Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Introduction to Experiments in Flight

Lecture – 21
Aerodynamic Parameter Estimation Using Delta Method Contd….

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Hello everybody welcome to the next part of the tutorial. So in the previous class we have learned about is delta method like aerodynamic parameter estimation in delta method where I have talked about the architecture of adopted by delta method where you are speed forward given above. And you have some got well in how you will for work and how it will be trace and that the like how did you use for the method. We will quickly revise what is with class.

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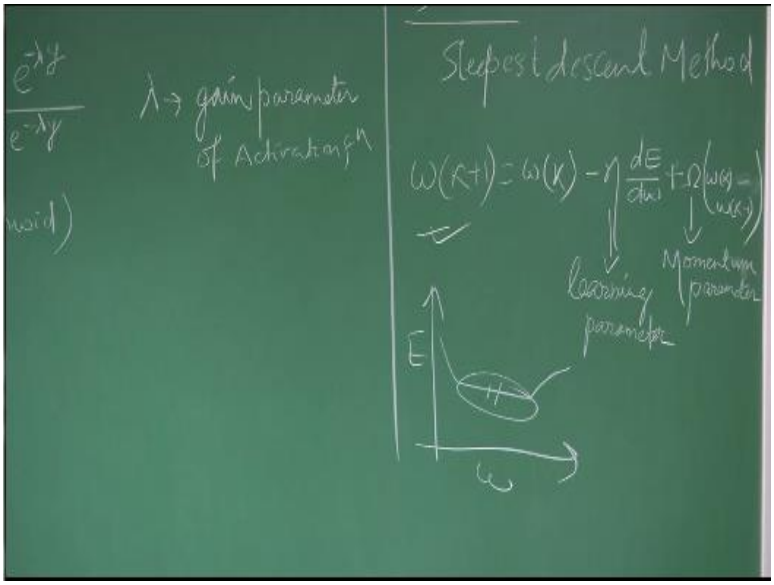

So as I said like is with our biological neural, neural so you can see this architecture of usually drawn it was like this, so it had some wires, inputs and certain bit do it right it is wires and you can have different inputs X1, X2, X3 and here you have some all those and pass non-linear activation function. And it could be your any kind of sigma in constant and then sigma hidden log it can also be an linear simple way.

So initially that will talks about your artificial neural, so this is the architecture of your single neural this one will be the single neural. So you have the then associated rates of W1, W2, W3 and bias let us B then you have to sum up all the effects and then pass non-linear activation function and then you will get here as output right.

So what we did like all the function not depends on the complexity of copies get the problem. So every kind of non-linear can be captured by in the suitable non-linear activation function. So that is why it is also called universal across the metal can approximate any kind of non-linearity, the activation function which we discussed was we will say that F(y) and if $1\text{-}e^{\lambda y}/1+2^{-\lambda y}$ and here now you can see here we can also modify this non-linear activation function with the λ parameter which will have the control on the function with the parameter.

Then this is called, λ is called gain parameter of activation function. So here you have the flexibility of selecting this activation function that is typically tan sigma okay. And then with that activation comes in once you got this output from the neural and then now it will propagate to the next neural if it had some other layers right. So that is how we understood and then getting the numerator model is about assigning them appropriate weighted of right weighted and bias.

So with that you can have a defined zero network model right, and the learning of this model can be done using this back proportion called which we have discussed earlier, so it is based on based addition method basically it is the bad proposition algorithm which is based on your sleepiest yours this is there is how the operation of weight is done so it was basically w of support one to obtained weight like this so it is K+ 1 stand weight was okay w(k) are here it depends on like how your selecting your error function so you am also write like this so ∂ dE/

dw right this weigh and then suppose your error is becoming constant for some rezone the to improve that you can add this momentum parameter right w(k)- w(k-1) one step back again.

This is you know that mean parameter they decides your convergence of powerful and this movement which improve the result momentum parameter when it use when your error as this in this case here it is constant so in this case Dw/ De / dW or directly teamed with 0 so that in that case it will allow it will not be able to update so that need additional term of momentum parameter where you will get the updated weight age yeah this what we learned and once you have the rate network with the help of your input and output.

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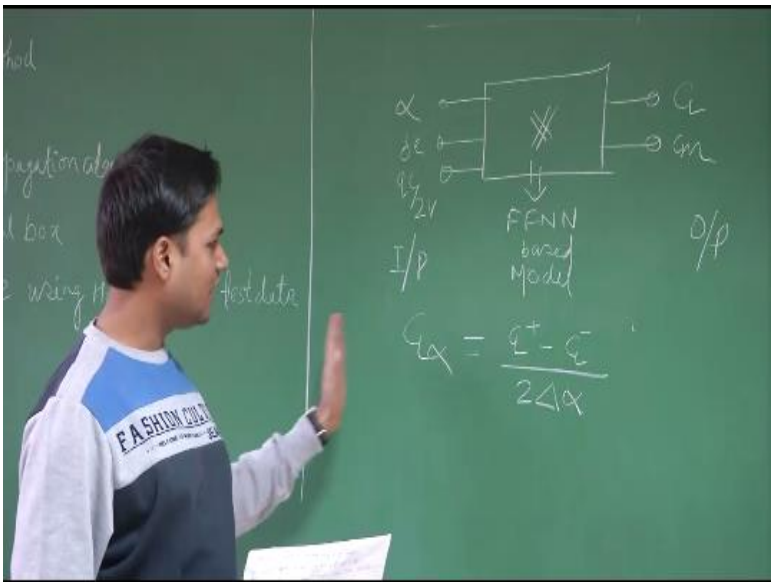

Let us say this is input and output in our example we will make it CL CM as output and then α δ e qC/2 v these our input these are our output now you got this model which was earlier back box you got this model it was earlier black box as straight forward user network based model you got the trained model so this part we have done now so further δ method what he suggest like you know start for input 1,2 find CL α then you further α in both the directions corresponding to that you will see the responses in CL the for quality for + α make it density CL – then twice of dealt α actually in boot the direction so you will get CL α like this so

other variables also like CL ΔE CM Δe if you Δ e Δ then you will see the changes in force and movement coefficients you can write like this and you will get that.

So now the how hard of this method is about getting this model FFNN based model fit forward based network model to just to make to make it simple you can also use this group of which is available in math lab software distracted in a simplest way so that you can actually model this once you have the flight data available α Δ CL and Cm then I will tell you how to design this network mode and then you can use this method to estimate your parameters L α.

So I will then later I will just explain you or I will demonstrate with the help of three data which I said like I will be talking about the examples to with data how to estimate the parameter then see the result and then you can also try with some of the different flight data to estimate the parameter on the after the learning met so I will start showing you the in this section and then with example.

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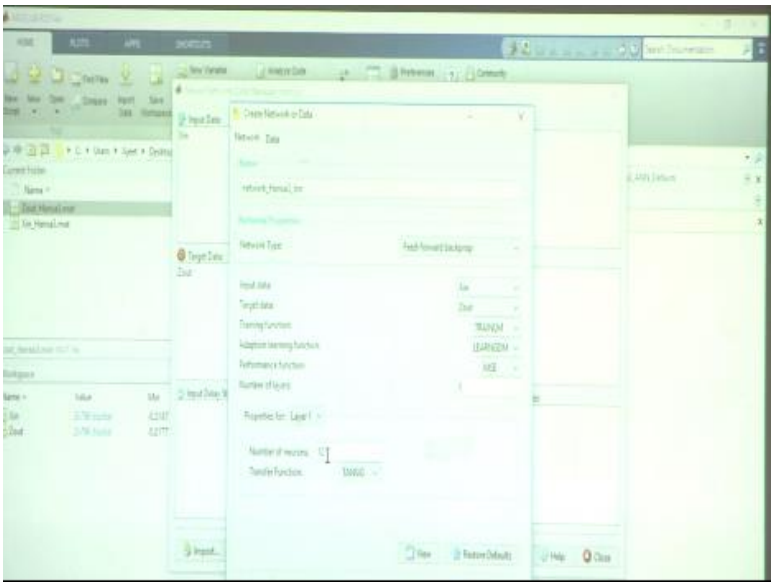

So I just can see in this screen this is a MATLAB software of 2040 A version right and this window is called command window most of you may be knowing it as I said like in this excel

we will be talking about its NN tool right NN tool box, now in and you have the data which I have written X in uncertainly dot MIT file mat file jet out put under certain category this is a output data for your problem so here now we are ready with the data input data and putout data.

So X in input data X out output data so first of all you can load the data once you lead this data so you have in the work space will see it is like XC input data this drop in command window you can see the data is loaded right and further information you can see banded you can see all those information so essentially expenditure free cost 796 jet output if your 2 x 7 and 96 so what its say like it means you have 3 input data of 796 sample, two output data 796 sample so it is like as you can find a minimum and maximum value in the row.

And this entire output now as we showing you about NN tool box so just you write NN tool here and pervious enters into series tool box here okay, so here what you can see here you have the box four input data and this input and this data we keep it out output data and here you can see these are network so I will just tell you how to design a network fit forward neural network in input data and output data.

So let us start loading the data so you can load the data remain this input so basically you are trying to import the data so input data is our FG so we select XC here input so here it is coming like variable X in has been default imported as input data into the network or data managing that mean we have imported the data now target data is our output data set it output data now you can import the output data, yes.

So now enclose it so now you are able to see input data box you have input data target data box we have output data next thing is now you design a network right so you select a new network that you can keep name of your work so I will write network under score answer three like simple way to answer this so we are getting a design of this particular network or example is about longitudinal you can write LON, so now we are trying to create a network for uncertainly longitudinal data right now you see the network time already we have discussed about free forward network.

Training done by math preparation so this is the structure default structure so you can select that you can also try with some of the deferent method which is prior interest like it want to showed further you can go for the next but juts forward backward days in network time input data already you have so we make it extreme other data get down so 20 algorithm I am leaving the default you just for a starting time from beginning.

You can more emotion the command motion of the data which we already is a time here default data and as I said this number of layers talk about hidden layers number of hidden layer, so you can take one without one it generate to 10 of to capture the complicity in times of a problem so we see that the layer, layer number one now in this number of neurons so you have a command over or control over number o9f neuron in hidden layer as I said number of neuron in input layer in number of input.

So whatever you have because you have two input so default we have 3 neuron in input layer and we have two output in LNCM so we can two output actually neuron in output layer but this number of neuron is about your number of neuron incident layer. So default we are coming then so if you want to change it you can change you can take ever number you want whether third like go to target that you call value that we would happen and then this is your transition that diffusion function.

So I just activation function can be of different type we call with ten signal function right, take this tan θ function and now you can with your network with values so this is enable greater network by clicking on wait, okay.

So now your new network call hands network that is why enter t that should long as I told data manger if you were able to create your network right, okay. If you want to leave your network you can see from data when you see what is your network look like right so here you have three inputs so number of you know that way input layer, number of you know if you done this you have selected 10 so it is 10 output layer you have two errors, okay so now you can close this.

So you have your network structure right, so if you want to take click on it so this is your network be forward me the model. Now you want to train your network right, so you go to training and train here so this air about the filling data so we have to fill input this about xn and target data is our data output so that because you do not have to manage it here you can see different taps are there you can explore more if you want let us do it with default data so the data is going network looking to data.

So now you will see your network you are trained and it can converge it see two iteration number of iteration you can see here because then permission relate to performance time and if you want to check your performance you can say it from here right, let us see so this y axis here talked about mean squared error a twinned data validation data and test data and this dotted line taught you about that the result where your valuation error came minimum for the first time right here, so ideally you are network will stop here and training should be done till this but it has taken it is more value so obvious augmentation of this feature here.

So blue line is about your training error in training data, green is about error in your validation data and red is about error in your test data and dotted line is about their performance. So bits number of iteration it call the if box your error is terrifically changing with it is results into a very low value even lower than your 10^{-4} and first time you are valuation error come minimum at this number may be around 56 this value before this into and here is your network is trained very well.

Here what, how it works like you itself 70% of the data for that training rest of the among with data 15% for validation and 15% for the testing of your results, so at that time makes your that you have not under over grating to that 15% of the data which we were not included in the training where used to check it is not over 15. Now you can see the regression value it confident in your result like this, so here you can see four different boxes first is your training validation test and this is about inputting very I think all the results, okay.

Now you see this how well they are fitting and the imposition of this fit you get from this parameter r, so basically you understand like this r, when r is 1 it means all the data samples are

fitting on hidden line the basic line right. So r traps your work the relationship between the spit data and from the observe data so this profiles at data and it further then it affect so if it is r values quite high all most close to one so that is the reason we can see all your data sample are able to spit on this blue line that is for the training vibration also you got very good result when 9997 almost all the data samples like you know you have it total 796 samples so all the samples almost all, the samples including few may be five 6 or all those likely although in line.

But this we have include so that is why you did not get r = 1 but evaluation r value evaluate in such it has got the good training and then you have tested with different data and then this also saying about confident in your train model with the very high equation of 0.9997 that is could all the until you get this then rather then.

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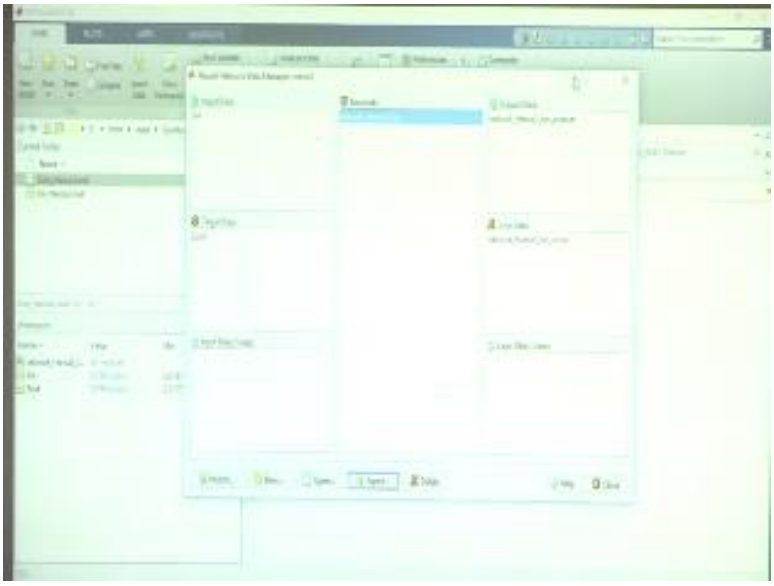

So at least now you have able to train your model with this train as it is suppose it is present conversing first time you can try this multiple time and then you can also ask the permission of about the weight and by as dropping of the critical dimension part you see that associated with that earth and including by it and if you want to change the weight and bios we want to prove

your all weights you can do it independently get to so her ideas can be excluded that different futures of this goal part and then accordingly it will be modified as the part.

Now again you are able to create this network model you can export this to the met lap fine so this network under so that is why we are knowing about training of the network you can export or you can also say that your, you know your option let us say that whether tin permission also that is important all the error we cannot check and see okay.

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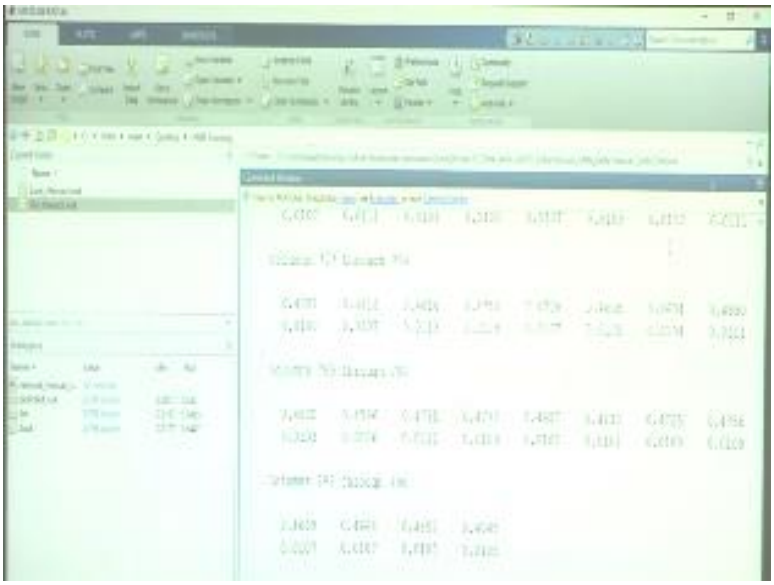

So now you got this network model so how will you test like the code if you have different data so for that we can try to dictate the data or good okay how good it was like that we can write the command then you can do it by your own simulation of since the network name is unsetting this from you have to write it just you can go for this okay, here write this name and here you can keep your different locoed okay.

So here I split this network using this input output data that will show you as option for input output data so I will just show you that input output data they could not be got data from different flight not different flight different set of flight data yeah so maybe two or something

along if you do it you can write that if you do not have data is available it is not sure so if we are extreme the name that I extreme so we going to this.

So her I have suppose you want first see the result for the same data you can write yes so it will give you about the next time will give you the result for predictor also, so now itself you got again 7986 samples of data for both the outputs then if we end here so future if it is won predictor so once you have designed your network like this then you will able to predict the output for any inputs which is suitable models.

And then once you got this predictor output like this so what essentially you want to do now you want to part of the inputs x data let us x in it can tells your input information about α δ nqc / 2v so you can give different input so you can add first time maybe difference in α you note down the value like it set it somewhere as it in part of the network connection maybe x – δ α you feed some design where name in different variables store it and then finally form the δ method if you want to find in all further α and then it will become your predictor out for those projective observation – predictive output for the negative observation divide by probe of for the term input will give you the result.

So this is what actually we have done it and I am shoeing you the method so this was the part of process and domination of entering code bond I hope you will be always appreciate and then you can also do it by as it.

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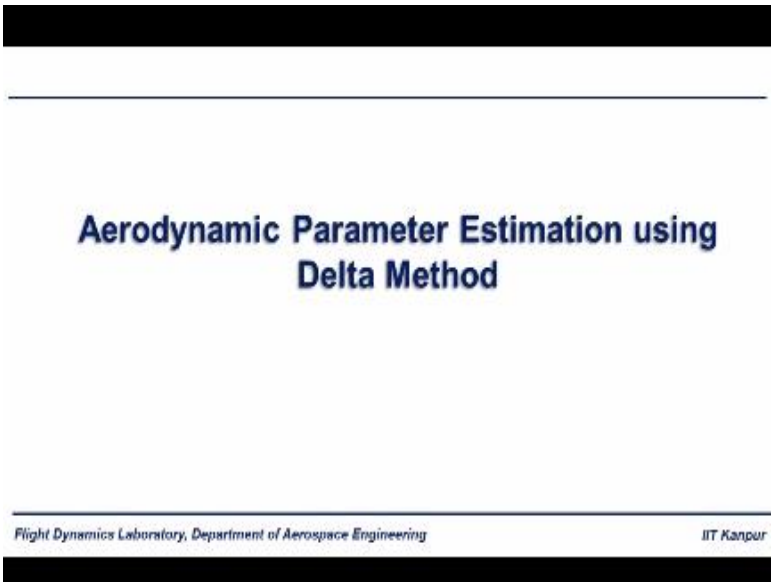

So let us see Aerodynamic parameter estimation will be delta method we have taken the same data or we have use for this estimation. So basically we have taken the same data what we have used for this illustration this is the aircraft we have already been earlier introduced that so this the parameter and for the data which you are familiar now if you see the will not be equal to α beta.

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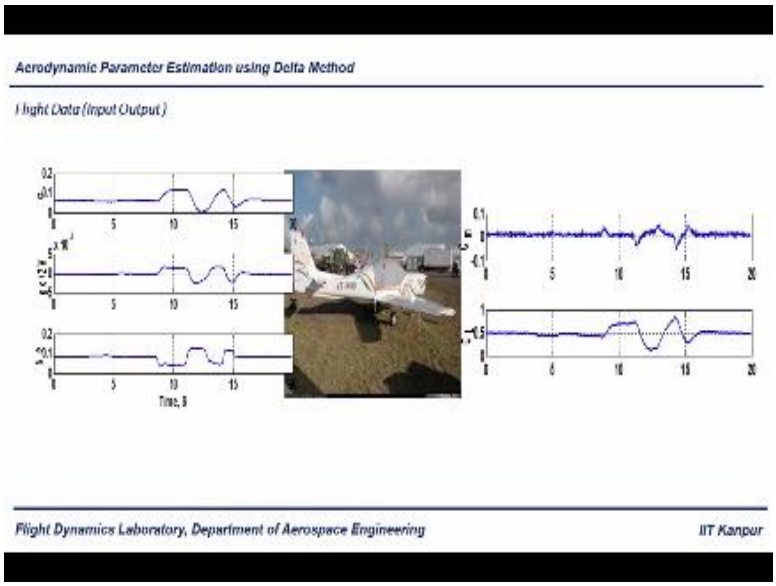

What we assume is that is the rate of input data, data connective data and this is the model actually the n coffins of 3 where you no more worried about the aircraft. Now we are treating the black box we have gathered the data from flight in terms of input data and output data and we are trying to model e. In the last year of the network ready coffin method it has said it can approximate any knowing aircraft.

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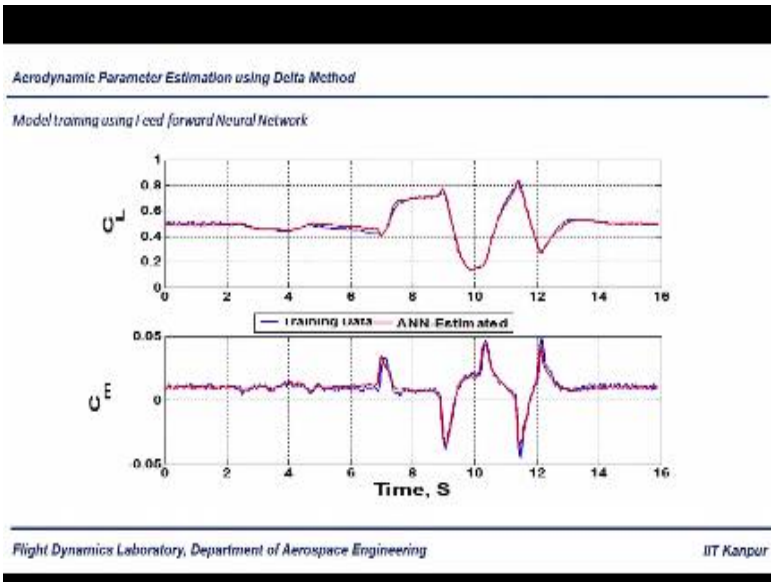

And once train this model we have it know our same model of that will be your longitudinal data in theatrically proved about the training data. The data which is for the training red line to show the power. Ann symmetric what we did like we have trained it's from the first flight data different flight datas and we have moved different flight datas to estimate the coefficient at the end movement coefficient so there is a well the match with each other and then once you apply your δ.

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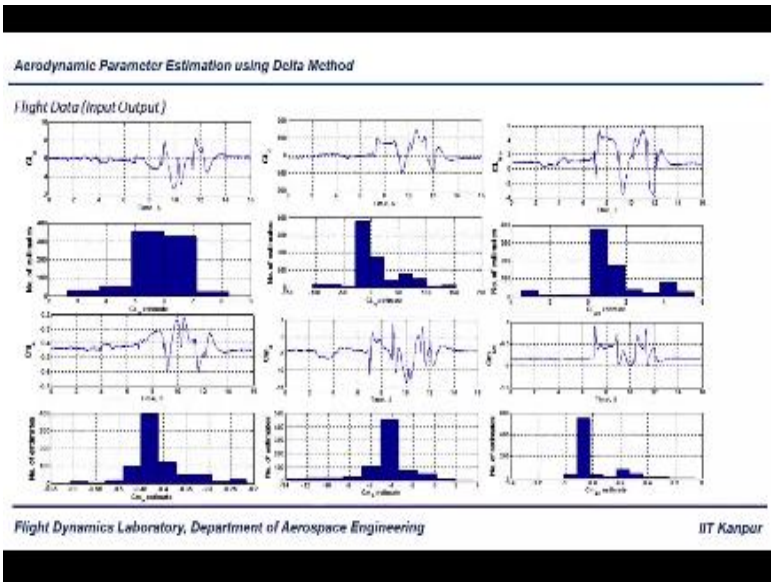

Once you applied the data all the parameters so all the parameter are seen here cl α Cl δ e cml α cmq δ e so this is the prime information what it says you had a multiple data sample like many example so this is this gives you the information about the maximum occurrence of the critical value from all the sample data example if you see α plot if you see that the cl α is estimated one it is close to between 5 and 6. So let us say 5 and 5.

Occurrence of right value happened more than around 50 times and the value also require let us see the estimate of all the estimated parameter values so how many times it occurs it we can also get the added value the maxi mum level of the value the which represents at a point cl aerodynamic parameter are about cl and cm wherever you see all the results are here and now you should compare this with your results which you have got earlier.

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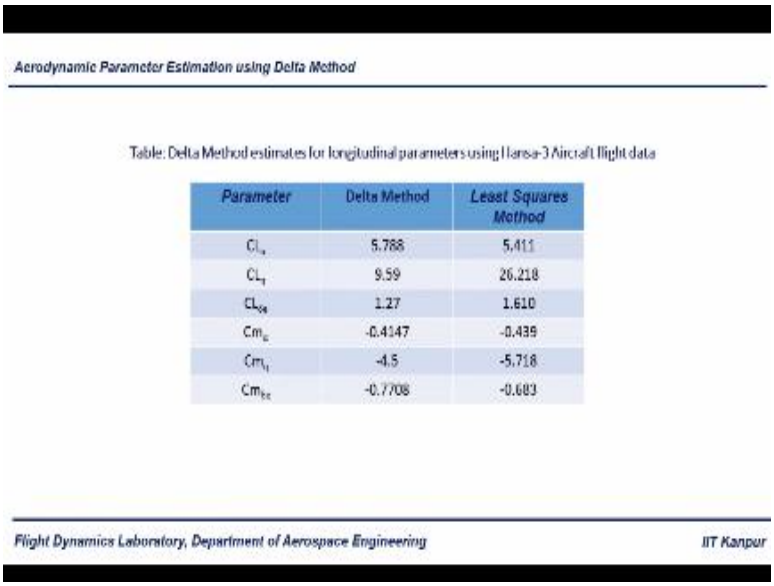

These are the test results they are getting δ method estimation for longitude parameters hansa3 aircraft like it okay. you see here you have cl α clq cl δ cmq and cl δ e estimated parameter and using this methods if you see they are in the cl α 5172 α this aircraft 5.411 these kinds of methods so here you are strong parameter are α cl α cm δ and cl δ e so those two parameter are in 5 with shape and you have done it from flight data.

Further this thing can be proved applied for the testable data accuracy is δ with performance and I said there are two derivatives cl and clq where not very much variable the nature of the data may be you can design a better input you have applied on the 3211 if you want to get those dynamic then you should capture the mode dynamic model and then you eill be seeing manages in this derivative and from there you can get better estimation.

So this was the idea of the to introduce with the δ method flight data and there are different set of data you can do this algorithm and you can look for the what has been prevented here I think it should be good enough to understand to that for a new flight data I talked about the proceeds I have talked about how to design this network and then from the network δ method estimate the

parameter I can switch all for this session you can practice more come up with your ideas and methods comparing with the results thank you so much.

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