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Lecture – 45
Human Error Quantification from Expert's opinions - Fuzzy Set Approach

Hello everybody, welcome to this lecture today's topic is Human Error Quantification from Exports opinion Fuzzy Set Approach.

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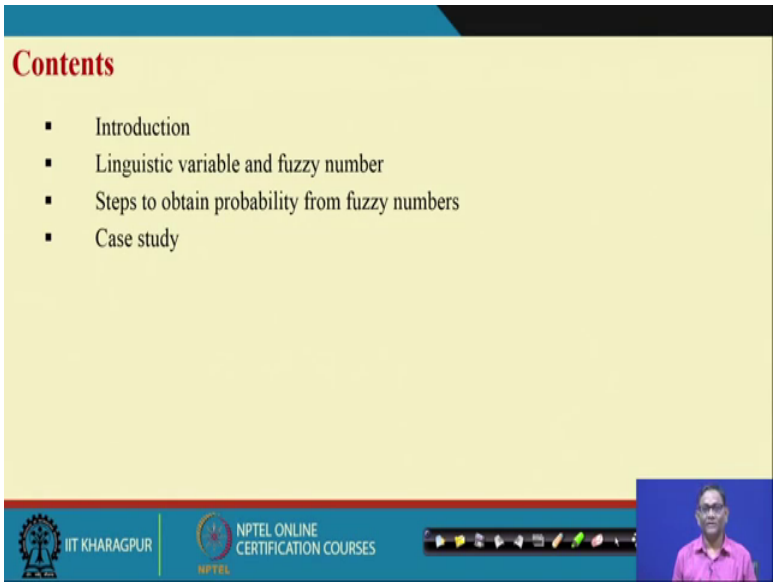

So, we will see little bit of Fuzzy number and how the linguistic variable can be converted into Fuzzy numbers. Then from linguistic variable using Fuzzy number how we will obtain the probability of human error or human error probability and case study.

As you know that getting human error probability is very difficult and most of the time we rely on experts opinion and experts are comfortable in giving responses in the linguistic terms and that is the reason we are adopting Fuzzy theory. And we will show you today how Fuzzy's theory will be applied to convert the linguistic form of probability values to numeric probability values.

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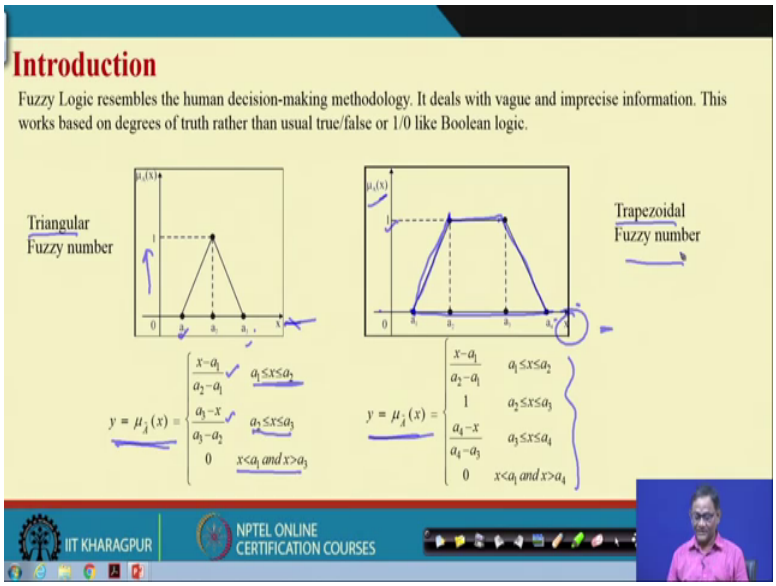

So, let us discuss little bit of Fuzzy set here what is Fuzzy logic? Fuzzy logic you know that it basically rely on two things, one is that the things what you want to measure; there must be some kind of Fuzzy needs which is basically ambiguity or I can say that overlapping nature and also the impreciseness.

So, under such information you it is better to adopt Fuzzy mathematics rather than the (Refer Time: 02:05) mathematics. Suppose, if we ask a expert that what is the probability that, the operator will commit mistake in closing a wall? Then it is very difficult for the expert to tell that it is 0.9 or 0.5 or 0.1; rather he given the context he will be able to tell that it is very likely, very poor something like this.

So, such information are represented by Fuzzy number and in Fuzzy number there are two important things one is that the value as well as the membership function. For example, if this is the variable suppose x is the variable which can take values a 1, 2, a 3 and in between that a 1 and a 2 and a 3 these 3 values you have considered and then this side is the membership function.

That means what is the shear that basically a 1 with in this particular Fuzzy set. So, accordingly we will define the variable like this where y is mu a x and if it is within this value a 1 to a 2; the membership value is this and if it is a 2 to a 3, the membership value is this and if it is either less than a 1 or greater than a 3 then the membership value is 0 ok.

So, I will not go into that depth of this membership function of the Fuzzy values because it is a standard thing now. And if you do not have much knowledge on this it is better for you to go through a good text like Ross and Fuzzy logic. So, that there you get the better treatment, but for the time being what I mean to say? I mean to say that Fuzzy number is different from (Refer Time: 04:13) number. In (Refer Time: 04:15) number if I say particular value the membership is 100 percent.

When in case of Fuzzy number we will say the value is a 1; so, with certain membership function or a 2 with certain membership function. So, there are different ways to represent Fuzzy numbers; the most popular one is triangular one, triangular Fuzzy number and trapezoidal Fuzzy number. In case of triangular Fuzzy number, there will be 3 values a 1, a 2, a 3 and a 2 is a value which is having the membership of 1 and a 1 and a 3 they have basically less than a 1 or less or a 1 a 3 there value membership value is 0.

So, that mean the X value lie between a 1 and a 3 and in case of trapezoidal Fuzzy number you see that the form is etcetera trapezoid; trapezoid this is the form. So, here what happened there will be 4 points this; a 1 this four vertices, you can say this one these and these. So, everywhere there is a value for X; this X is the Fuzzy number. So, a 1 with membership value 0 a 3 with membership value 0, but in between when it is a 2 membership value is 1 and a 3 membership value is 1.

So, in between in between the membership values will be less than 1. So, then when we are talking about trapezoidal Fuzzy number you will be using this kind of mathematical form ok. So, today what we will see now that using the trapezoidal Fuzzy number; how the linguistic responses given by the experts will be converted to the probability values.

As you are dealing with the human error; so our discussions ultimately or all resultant all calculation ultimately gives you the human error probability. But this is a general topic the mathematics is generic one; so it can applied to any kind of probable any kind of linguistic variable; the responses are giving by the experts ok. But for our context it is human error and we are asking the expert you tell the probability or possibility of committing errors by the human giving the particular type of errors ok.

So, you all know what are those errors?

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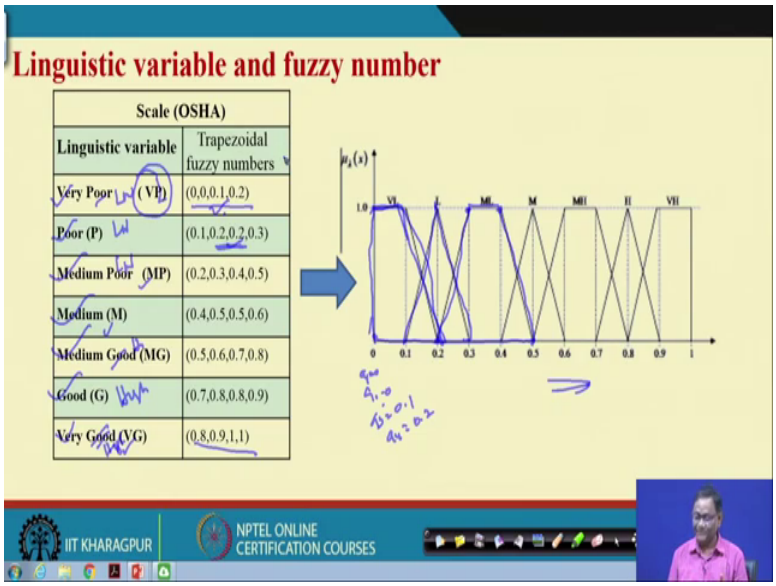

So, there is a scale suppose you are going for linguistic variable with (Refer Time: 07:14) and converting to Fuzzy numbers; then there is a scale. Now this is linguistic variable very poor, poor, medium poor; medium good, good and very good such kind of things will be there.

So, if I want to if I want to say that in terms of probability; if I ask that, what is the probability of committing error when we are saying very good means it is basically very very high. So, good means high; medium good means medium high then medium then medium low then low then very low. So, the very poor to very good this is giving by the scale is given by OSHA.

So, you have to make change to should the context and if it is very low probability and you are using for trapezoidal Fuzzy number; then you have seen already suppose this is my let us consider a trapezoid trapezoidal like this one this is the first one. So, in this case what is a 1? A 1 is 0; what is a 2? A 2 is 0; what is a 3? A 3 is 0.1 and what is a 4? A 4 is 0.2.

So, this is what is given here 0, 0, 0.1, 0.2 so; that means, if the response is very poor or very low; then this is the representation in terms of Fuzzy number ok. In the same manner the second one 0.1, 0.2, 0.1, 0.2, 0.2, 0.3 this is my triangular Fuzzy number because these 2 are same 0.2; 0.2.

Suppose if you consider the third one 0.2; 0.3; so it start from 0.2 then 0.3 second, but this is 0.3 then 0.4 and then 0.5. So, then this particular response is represented like this if your response is medium low or medium; then this is the Fuzzy represent triangular trapezoidal Fuzzy representation. So, what you will do you have already seen that using terb and we have actually and in previous lectures like terb, herd and me sherpa and we have identified different kinds of human error modes.

So, all those modes when it is giving to the expert who knows the totality of the situation then you will you will give value; probability or possibility values in this form either very low, low, medium low medium then medium high and very high. And then the scale is given by OSHA; what you required to do you required to just convert this very low to this or very poor to this and very good or very high to this and accordingly the graphical representation is this.

So, let me this is basically data coming from the expert in terms of linguistic variable converting to Fuzzy variable and Fuzzy numbers using the trapezoidal trapezoidal membership function and the scale using that in by OSHA. So, let us see next what is what we are discussing.

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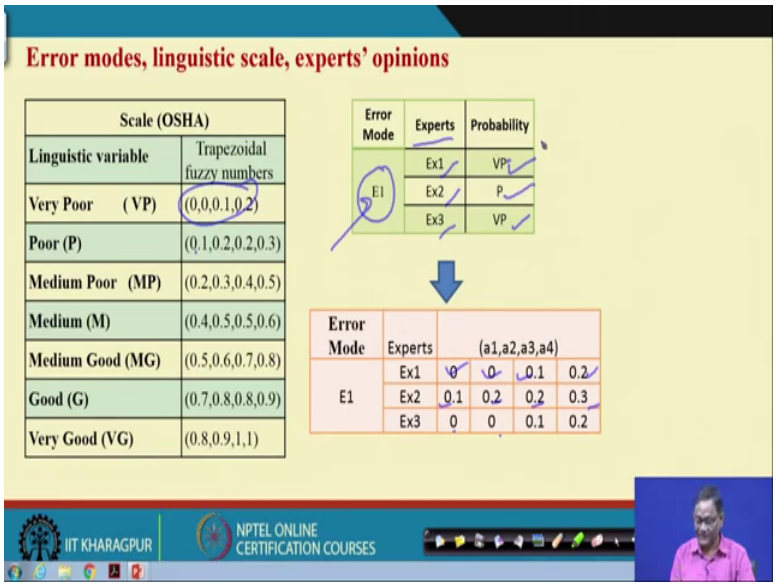

Now, let us think of checking error ok. So, given in a particular inspection you have to check whether there is a defectives or there is defect or not. So, while checking you may

commit mistake. So, let hypothetically we are saying this error mode is E 1; this is basically the error number in a particular mode.

It may be checking error, it may be action error it may be selection error it may be inspection error, but you have several such errors you have identified from the task analysis. Then what happened you have you have to you have to given this; this particular error to 3 expert, expert 1, expert 2 and experts 3 and you ask them you tell me what is the linguistic possibilities values.

So, let us in this form report to very high and the anagogic with the probability; I have already explained. Suppose the expert has given first expert has given at the very poor; second one says that the error, error mode occurrence which poor and third one given as very poor. So, two has given very poor and one given as poor then if it is very poor then which one?

This; so this expert 1 given 0, 0, 0.1, 0.2 expert 2 given 0.1, 0.2, 0.2, 0.3 and expert 3 has given again 0, 0, 0.1, 0.2 ok. So, this is basically the; what way this Fuzzy numbers from the linguistic responses of the experts and this is what is the mapping ok; so, you have do first this.

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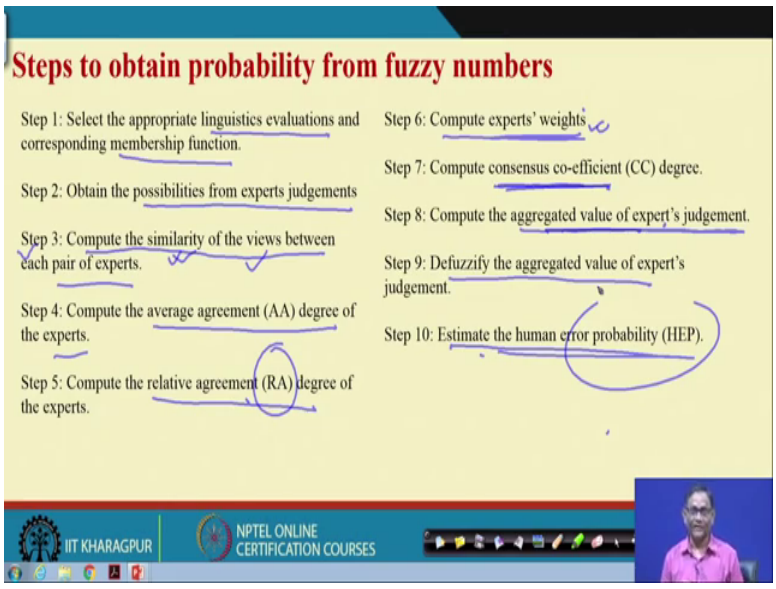

Then in fact, I should give you the steps first. So, how to obtain probability using the Fuzzy numbers? First step select appropriate linguistics evaluations I have already

explained and corresponding membership function. Then obtain possibilities from experts that very poor or very high very low like this compute. The third step is compute similarity of the views between in the each pair of experts it is important.

Because 3 experts are or 5 experts or even more experts; usually 3 or 5 is better, so, 3 experts are chosen and they were given this context and the error modes also given to them; you are asking them what is the possibility that operator will commit mistake or commit error? So, under such situation if the experts are really experts it is quite possible that they will give you more close values.

So, that is the similarity of views. So, given the expert responses find out the similarity of the views. Then fourth step after similarity calculation, you find out the average agreement degree of the expert. So, every expert how they are agreeing with the other experts; after that you find out the relative agreement degree, then after that you compute the weights of the experts because all experts are not equally expert; so, there will be differences.

So, that differences also you have to consider; so, consider the weights. Then using these relative agreement with weights you compute coefficient which is basically consensus coefficient. So, once you have consensus coefficient then you will be able to find out the aggregated value of expert judgment and then these judgment you will be getting in terms of trapezoidal manner form. So, you require to defuzzify this one and then you will get a (Refer Time: 15:10) value that is (Refer Time: 15:12) value with certain; certain equation will be converted to human probability values

So, very quickly I will show you each of the steps now.

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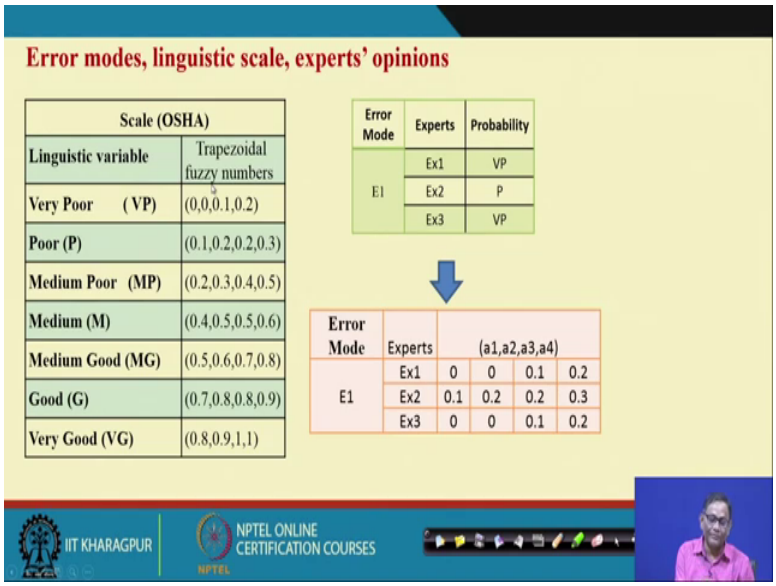

Step 1 is these identify all the error modes for every error mode ask the expert to give their opinion. So, error mode 1, 3 experts opinion opinions are giving 3 experts opinion like this ok. So, then from the Fuzzy scale you found out this values this is first second one.

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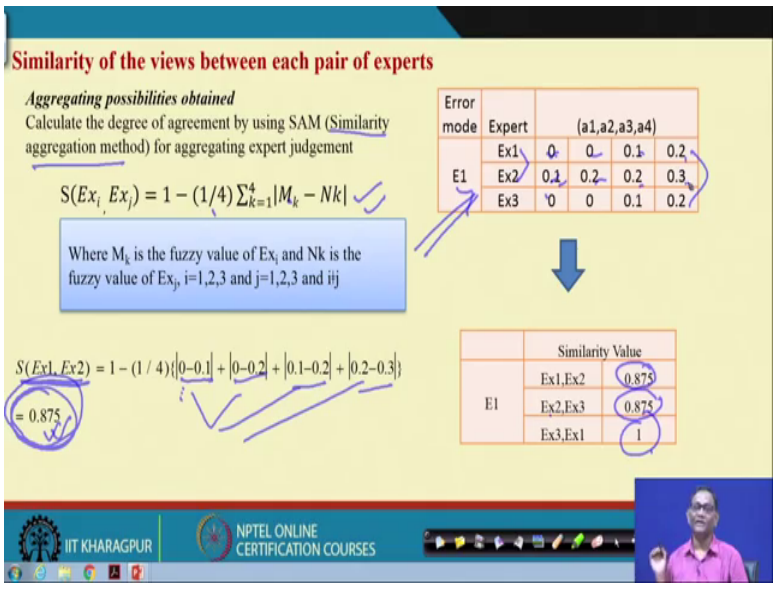

Similarity of the views how do know the experts are similar? So, that will be known using this formula. So, calculate degree of agreement by similarity agreement method the

formula is this. So, how many expert yeah your experts are there? There are 3 experts. So, how many members values are there; Fuzzy trapezoidal case? There are 4 values.

So, use these equation and then using this equation and the data from the Fuzzy that may numbers that is basically from the trapezoidal membership; you got these 2 when these values when you put in these equation, then you will be finding out the similarity between expert 1 and expert 2 is 1 minus 1 by 4; then 0 minus 0.1, you see then we are talking about the similarity these two.

So, 0 minus 0.1; 0 minus 0.2, 0.1 minus 0.2 0.2 minus 0.3; we are interested in the difference. So, with that minus plus all are same that is why you put the mode value the absolute value. And using this formula now you got the ab similarity or degree of agreement which is 0.875.

So, in between expert 1 and expert 2 similarly you can find out expert 1 expert 3 and expert 2 and expert three. So, expert 1 expert 2 similarity value is 0.875; expert 2 expert 3 again 0.875; expert 3 and expert 1 is 1 because you see they are same values giving same values they are having same values.

So; that means, experts responses for every error mode is used considering here trapezoidal membership function, similarity value is calculated using these formula; you just practice it is not if tough task.

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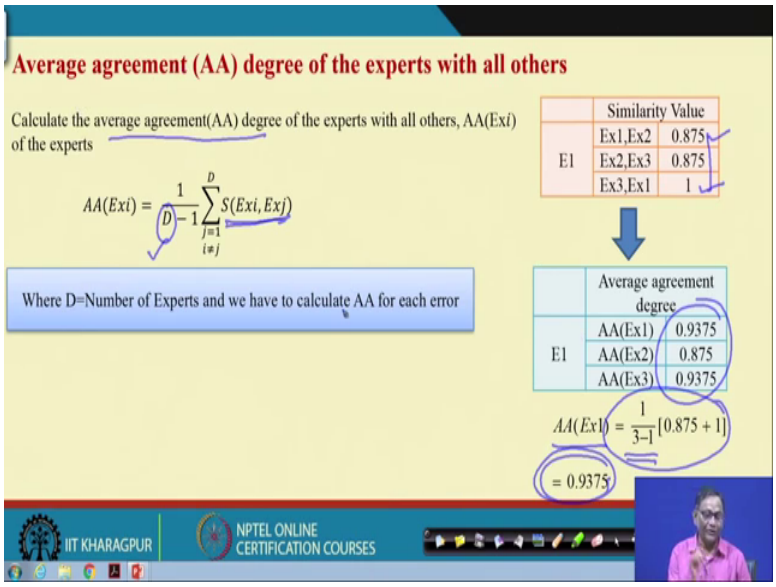

Then you find out the average degree of the expert with all others. So, so what you got? You got the similarity value, use this formula then find out the average agreement degree ok.

So, average agreement of expert 1 with other experts. So, what is what is you required to be used, how many experts are there? 3. So, 1 by D minus 1 1 by 3 minus 1; then this is the similarity value between expert 1 and expert 2 and expert 1 expert 3; expert 1 expert one is not required and expert 2 and expert 3 is also not required because we are interested to find out the average agreement for expert 1. So, as a result you will be considering 0.875 and 1. And using this formula you are getting average agreement for expert 1; similarly for expert 2, similarly for expert 3 and this is the calculation understood.

So, so using this formula find out average agreement then let us see what is next.

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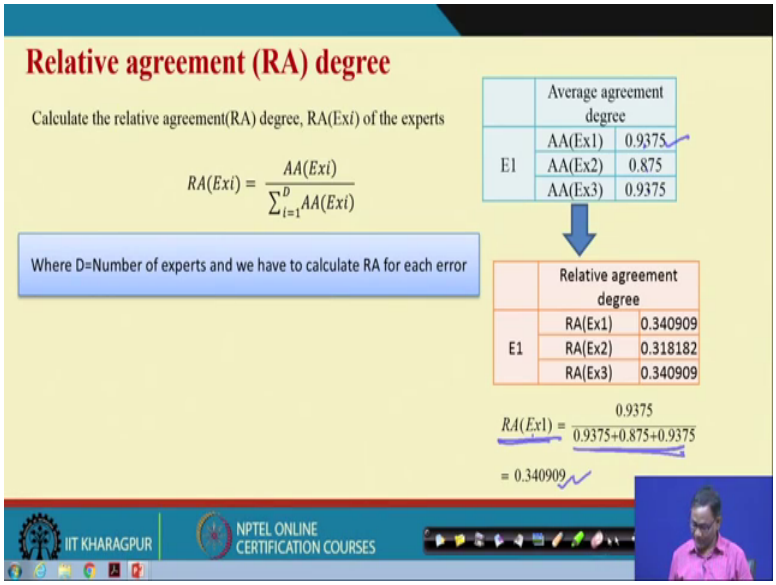

Next is relative agreement; relative agreement is again another easy concept; that means, the agreement some your one is first experts agreement divided by the sum of the agreement of all the experts; that is what is done here. What is the agreement for first one? 0.9375 What is the sum? This plus, this pus this.

So, the denominator is the sum of all those agreements numerator is that concerned expert agreement; then relative agreement for expert 1 is this. This is done so that

ultimately the agreement relatively agreement of all the expert will be sum to 1. So, this is our; now we will go for the next step now.

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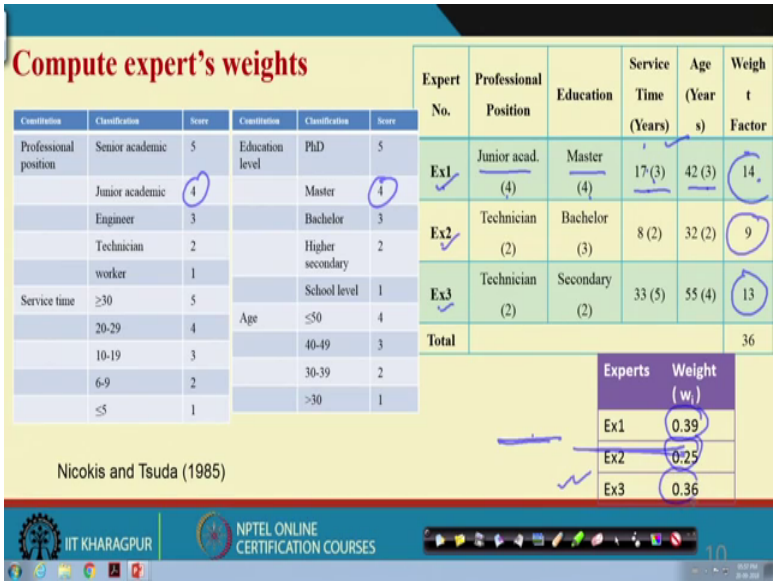

Constitution	Classification	Score
Professional position	Senior academic	5
	Junior academic	4
	Engineer	3
	Technician	2
	worker	1
Service time	≥30	5
	20-29	4
	10-19	3
	6-9	2
	≤5	1

Constitution	Classification	Score
Education level	PhD	5
	Master	4
	Bachelor	3
	Higher secondary	2
	School level	1
Age	≤50	4
	40-49	3
	30-39	2
	>30	1

Expert No.	Professional Position	Education	Service Time (Years)	Age (Years)	Weight Factor
Ex1	Junior acad. (4)	Master (4)	17 (3)	42 (3)	14
Ex2	Technician (2)	Bachelor (3)	8 (2)	32 (2)	9
Ex3	Technician (2)	Secondary (2)	33 (5)	55 (4)	13
Total					36

Experts	Weight (w_i)
Ex1	0.39
Ex2	0.25
Ex3	0.36

Next step is once you have the relative agreement for each expert find out the weight of the experts. So, for weight of the experts Nicokis and Tsuda, 1985 given this scale what is this scale here?

They have considered professional position, service time, educational level and age of the expert. And there are different classes of professional position, different service time, different educational level and age and some scores are given this scores defiantly based on certain scientific measurement either may be through expert opinion or through stimulation or through phase studies.

So, then in our case we had 3 experts expert 1 expert 2 expert 3 and their details on those first second third 4 different fact criteria; 4 different I can say features. So, junior academian will get 4; so, like this master degree you where it will be 4. So, like these 4 4, 3 3 it is total. So, come weight for expert 1 is 14, weight for expert 2 is 9 and weight for expert 3 is 13, these basically we calculated from this from the data given Nicokis and Tsuda.

So, now you have to find out this weight normalized weights. So, normalized weight will be individually divided by the sum. So, 14 by 36 is 0.39, 9 by 36 is 0.25; 36 by 13 by 36

is 0.36; so this is experts weights. So, it is how it will be explained? It will be explained something like this; expert 1, expert 2 and expert 3 if you compare then expert 1 and experts 3; they are almost equally expert where expert 2 is having little less expertized.

So, that is what the weight. So, relative agreement is known to you for a particular error for the 3 experts; now experts weights are also known we will use these to find out to find out consensus coefficient.

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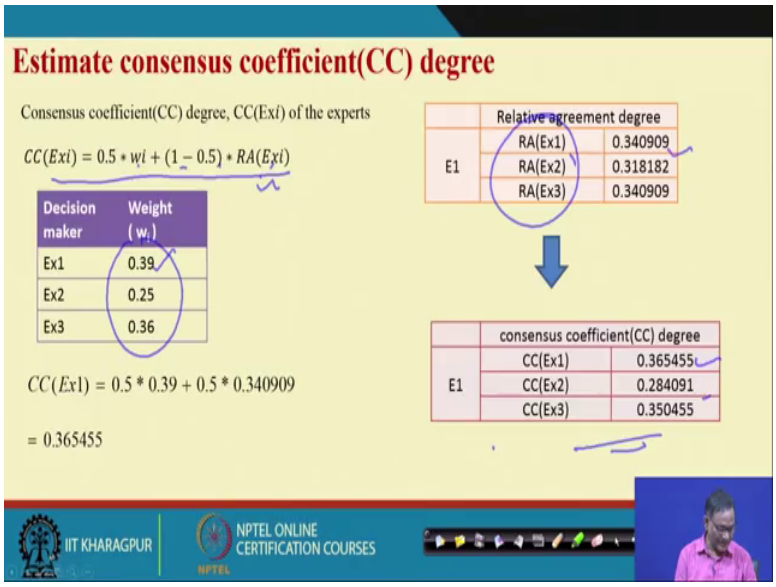

Consensus coefficient means how the experts ultimately the; what is the consensus in the sense how much; so, what is the agreement they are made here.

So, we use these formula 0.5 into the weight of the expert 1 minus 0.5 into that relative agreement. If we this is known this is known and finally, for and this is the relative agreement is known, weight is known these 2 combine will give you this even this formula. So, 0.5 into these 1 minus 0.5 into these this will give these values. So, this is basically consensus coefficient amongst the consensusness amongst the expert; so, for every expert consensusness coefficient is found out.

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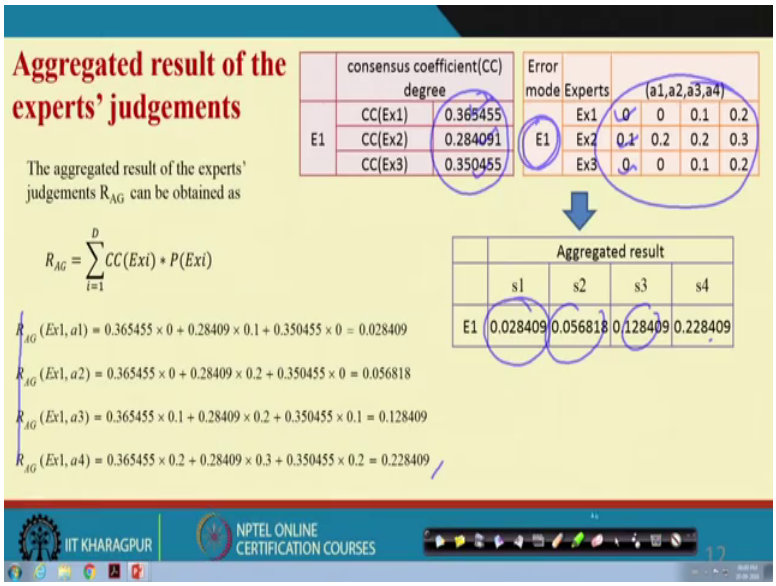

Using consensus coefficient, we will you go for the next step; in the next step is basically the aggregated result of the expert judgments. So, now, see you have the consensus coefficient and use for the error mode E 1; the 3 experts and given this values in terms of Fuzzy numbers.

Just what you are finding out? You are finding out the aggregated results using these. So, these multiplied by these plus these multiplied by these plus these multiplied by these this nothing, but this. So, similarly second one, third one and fourth one because it is the trapezoidal Fuzzy number; so, 4 vertices are there 4 points, so all those values calculated here. Now what you do? You this is to be defuzzified. So, how we will do the defuzzification; defuzzification will be done using the center of gravity role.

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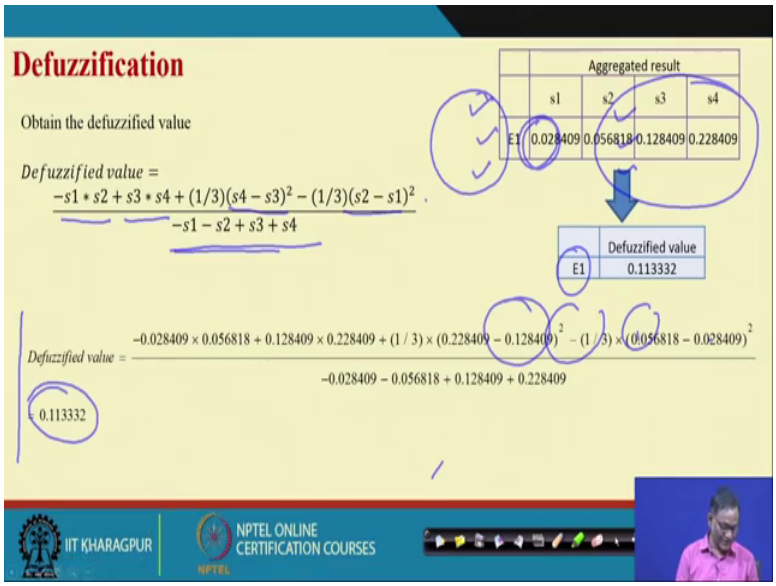

So, the that formula is this minus s 1 s 2 plus s 3 s 4; 1 by 3 these s 4 minus s 3 square minus 1 by 3 s 2 minus s 1 square divided by s 3 plus s 4 minus s 1 minus s 2; then s 1 s 2 s 3 s 4 these values are known to you already computed aggregated values. So, this values once you put here the defuzzified value is this one.

So, using; so that means, the defuzzified value for error you got; error mode using these we will go for to the next that is basically how to find out the probability human error probability.

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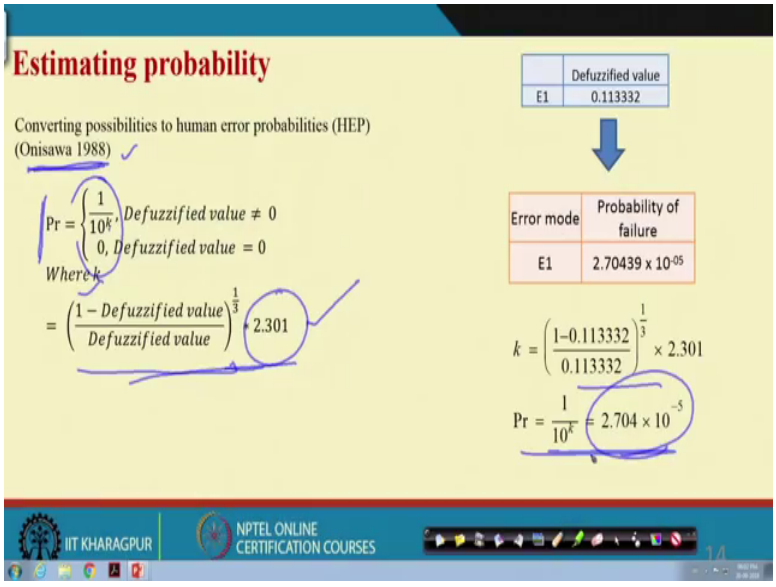

So, this one is written here; so, Onisa; Onisawa 1988 given this formula to calculate the probability. So, HEP 1 by 10 to the power k; k value you already you have you know E 1 defuzzified value is this.

So, here k each sorry k value will be this value; now 2.301 are multiplied with the defuzzified 1 minus defuzzified value by the defuzzified value to the power 1 by 3. And then after you got this k value; put in this equation 1 by 10 to the power k. So, k value is our, these once you put into the formula we got this is the error probability. So; that means, for the human error mode u 1, it can be anything; checking error, inspection error, counting error or whatever anything operation error.

So, that error when you have the expert judgment values and you please take at least 3 expert. And then you use these steps what I given to you and then finally, come to the probability of committing human error mode E 1 is this that is what is the thing we want to calculate it. I hope you have understood it and there is a case study, but I do not want to show this case study now; if time permits we will show you in some later classes.

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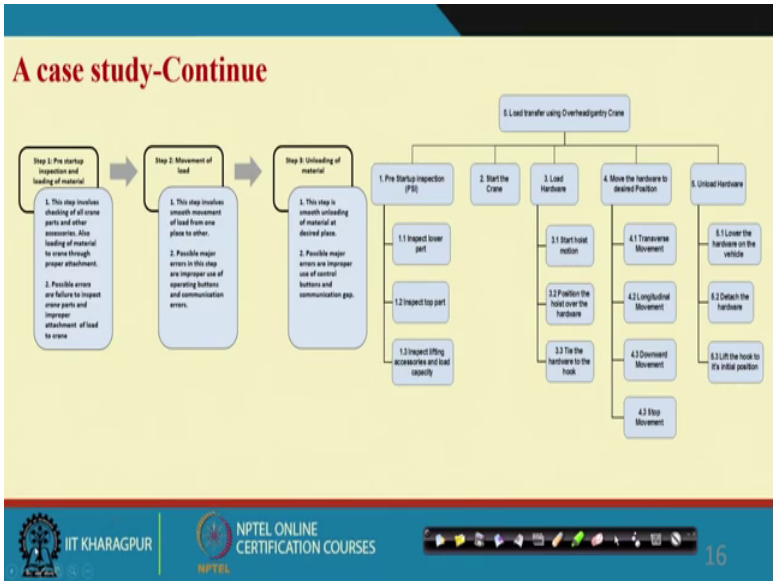

So, what is this case study known to you? This case study is nothing, but the crane study and then we have done task analysis.

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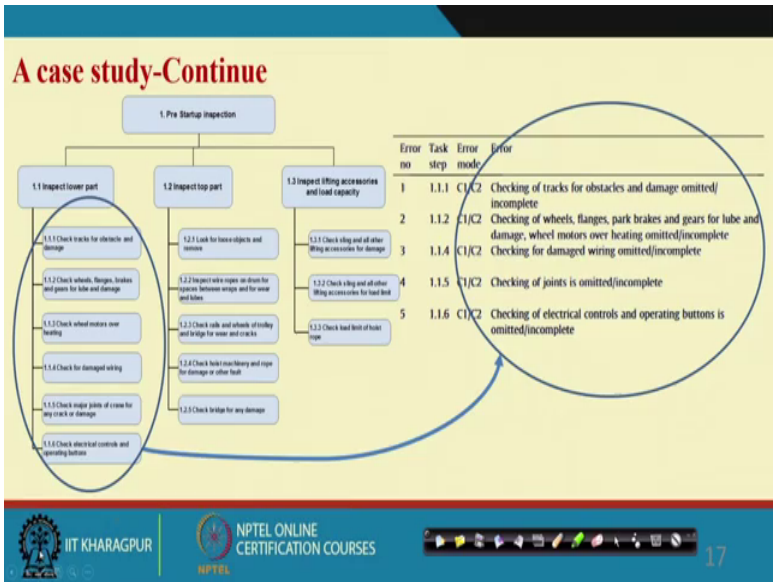

Then finally, using this all the error modes you have found out so many error modes.

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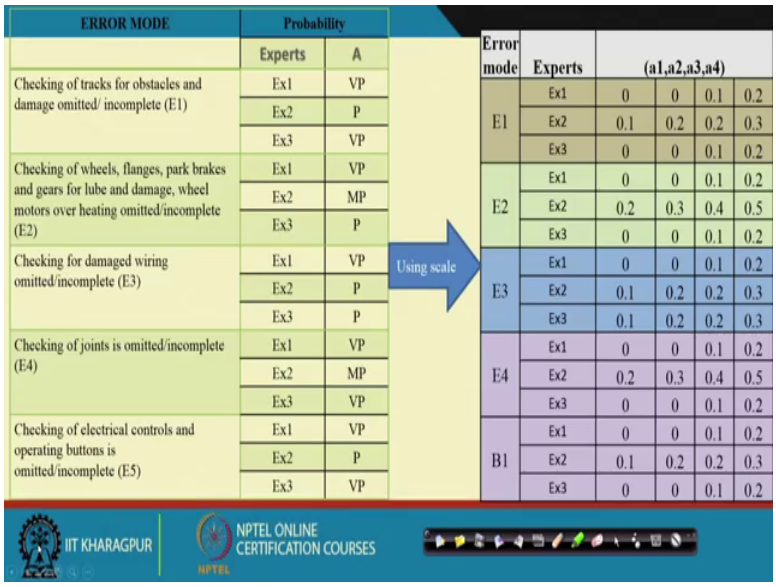

And then we have collected expert opinion; here we are showing only these portion that inspect lower part what are the different task elements and what are the different error modes that happen. And then with these the x 3 experts opinion we have taken; we have converted into the Fuzzy values.

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Then finally, all the calculation what I have explained so, far is used.

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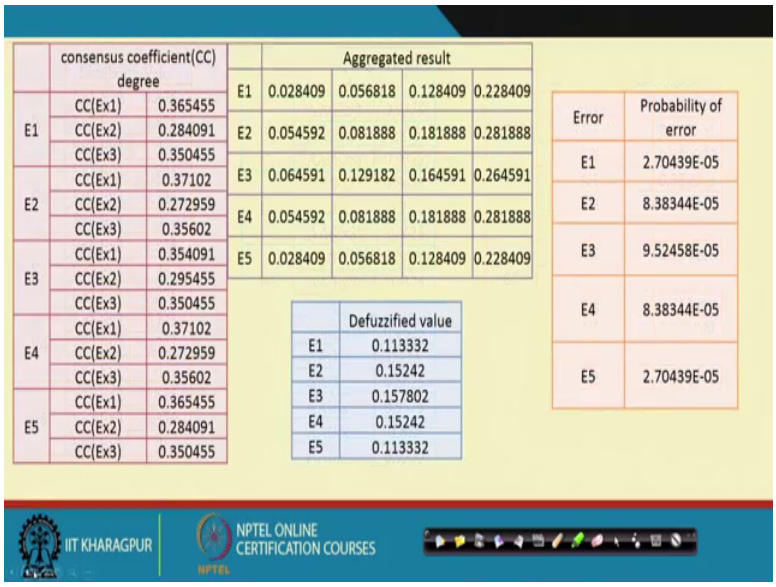

And then the error probability values are computed.

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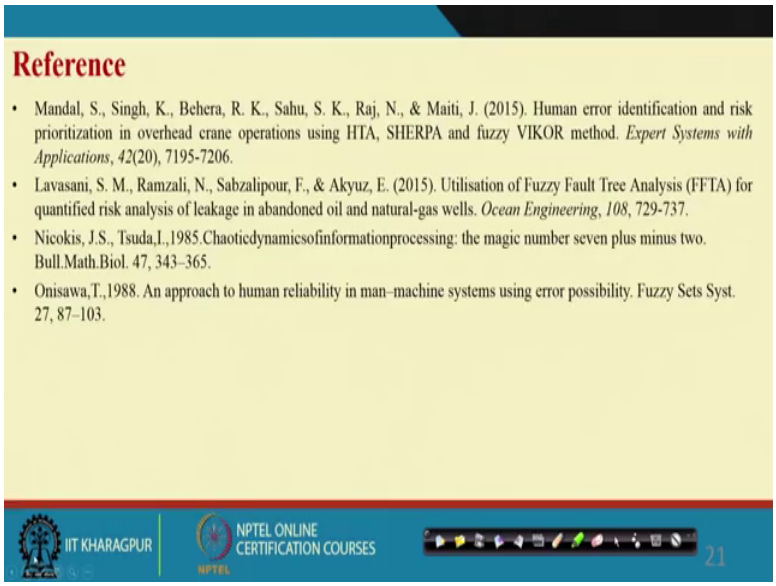

So, this is interesting one and I very hurriedly I can say that very quickly, I have completed this one. I hope that you have you really understood it; if not please put in the discussion forum; may be in next class I will revisit it, if it is required please put in the discussion forum.

Thank you very much.