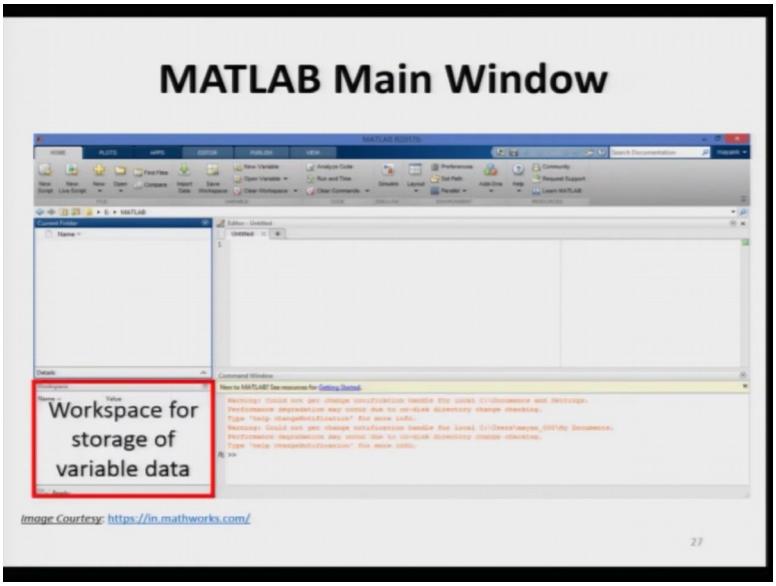

And then the workspace. So, let me quickly tell you what are all these the editor window where you can basically write your program in m file MATLAB m is designated as a MATLAB. So, here you can write your program and edit the MATLAB subscripts and then the current folder will tell you as to the paths for showing the current operating folder then the command window basically will show you the running simulation. This is the, this is where you get to see all your results.

Work space window will show you the space for storage of variable data and that's how we can start working on the MATLAB and if we go through all these functions that were mentioned we will certainly have a fair idea of MATLAB with respect to fuzzy systems.

So, I would suggest you to go through all these inbuilt function first, but at the same time I would like to tell you that you try to build your, you try to write your own MATLAB code in a MATLAB editable file and avoid using these slowly avoid using these functions and try to learn further in writing the better programs with respect to the fuzzy logic.

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In the next lecture I will be covering the fuzzy membership functions of different types.