Fuzzy Sets, Logic and Systems & Applications
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Lecture - 02
Introduction: Real Life Applications of Fuzzy Systems

Welcome to the lecture number 2 of a Fuzzy Sets, Logic and Systems and Applications.

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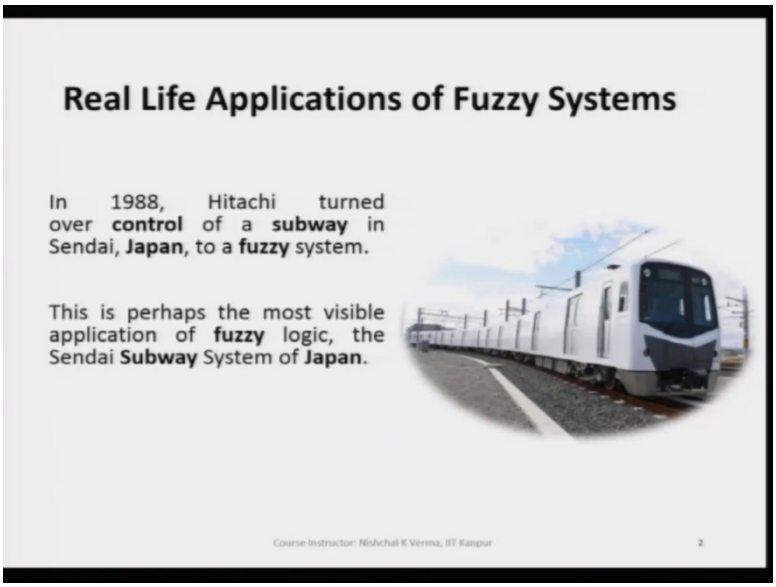

So, today we will be discussing the real-life applications of fuzzy systems. So, first and foremost application that I would like to discuss here is the Hitachi subway which is in Sendai, Japan and in 1988 this turned into the fuzzy system. So, this means that the controller that was already there was converted into a fuzzy controller and this was perhaps the most visible application of fuzzy logic that time and this was in Sendai, Japan.

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And the second application that I would like to mention here is the washing machines, very popularly we see even nowadays also these are fuzzy logic based washing machines. So, in these machines we see lots of linguistic terms like, if we have to select the water supply we see cold, hot; for water levels we select high, medium, low, extra low, and then similarly for the functions like soak, wash, rinse, spin and then for course we see digital, blanket, speedy, wool.

So, like that we see lots of linguistic terms here. So, here in this washing machine the fuzzy logic controller is sitting and this controller is taking inputs from the users in terms of a linguistic variable. So, linguistic variable here as I mentioned here are like cold, hot, then high, medium, low, extra low and like that for function soak, wash, rinse, spin.

So, instead of the you know the crisp input like the numbers here the inputs that consumer or the user feeds here are these values and these control, the controller which is sitting in this machine takes these as the input and accordingly produces the control output and which in turn you know helps in managing the performance of the machine.

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Then comes the fuzzy auto controller in cars, like a very recently Nissan patented a fuzzy automatic transmission that saves fuel by 12 to 17 percent. So, here also the controller in this car is a fuzzy controller.

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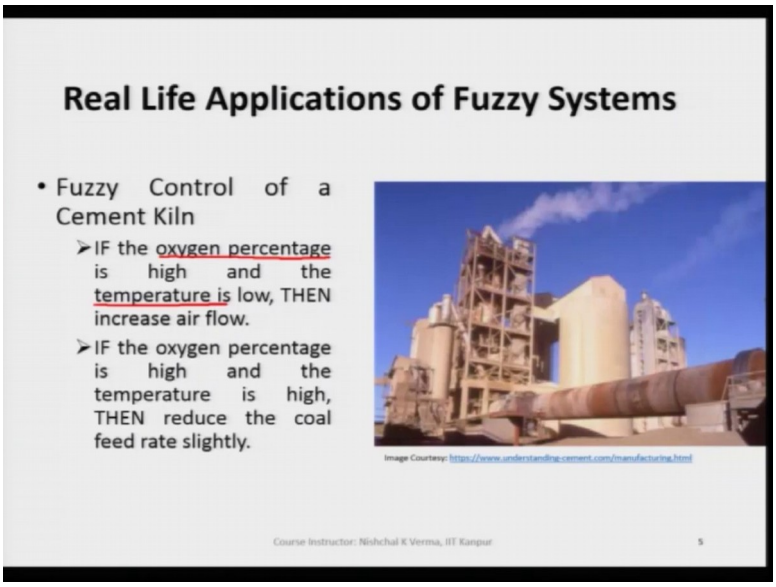

Then coming to the next controller which is the fuzzy control of a cement kiln. So, here also the controller which is sitting is fuzzy control and takes the inputs in terms of the linguistic variables like, if the oxygen percentage is high and the temperature is low, then increase air flow. So, what does it mean? It means that the inputs that are coming in the fuzzy controller

is in terms of the linguistic values, like high, the oxygen percentage is high and then the temperature is low.

So, if these two are existing then the output should be in the region, the air flow has to be increased so like that and similarly we can have multiple rule basis fuzzy rule basis and based on that this fuzzy controller works. So, what I am trying to say here is also we have the fuzzy controller which is acting based on the input, inputs that are fuzzy inputs. Fuzzy inputs means the linguistic variables or values and then the output is also output out of this fuzzy controller is a fuzzy and this is again used for further decision making.

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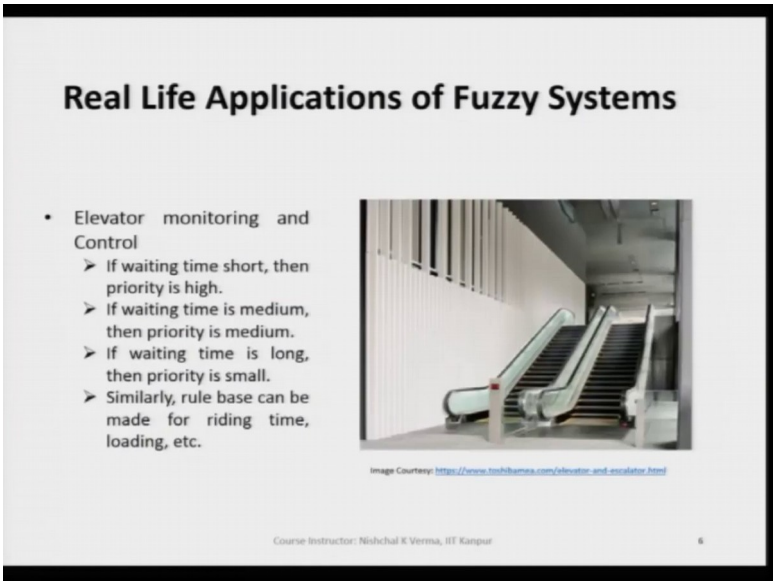

Another application which you see here is the elevator monitoring and control. So, here also the controller that is sitting here for this elevator monitoring is fuzzy controller which takes inputs as the waiting time short, priority is high. So, like that we have so many inputs, linguistic inputs coming in and then based on the inputs the decisions the controller give controller produces the output in terms of, again either the linguistic output or the you know the crisp output. So, based on that further decision is made.

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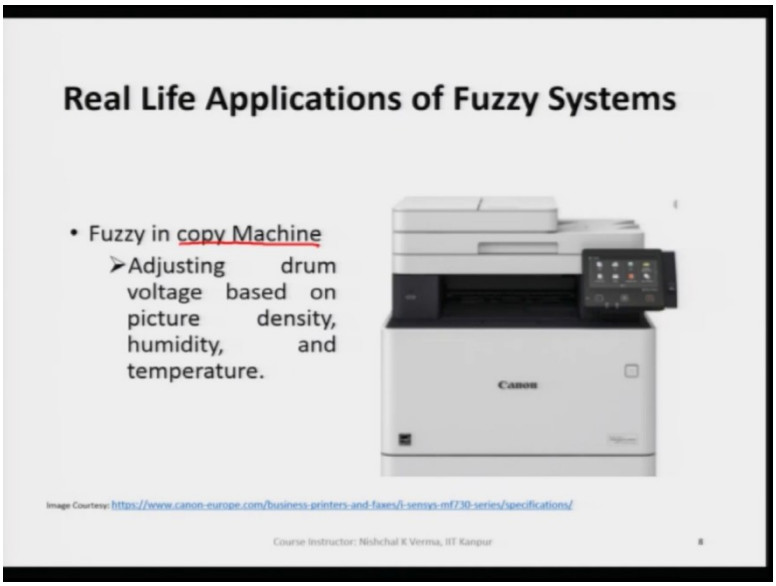

So, then another application which is which we see here is the fuzzy controller-based copying machine. So, we see here the copying machine and here also the fuzzy controller in many of the machines fuzzy controllers are being used and here the drum voltage is adjusted based on the picture density, humidity and temperature.

And these the variation of these parameters are basically course parameters, I mean the linguistic terms like humidity, it can be either low, medium, high and so on and based on that the controller makes the decision.

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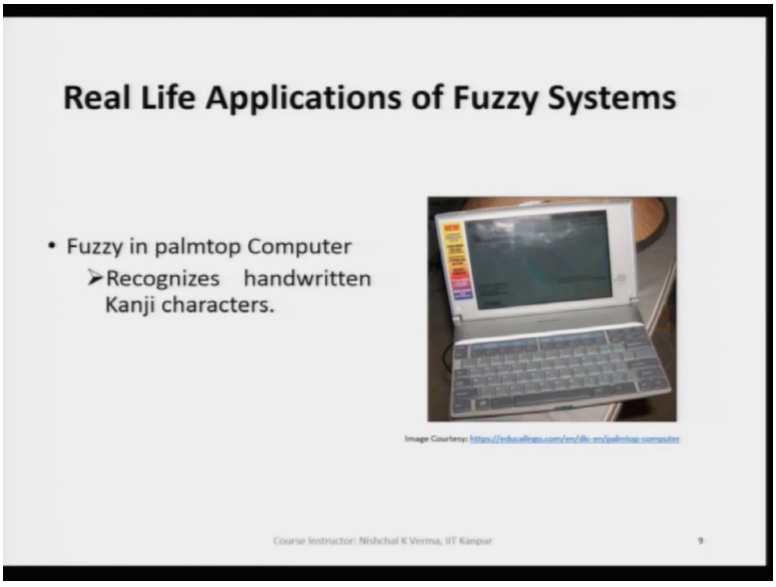

Here we see another application which is fuzzy based palmtop computer. So, here this palmtop computer recognizes the handwritten kanji characters.

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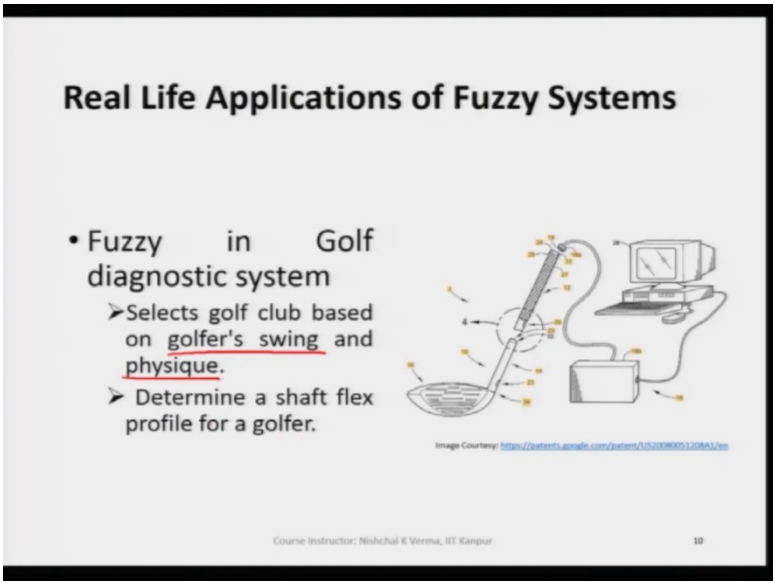

Then we come to another application of fuzzy logic here is used in golf diagnostic system. So, what is done here is that this fuzzy logic helps in selecting the golf club based on golfer's swing. So, the golfer's swing and physique. So, based on these two factors the golf club is selected and then another point here a very important point here is to be noted here is that it also determines the shaft flex profile for a golfer based on these parameters.

So, here also we see that based on the linguistic terms the fuzzy controller decides the what I mean a particular golf club based on the parameters which are fed which are in the linguistic terms.

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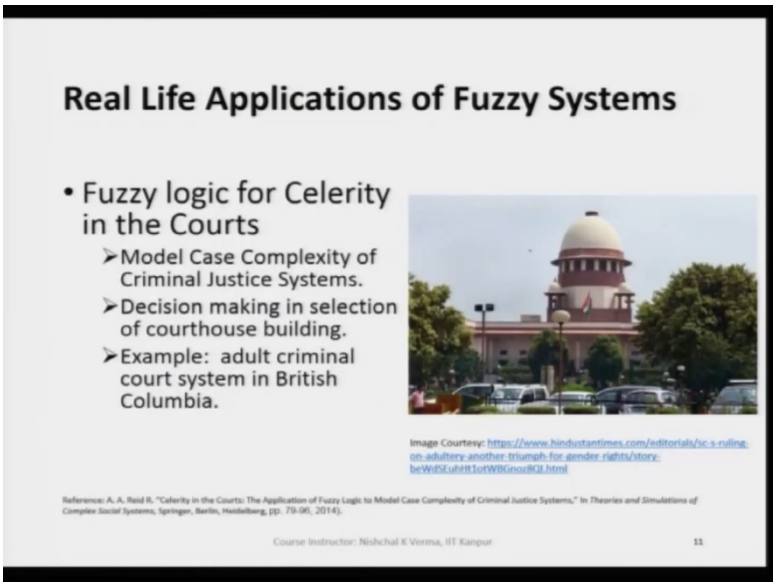

Then we see a fuzzy logic application here in celerity in the courts. So, what we mean by, celerity in the court is like fuzzy logic is helping various courts in managing the decision very quickly in or in accelerating the decision making process.

So, a model case complexity of criminal justice systems. So, basically if we use fuzzy logic the complexity is very well dealt by the fuzzy logic and you know with linguistic terms which otherwise it is very difficult to be understood, fuzzy logic is helping this system the court system to manage the complexity which is present in the you know this justice system and then in the decision making in selection of courthouse building and similarly lots of other in decision making this fuzzy logic is helping us very well.

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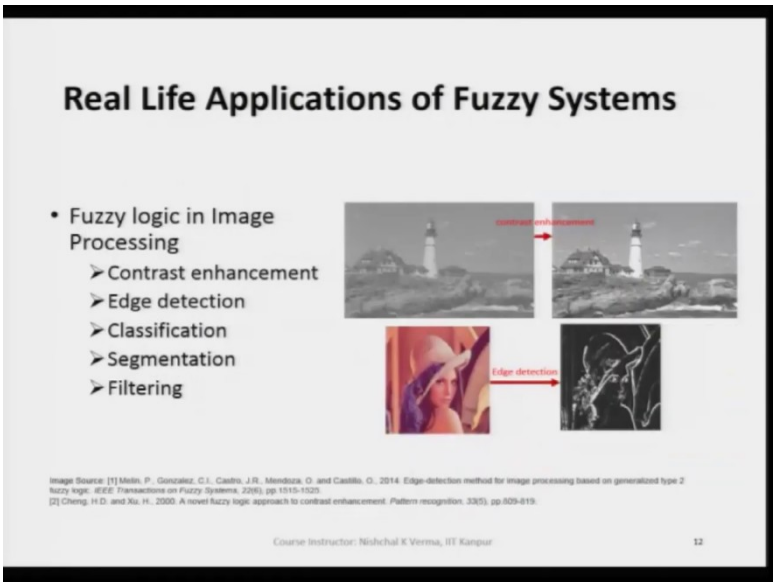

Very interesting application we can see here is the fuzzy logic full in image processing. So, in image processing fuzzy logic helps in contrast enhancement, the edge detection, classification, segmentation, filtering. So, here we see you know some of the some of the applications that is done by the fuzzy by the use of fuzzy logic or fuzzy logic-based system.

So, the fuzzy logic is very very helpful in image processing and if we are further interested in few more application related application we should try going to or referring to the IEEE transactions and fuzzy systems and we may see so many other similar applications.

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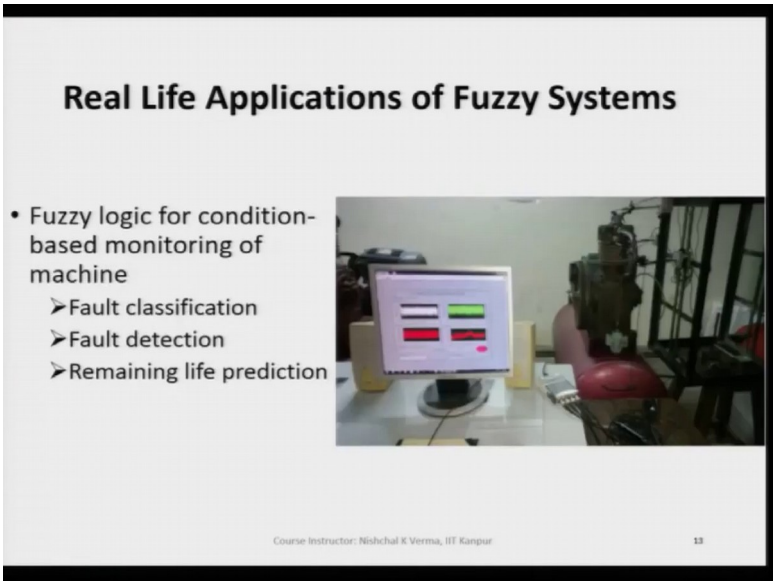

So, here also we see one application which is fuzzy logic-based application and this is a condition-based monitoring of machine. So, what do we do here is that various parameters for example, the vibration, temperature, voltages and few other parameters are you know picked up from the machine and these parameters are used for diagnosing the condition of the machine.

So, the fuzzy based fault classifications are very helpful in recognizing the the status of the machine, whether the machine is healthy or faulty and if the machine is healthy its fine, but if the machine is faulty then what kind of fault in the machine is present. So, like that fuzzy system or fuzzy logic based system especially the classifiers, the feature selectors, feature extractors all these are helping us in managing the fault recognition process very well.

And another thing here is that fuzzy based algorithms are very very helpful for estimating the remaining life prediction means, remaining useful life of a particular machine.

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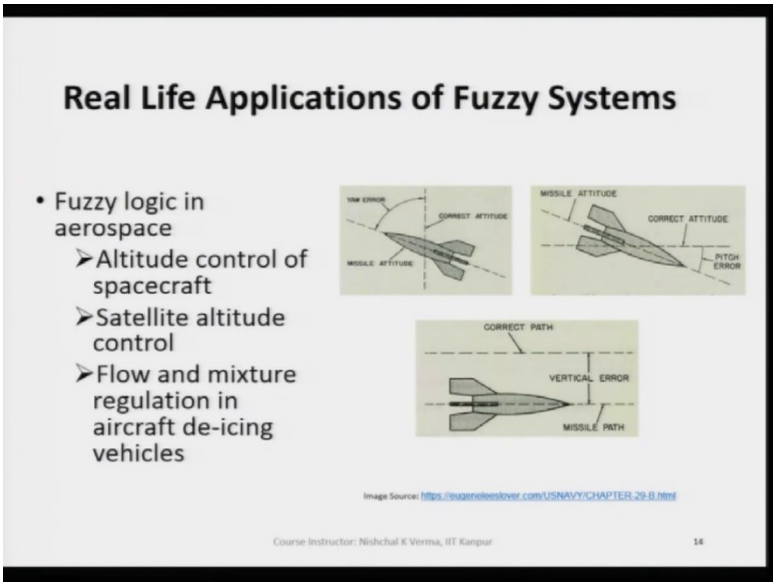

Another application that we here we see here is the fuzzy logic in aerospace. So, we see here that the altitude control of a spacecraft is managed by the fuzzy based controllers and then fuzzy based controllers are also helpful in managing the satellite altitude control flow and mixture regulation and like that we use fuzzy logic based controllers in similar aerospace applications.

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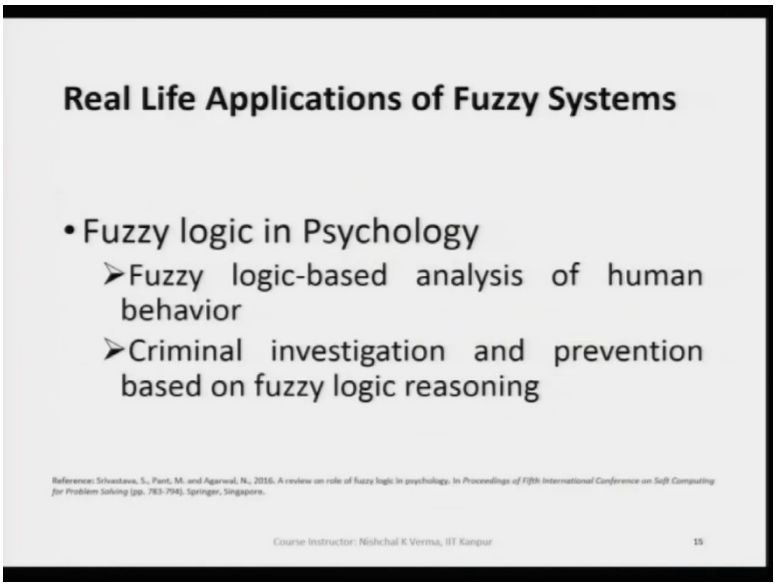

So, these are very helpful in aerospace. And next application here is the fuzzy logic in psychology. So, in psychology also the fuzzy logic based techniques, fuzzy logic based algorithm approaches are very very useful in analyzing the human behavior and criminal investigation and with this through you know the prevention is also prevention of the criminal attitudes are also done.

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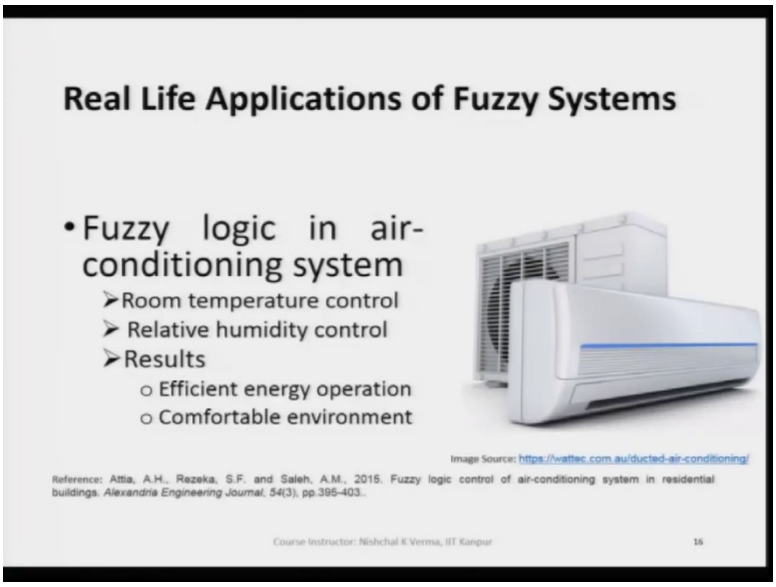

So, next application is the fuzzy logic based air conditioning system. So, here also in air conditioning many of the air conditioners nowadays coming with fuzzy logic based fuzzy logic controller and these controllers are taking inputs in linguistic terms again.

And these input inputs are in terms of like linguistic values like room temperature control and this room temperature inputs will be like the temperature, low temperature, high temperature, medium temperature and like that. And then humidity control if this has the fuzzy controller based humidity control then we have the low humidity, high humidity, medium humidity or like that.

So, all these linguistic values are selected and based on this the controller takes the appropriate decision and this decision values are fed to the respective systems to manage to give the appropriate performance.

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And another application here is the fuzzy logic-based recipes recommendation. So, here also we see that the we have certain linguistic values that is a given as the input for decision making and this linguistic values could be based on the person mood, person's mood, healthy eating, balanced meal, appetite, spare time.

And all and all these will be affecting the decision and here the decision maker, the decision you know the system is fuzzy and this decision system is taking the inputs in terms of the linguistic values.

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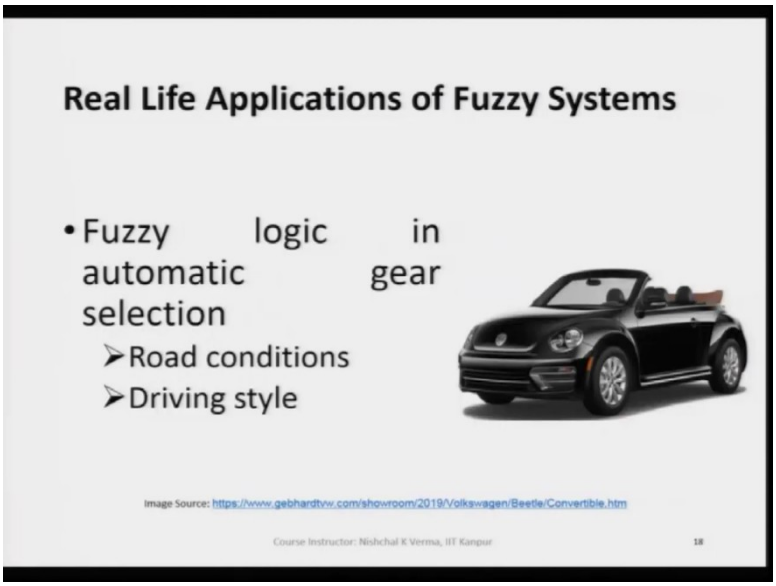

So, fuzzy logic can also be very very helpful in automatic gear selection. For example, based on the road conditions and driving style and so many other features could also be added in order to make the decision in terms of the gear selection and other things. So, this can also be these are these are also possible and being used in some of the cars.

So, road conditions here would mean like if the road condition is very good or bad, very bad or like that the linguistic values if we select and based on that the driving style also if this is also you know this is also given as the input like good style, bad style or whatever. So, based on these inputs the gears selector prompts are it helps in selecting the gear, appropriately to give the better performance of the car.

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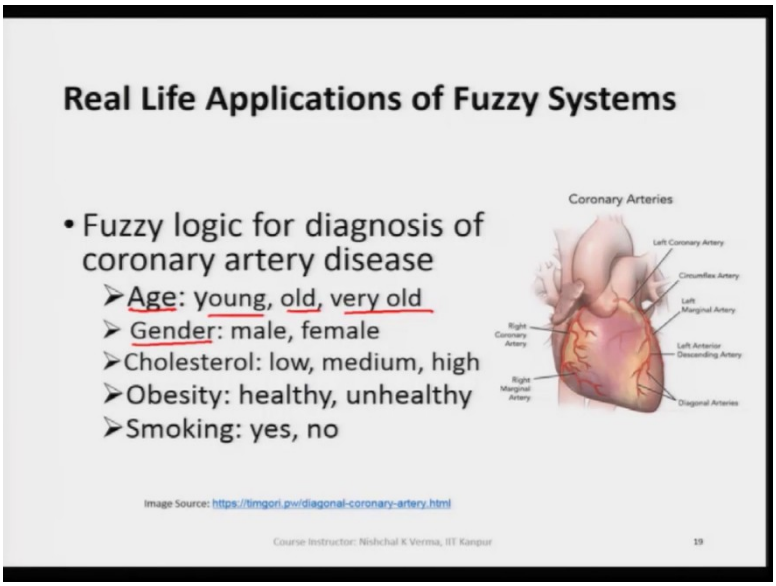

And fuzzy logic in another application here is very helpful for diagnosis of coronary artery disease. So, if we look at the features here and based on these features this diagnosis this diagnostic system which is based on fuzzy logic takes the decision. And based on the age, like age could be young, old, very old or similar values linguistic values and then the gender and this gender could be male value or the female value.

And then the cholesterol, obesity, smoking and all these are normally used as input of the fuzzy logic based diagnostic system and based on these inputs the fuzzy logic based diagnostic system gives us the appropriate output and this output helps us in the diagnosing the condition of the health of the heart.

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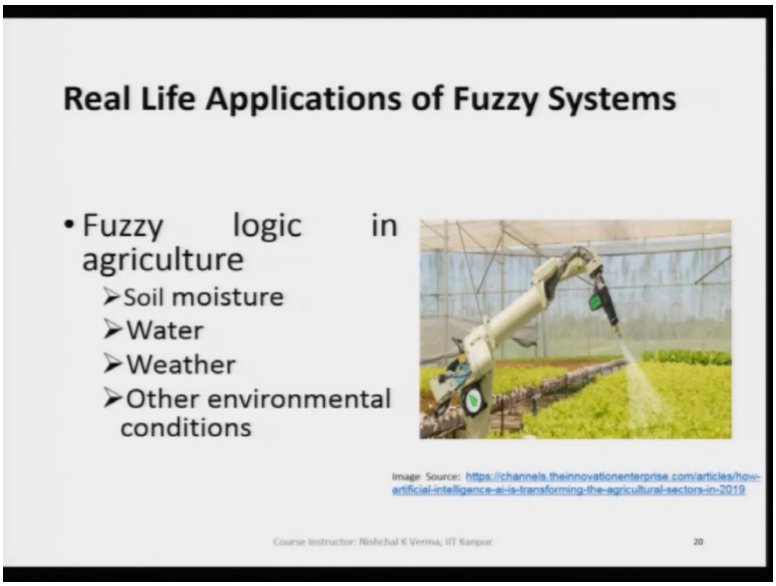

Similarly, we have another application which is in agriculture. So, fuzzy logic is being utilized, fuzzy logic based systems are utilized in agriculture in soil, moisture, water, weather, another environmental conditions based you know decisions are made.

And as I already mentioned that based on these the linguistic values appropriately you know like soil moisture is low, high like that very high or like that we can have the inputs, similarly for water for weather for you know the environmental conditions. So, all these are fed as the inputs and based on these inputs the appropriately decisions are taken by the fuzzy based decision system and this enhances the overall performance of the agriculture.

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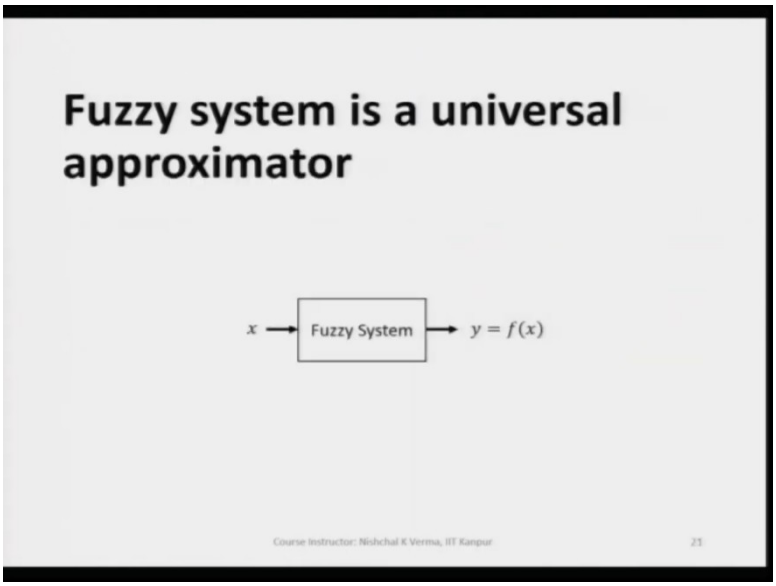

So, if we look at real life applications we see that we have nowadays so many areas where fuzzy logic-based systems are being used and only a few of these areas I have covered. But there are so many applications existing. So, if you are interested you may go ahead and explore other areas also where the fuzzy logic-based systems are being used. Fuzzy system is a universal approximator. So, what does it mean here is that see the fuzzy system can approximate any function.

So, when we say any function means if the function is linear we do not need fuzzy system, but if the function is the non-linear highly non-linear very complex function then the fuzzy logic can approximate it means it actually finds the f by using the fuzzy logic.

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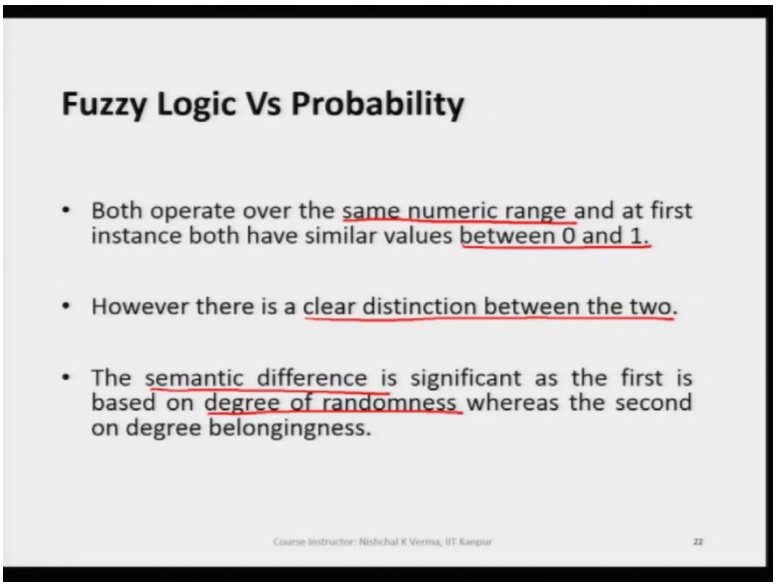

So, let me also discuss here the fuzzy logic versus probability. So, many of us often get confused by the fuzzy logic and probability because both of these operates on the values in between a 0 and 1. So, that is the major confusion normally students face. So, both operate as I mentioned, both operate over the same numeric range; same numeric range and at first instance both have similar values in between 0 and 1.

What does it mean here is that the fuzzy logic when we see takes the values in between 0 and 1 for its belongingness and similarly the probability values are also in between 0 and 1. So, that is how we often get confused. However there is a clear distinction between the two. So, let us understand the distinction between the two. So, the semantic difference here is the significant as the first is based on degree of randomness. So, when we talk off the probability, probability is based on the degree of randomness whereas, the fuzzy system fuzzy logic is based on the degree of belongingness.

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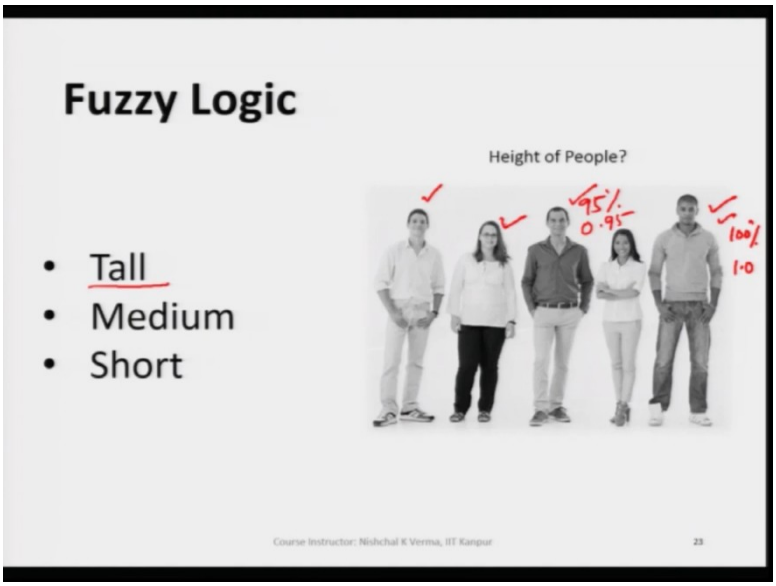

So, let us now take some of the examples and by these examples we will be able to understand the distinction, clear distinction in between these two. So, fuzzy logic basically has the fuzzy boundaries, fuzzy logic deals with the linguistic values and if we have the, you know the groups and these groups, they do not have the clear-cut boundary the sharp boundary.

So, like if we see, if we see here in this picture the height of people. So, if we see that we have three categories here in terms of the height. So, three category categories of people are present. So, tall, medium, short. So, it is very difficult to draw a line in between the tall group, medium group, short group.

So, if we talk off the tallest, he is the tallest, but since there this in when we talk of tall. So, tall is the group of person who has the in terms of height who are tall. So, this person can belong to that group, this person can also belong to that group, this person can also belong to that group. When we talk of medium so, we do not know whether I should put this person, this lady in the medium group or the tall group. So, that is why we can always say that this lady can be in can be partially present in the tall group and can be present in the medium group. Similarly, for other group also this you know distinction this partial belongingness can be there.

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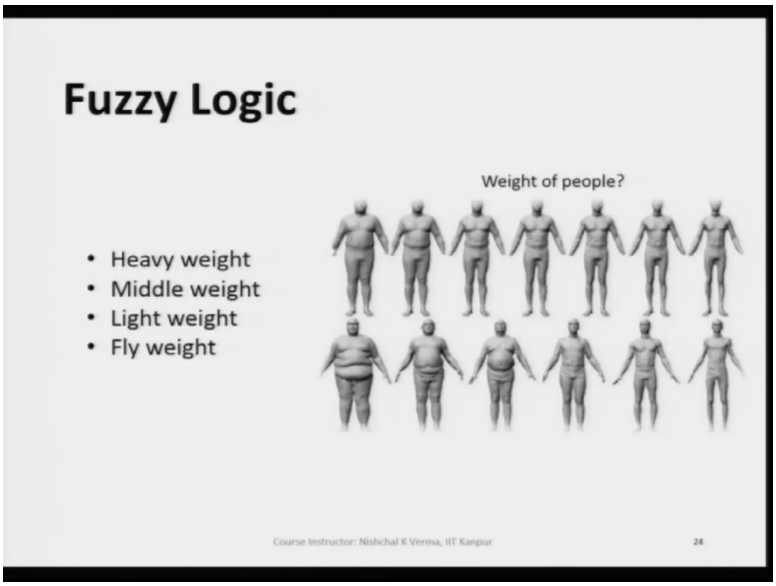

If you take another example, similarly for weight of the people. So, similar clear boundaries cannot be drawn like heavy weight, middle weight, light weight, fly weight. So, it is very difficult to clearly sharply draw a boundary and based on that we cannot separate these people in terms of these groups.

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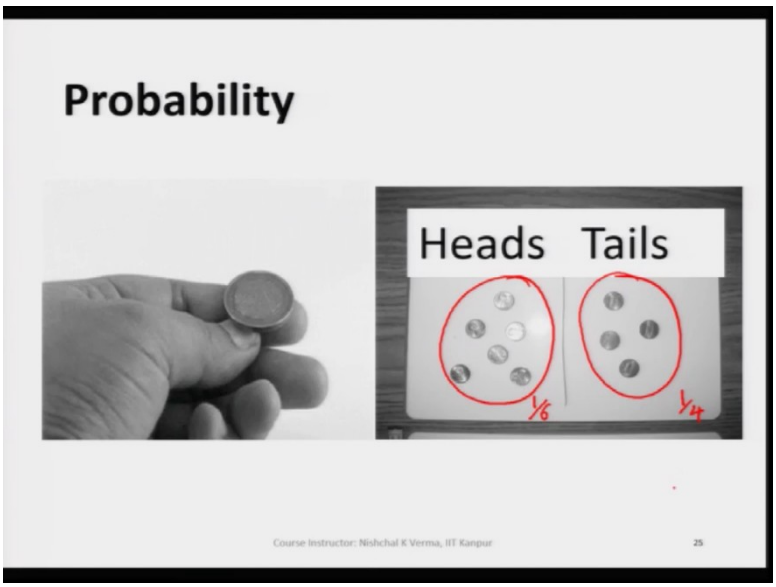

And when we talk of probability so, probability you see if we toss a coin let us say 10 number of times, 10 times if we toss coin. So, few times let us say here as you see the 6 times we get the heads and 4 times we get tails right, so, for probability you see the probability is 1 over 6,

probability of getting the head and then probability of getting the tail is 1 by 4 and here the probability is 1 by 6.

So, if we see these values which are coming here because of the randomness these probability values are coming in between 0 and 1. But if we talk of fuzzy, so there if a person belongs, let us say this person belongs to a particular group completely like a tall group completely it means this person is belonging to that group with 100 percent belongingness.

And if this person may belong to that group with a less than 100 percent say, 95 percent, so the degree of belongingness here could be 1 and here that degree of belongingness could be 0.95. So, here also the degrees of all the degree of belongingness, all the degrees, will be coming in between 0 and 1. So, that is why we all we often gets confused get confused with these values and we confuse with the cases whether this is fuzzy logic case or probability case.

So, we need to be very very careful while dealing with some of the problems. So, we look we should first check whether the process is based on the randomness or process is based on the belongingness.

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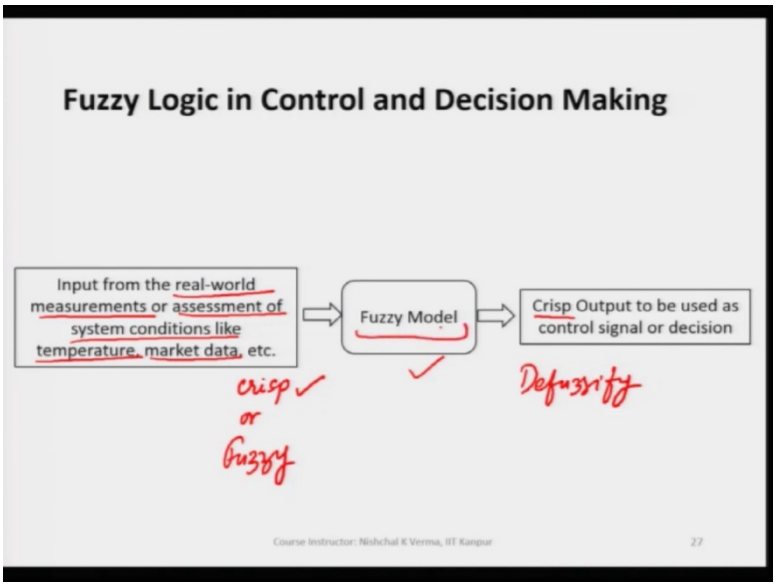

So, now then let us come to the block diagram of the fuzzy logic in control and decision making. So, we have a fuzzy model here. So, input of this fuzzy model is this fuzzy model is

basically from the real-world measurements or assessments of system conditions like temperature, market data and all.

So, here the input to this model can be either crisp or fuzzy, if this is crisp we need to fuzzify it in order to feed this data into the fuzzy model or if it is already fuzzy that we can straight away feed this data as input to this fuzzy model. And then the output of this fuzzy model is generated, this could be fuzzy or this could be the crisp if this is fuzzy value as the output of this model then we defuzzify.

Then we defuzzify before we use. If this output is already crisp then we can straight away use this for further processes as input. So, this way this fuzzy model is or this fuzzy model can be regarded as the decision maker.

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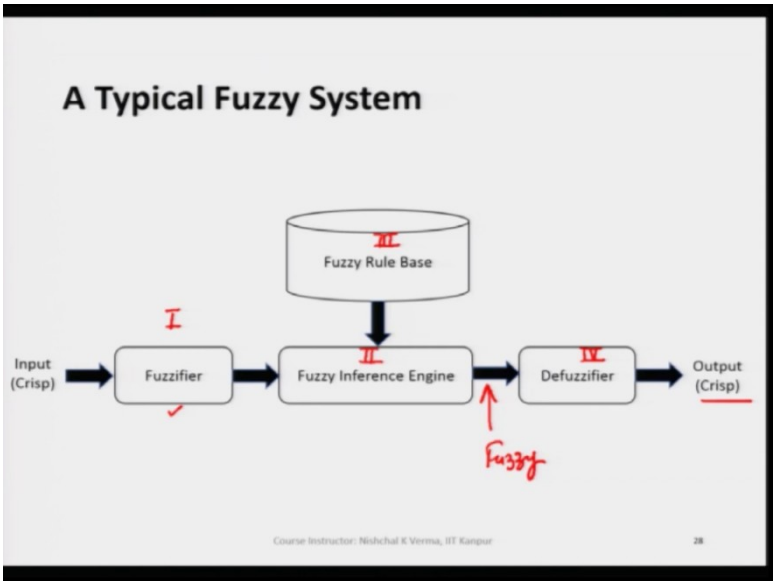

Let me briefly tell you here about a fuzzy system. So, what is a fuzzy system is system which contains these four blocks. So, first block is the fuzzifier and then the second block is the fuzzy inference engine, third block is fuzzy rule base, fourth block is defuzzifier. So, any typical fuzzy system will have these four blocks.

So, if we come across any system, any fuzzy system we have must check whether all these four blocks are there or not. If any of these blocks are missing it means the system which we are dealing is not a fuzzy system. So fuzzifier here is fuzzifying the input data which if which

is a crisp, if it is crisp fuzzifier fuzzifies the input data and feeds it to the fuzzy inference engine.

And fuzzy inference engine takes the help of fuzzy rule base and based on that the suitable output is generated and if this output here is fuzzy a defuzzifier is used for generating the crisp output. And here this can also be possible that this output is a crisp output then we do not need a defuzzifier, we can straight away use this output as the input to the other system.

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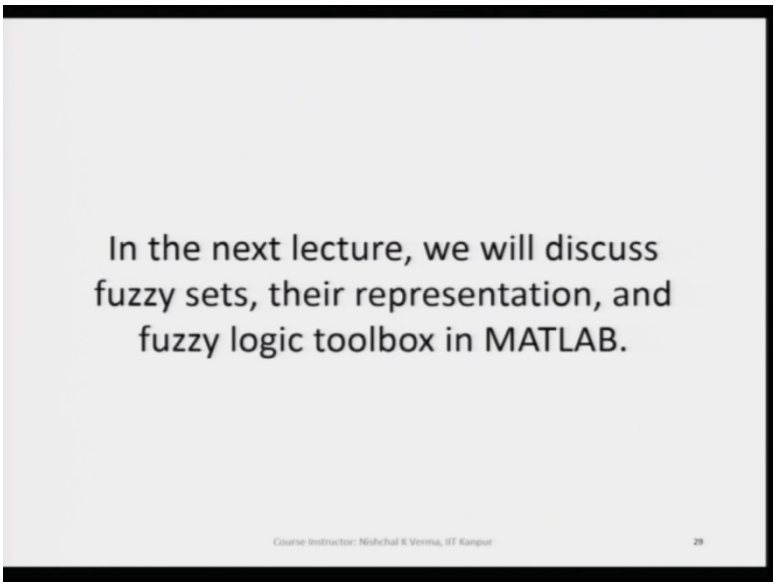

So, I would stop here for this lecture and in the next lecture we will discuss fuzzy sets, the representations and fuzzy logic toolbox in MATLAB.

Thank you very much.