Predictive Analytics - Regression and Classification
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Lecture - 35
Hands on with Julia: Implemente Chennai Temperature Analysis with Julia and CRRao

Hello all. Welcome to the Part B of Lecture 10. In this video, we are going to handle we are going to do some hands-on using Julia on Chennai's temperature data.

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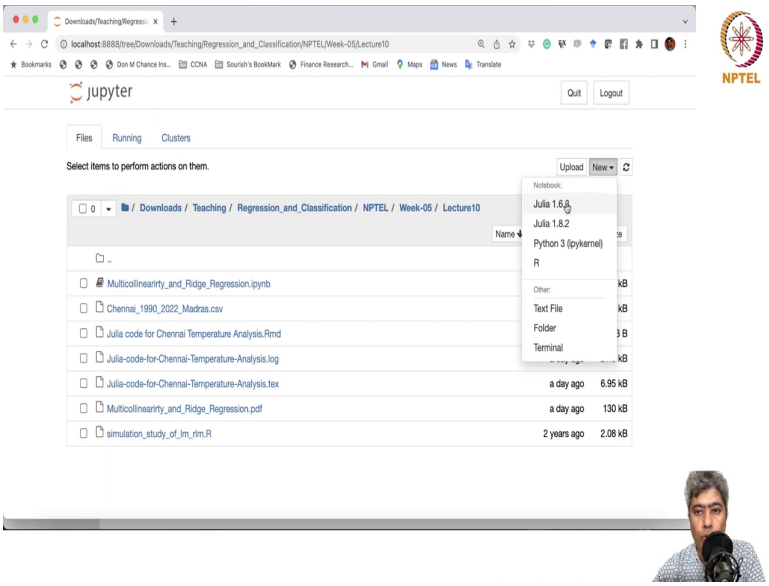

So, we will open Julia notebook.

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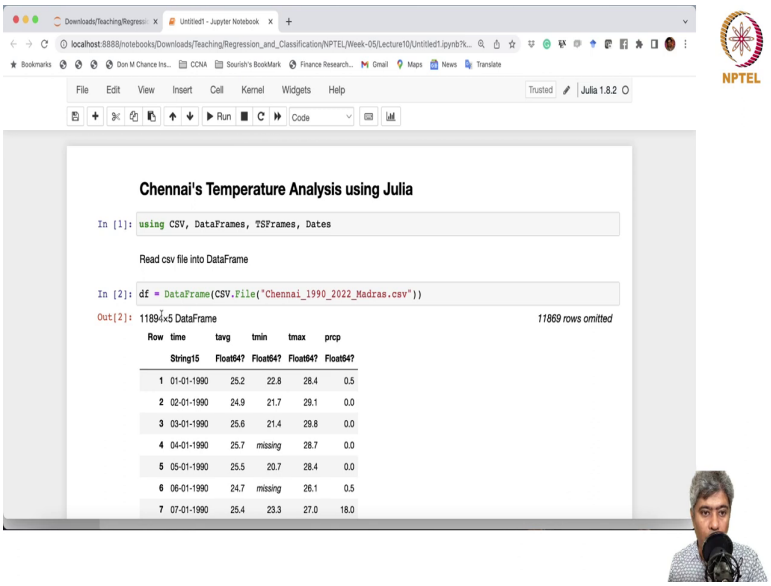

We want to open the Julia 1.8.2. So, first we will do some, give some headings that Chennai's Temperature Analysis using Julia. So, let me Run it.

Now, first we will do using CSV, comma DataFrames, comma, TSFrames, comma, Dates. So, these are the packages we will need CSV, we will read the CSV file and then we will put in your data frame. TS frame is another package which is built on the top of data frames. It helps us to handle time series data and then dates are essentially help us to do some data operations. So, let us Run this.

Next, we will do read CSV file into data frame. So, read CSV file into data frame. So, what we will do is a df DataFrame C from CSV dot file will do open, quote unquote.

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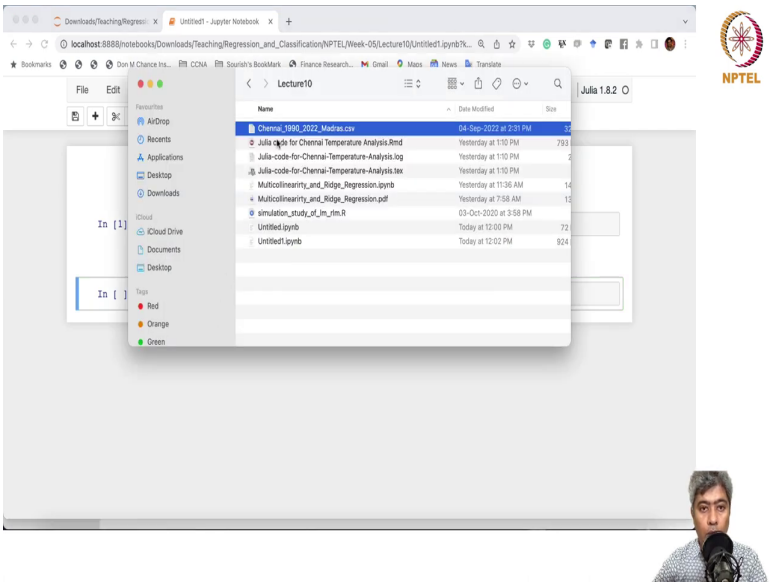

And, then this is the file that we want to read and let us Run that. So, it has read 1108, 11894 rows and five columns. So, first column is time, but it read it as a string. So, date is dated as a string. So, we need to convert it into string. taverage is the average temperature of Chennai, tmin is the on that particular day. So, 25.2 is the average temperature of Chennai on first January, 1990.

So, tmin is the minimum temperature of Chennai on 1st January, 1990. tmax is 28.4, which is 28.4 is the max temperature on first January 1990 and precipitation 0.5 some precipitation took place on that particular day.

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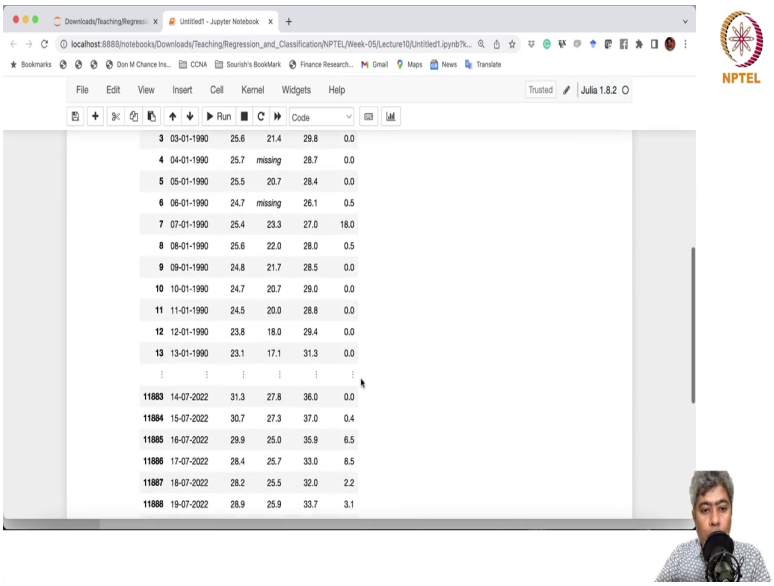

So, next what we will do?

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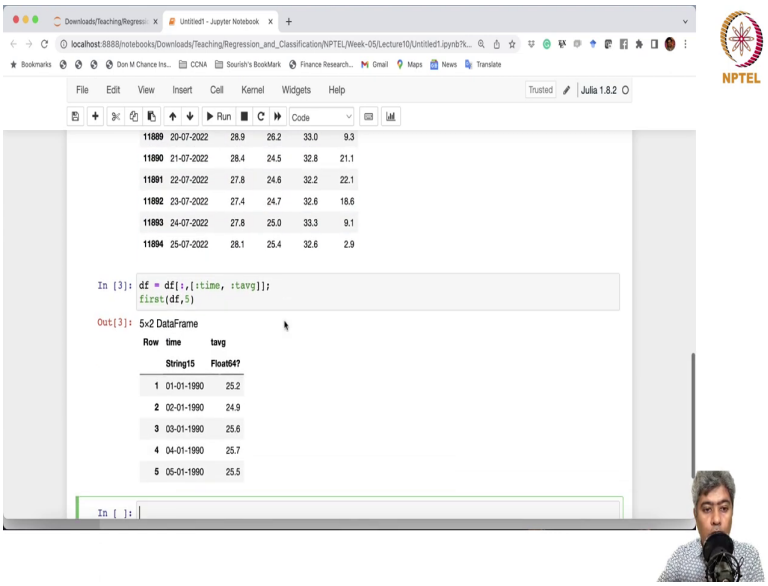

We will we just want to work with average temperature and the date. So, we will keep these two columns and so that you know it will become we do not have to worry about the other columns. Ok.

So, what we will do, we will just write df colon and we will have time comma taverage v g and we do not want to print the entire column. So, we will just say first print the first five columns. So, now it has the printed the first five columns. Now, df has only two columns time and the taverage. Ok.

Now, we will do some data cleaning and data pre processing. So, data cleaning and pre processing. So, ok.

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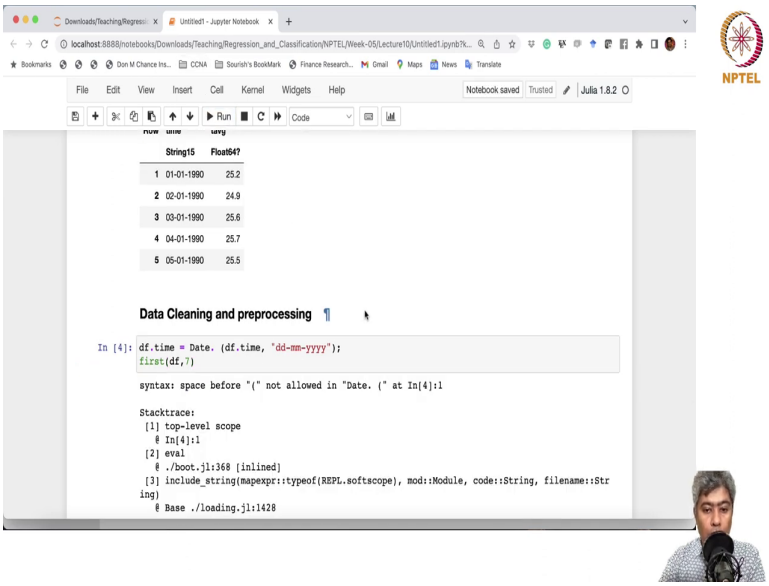

So, the first thing we will do, we will take this string and we will just convert it into date column. So, df dot time, we from df I am just expecting the time dot df dot time comma. The format that we have is dd mm y yyyy and obviously, I do not want to print the whole thing.

If you do not give this semicolon, it will just print the whole thing. If you go up, you see, I have not put that semicolon. So, pretty much it printed a big chunk. So, I do not want to print the big chunk. If I want to just say, ok, print the first 7 columns, ok. It has something to related to this maybe this will work. Yeah, ok.

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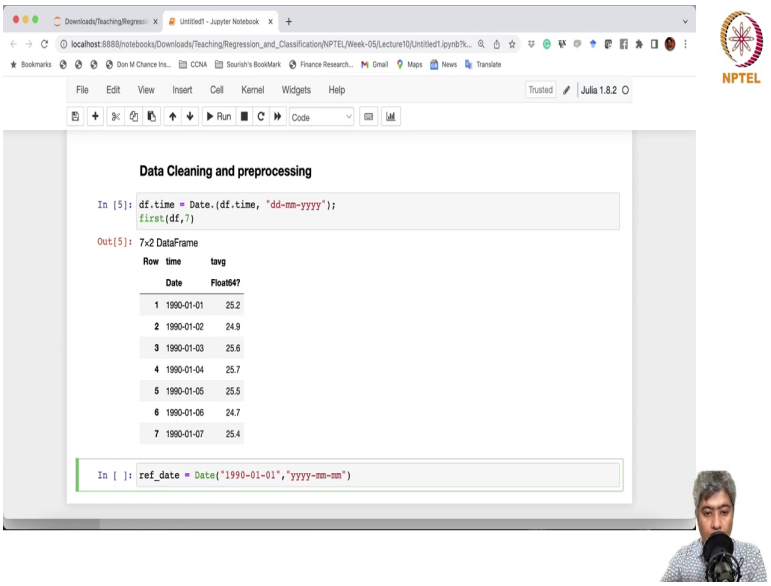

So, there was a unnecessary space was there. Anyway, so, now, we can see that the string is now being fixed to convert it into Date. Ok. Now, what I want is, I want to use this as a reference date and from this reference date, how many days of data we have, say, if it is zero point 5th January from 1st January, it is a five days so, I want to create the column with 1, 2, 3, 4 like that. Ok.

So, first what I will do, I will create a write a reference date, reference date, which is simpler date and 1990, 01, 01, and the format is. So, I am giving a string and then I am telling ok boss, this is the format is this. Ok.

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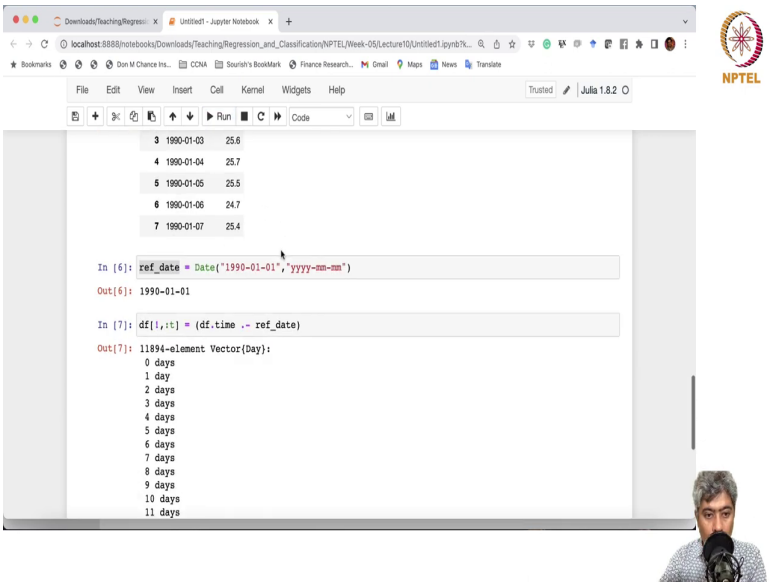

So, this is the, I have defining a variable and then I am saying, I am going to say that, create a column, df colon, exclamation mark colon t. And, in this, you create a column where you just subtract time dot minus this reference date. Put it in a ok yeah.

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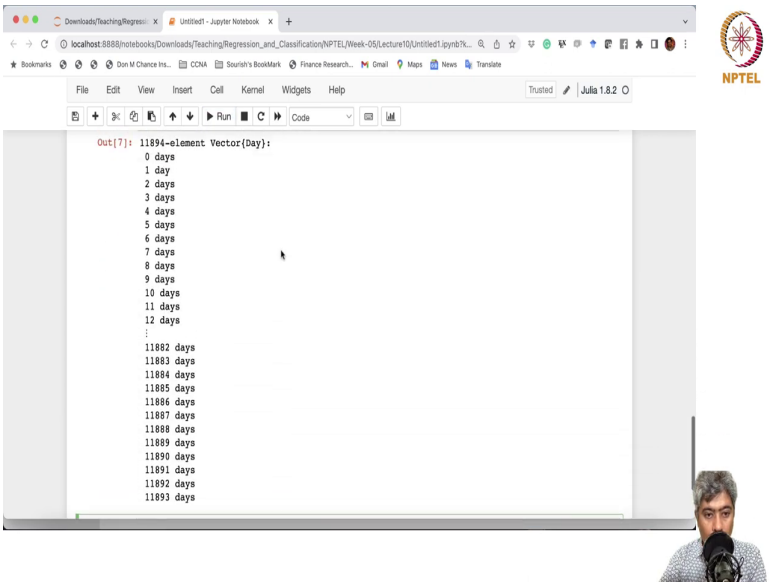

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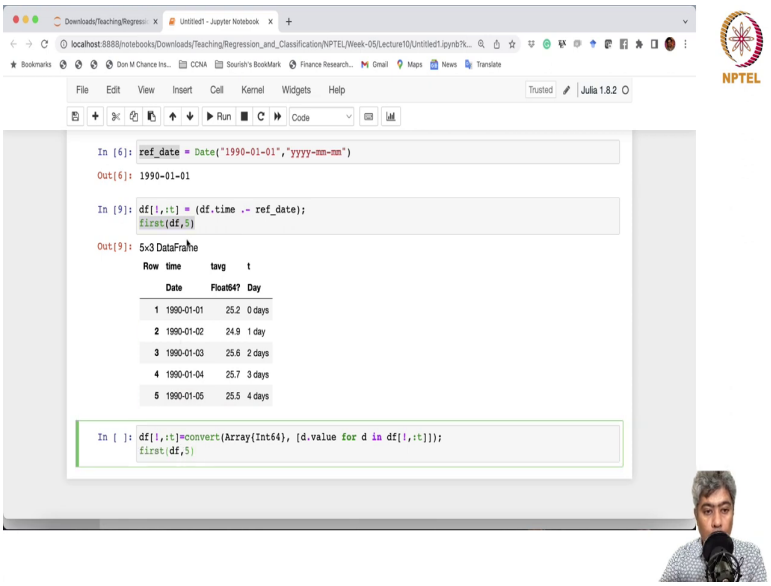

So, I will just put it in this and then if you just essentially print the first few columns, maybe five columns. So, you can see that it has created a new column with 0 day, 1 day, 2 day, 3 day like this. But this is a day column, I want to convert it into integer because if I end of the day, I want to supply this t as a, in a as a part of my model because I want to check if over time, over time these function, this average temperature is increasing or not. So, I want to model average as a function of t. So, that is what I want to do.

So, df colon t, sorry, no, I should have this comma exclamation mark colon t. So, I have to convert this, convert this array to integer 64, int 64, comma, d dot value. For d in df exclamation mark comma colon t. And, I want to just Run this guy.

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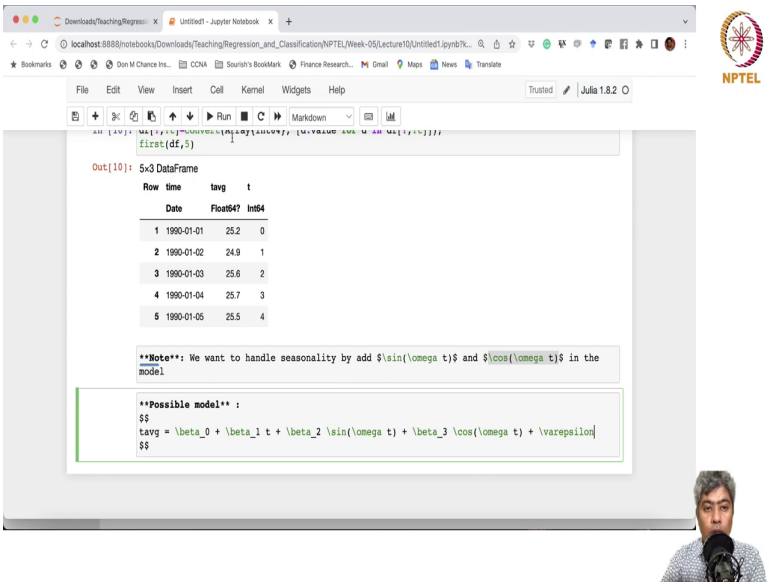

So, now you see the initial, it was a day and now it is being converted into integer 64. So, eventually I want to model t average as a function of t. So, I cannot, and in the model, I cannot give it as a day, it cannot handle day in the model. So, I have to give it as a either integer or a float. So, that is why I need this column as a integer. I have I can define it as a Float also actually. Technically, I can define it as a Float. No problem.

Next to handle seasonality, I need, so, it is a daily data. I want to handle seasonality. Let me just put a note here. So, note, we want to we want to handle seasonality. So, so, by adding sin omega t and cos omega t in the model, right.

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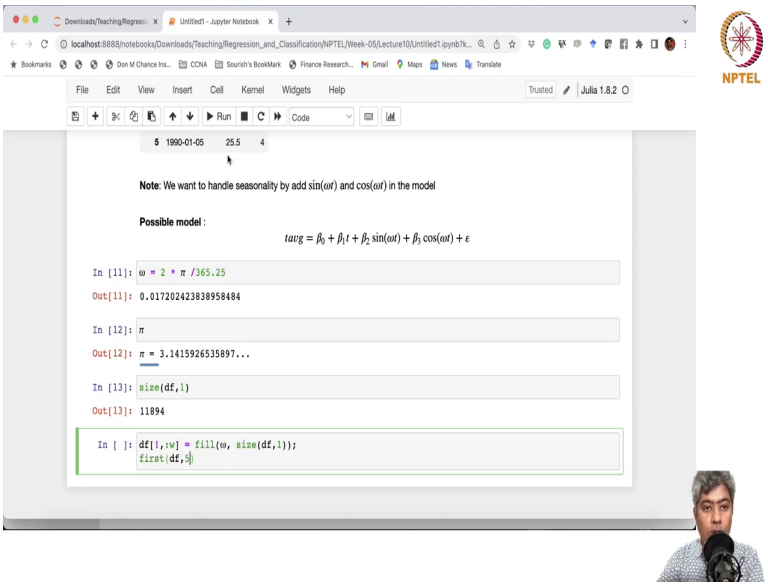

So, we want to add sin omega t cos omega t in our model. So, you can ask me what kind of model we have, we want to fit possible model could be like, a simple model could be possible model. Possible model could be easily say t average equal to beta naught plus, so, t average is already there. t say and t we want to put, so, beta 1 t plus beta 2.

So, we just want to take sin omega t to model the seasonality, then beta 3 cos omega t right plus epsilon. So, this is the model that we want to fit. Suppose, this is the basic model that we want to fit. Now, we have t column, but we have to have a omega column as well because sin cos and the formula term can handle it, but we need to provide a omega. So, let us define omega, what will be our omega.

So, this is the advantage of you know, Julia where you can, because it allows you idea, allows you to be or you unicode. So, you can use unicode for defining variable. Now, so, I am saying

that 2 pi by f, f is my frequency of the day. So, this is a year when a year, I have 365.25. So, technically on we typically take year to be 365 days, but we know in order to handle the leap year, I am giving it as a 365.25. So, that you will not have to, we do not have to worry about the leap year thing. So, it will be automatically taken care of.

So, let us write this. So, this is the value of omega. If you want to check, in fact, what is pi? Pi is 3.141. So, this is a all default setup, we just defined it. Now, we want to add a column of omega df comma colon so, w stands for omega. Fill with omega and how many the size, whatever the size of the data frame, the first. So, let me just what is size of the data frame? Size of the data frame is 11894.

So, I am just saying that create a random, create a vector of 11894, fill it with the value of omega and add it as a column named as omega. So, I want to print the first column, first five rows. Ok.

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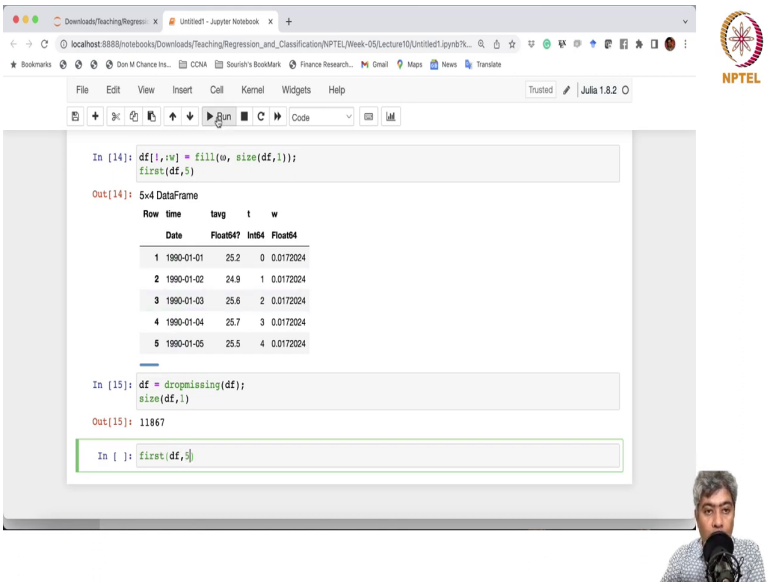

So, now, you can see that we have a column with all values to be omega, the constant values and t values. Alright, so, I think now we are almost done. But, remember that in the t average, still we have this question mark means there are some missing values are there. So, let us drop those missing values because currently we are going to use a package called CR Rao which handles the fits, the simple linear regression, but unfortunately it cannot handles the missing value at this moment.

So, so, we are going to drop the missing df and print the size. So, you see before drop we have 11,894 rows after dropping 11,867. So, about 30 odd values were missing, but now it is better. We do not have to worry about the only so, we drop if we drop those with missing we do not have to worry.

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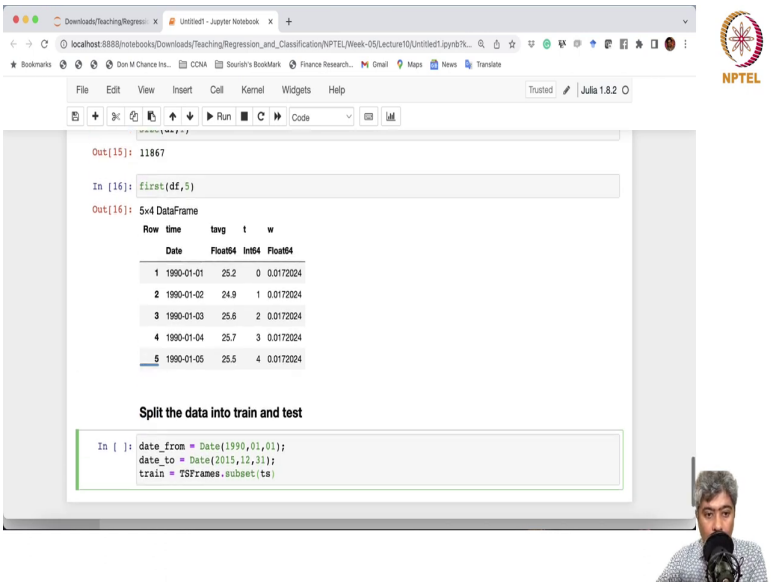

So, if we just print the first five rows and since now there is no missing. So, the question mark is gone. There is no missing now. So, we have about 11867 data points. And so, now what we have to do, we have to split the data into train and test, alright. So, I will just make a comment. Split the data into train and test. Now, the problem with this particular data is it is a time series data. We cannot randomly shuffle the rows and choose the data. So, how what to do?

In this case, what we will do is from 1990 to 2015, we will use as a the older data we will use as a training data and the newer data we will use as a test data. So, first we will say date from, we have to define from which date. So, Date is 1990, 01, 01, to date to 2015, 01, 01. Sorry, we should take 12, 31. I do not want to print here and my train data will be. So, I am going to

use the TSFrames; TSFrames, a subset function. It will take a time series data frame and subset the data by dates and that is it pretty much.

So, ok, I think, I do not know, I have to first define the data frame as a TS and then TS frame. So, ok, I will just do that before, in fact.

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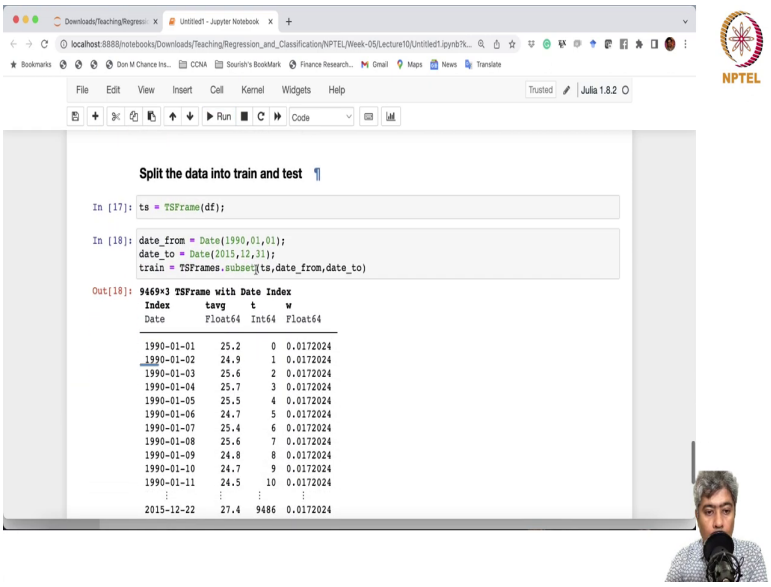

So, I am just going to define it as a TS frame. I have not done that. So, it will be defined as TS frame and then I have to say that, ok, this is from date, this is to date. Ok.

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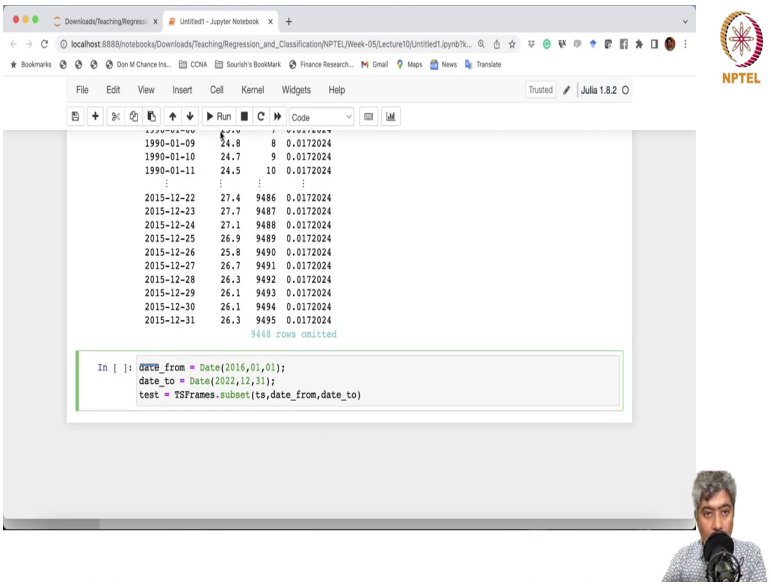

So, you can see this is a TS frame with the index date as the index and rest of them are exactly same as it is and from starting from first January 1990 to 31st December 2015. So, 9448 rows are being included as training data.

Now, we are going to define the test data. So, test data, I am going to just copy and paste it here, but here instead of Date from will be from 2016, 01, 01 to 2022, ok, and TS and this will be test data, ok.

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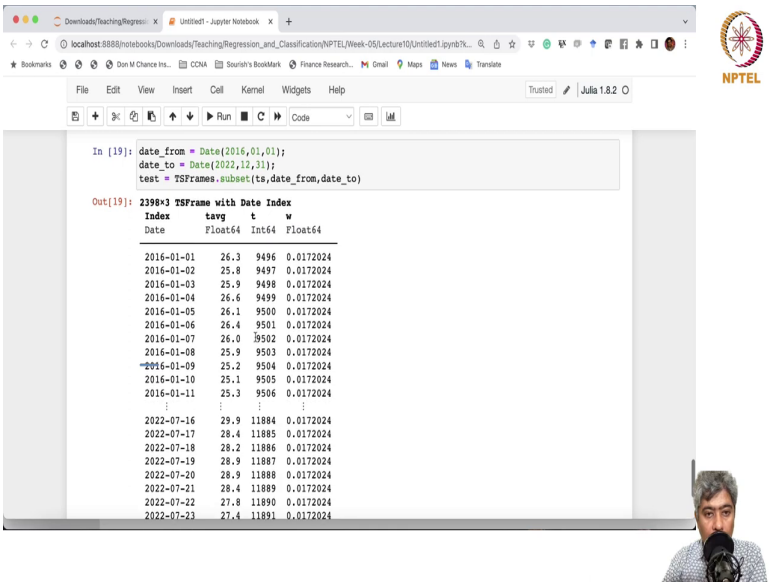

Now, if you Run this, you can see that it is starting from first January 2016.

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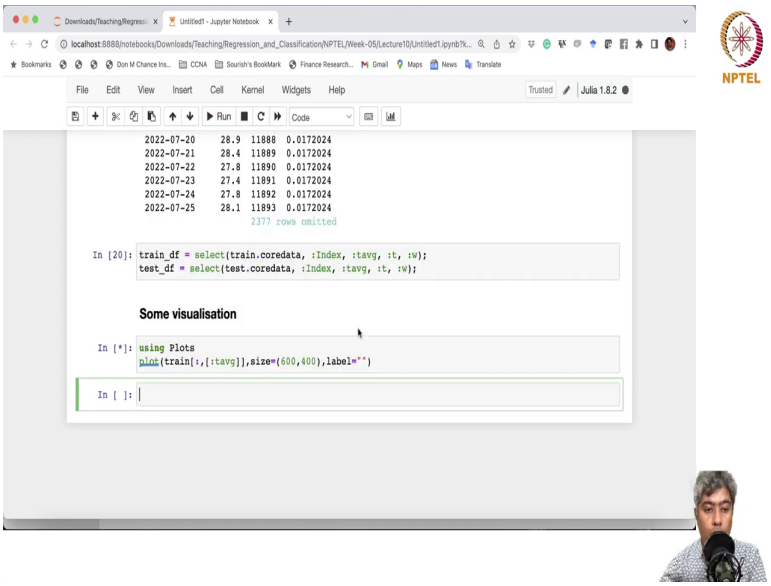

It is ending at 25th July 2020, though I gave a 13 so, it is just in that range, it will just whatever data, it will pick it up and give you as a TS frame. So, though it is as a TS frame now, we will just convert it into data frame and that is it then we are ready. Convert it into train df equal to select train dot core data colon index colon tavg colon t colon w and then we should do the test data as well test df, ok. I think we are done.

So, I think we are done. We do some visualization that will be, this is not a regular visualization, it requires lot of more thing, but I am just saying some visualization I am doing just to see the how it looks like, but not a detailed visualization. I am not going to do a so, using plots, I am just going to do a plot, simple plot of train colon comma tavg size equal to 600, this is the width, this is the height, I do not want any label.

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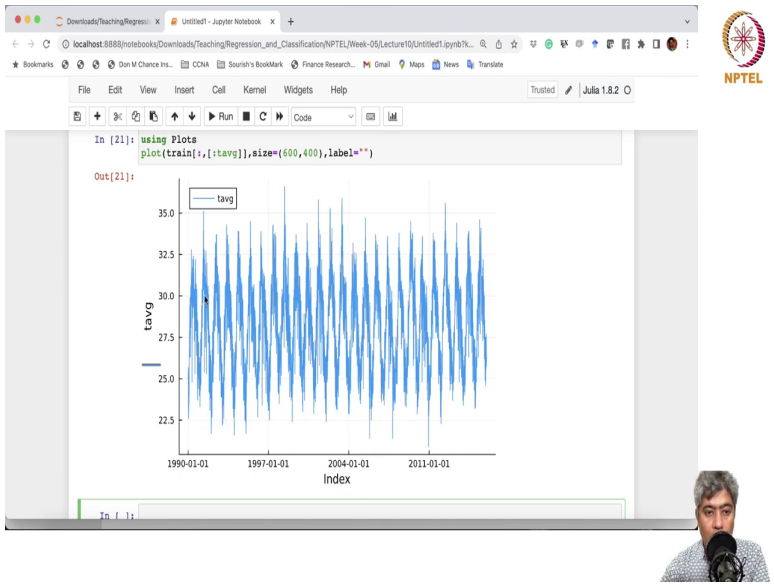

So, if you just run it, ok. So, over time it has, you can see that there is a clear sinusoidal behavior. So, let us try to model it, ok. Now, we want to start, do the predictive modeling with CR Rao package.

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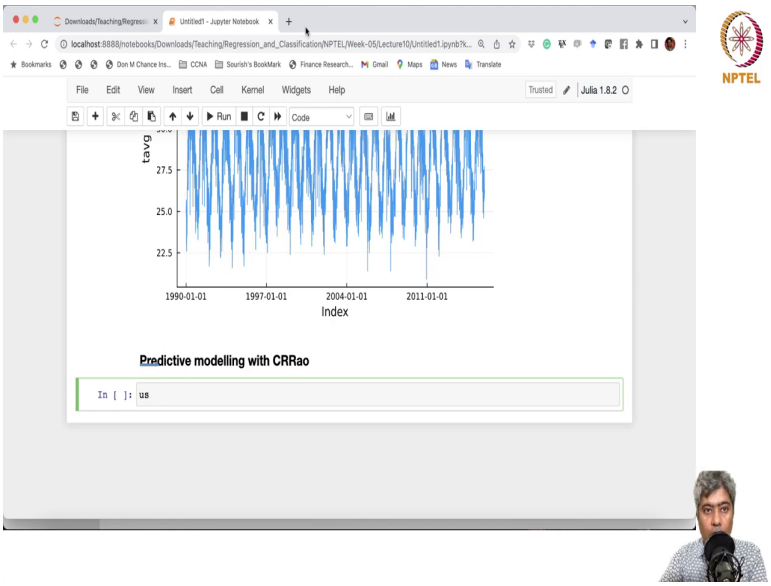

Now, we can ask predictive modeling with CRRao package. So, CR Rao is a package that we are developing in CMI, the CMI students and faculty are developing.

So, what we are going to do?

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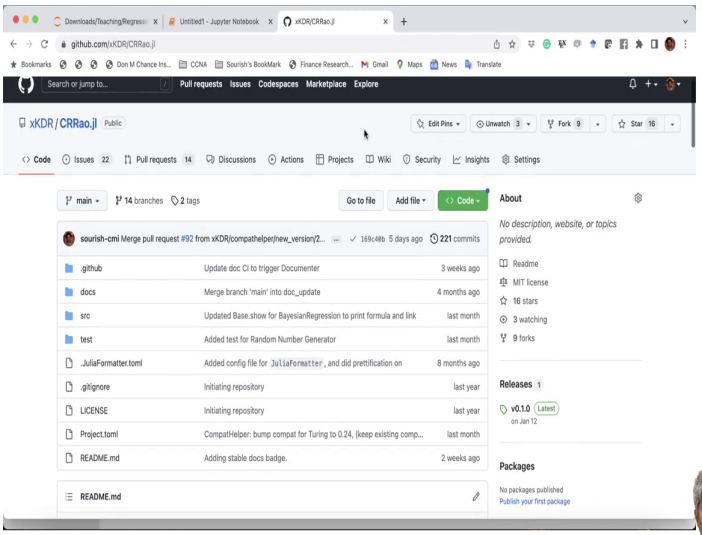

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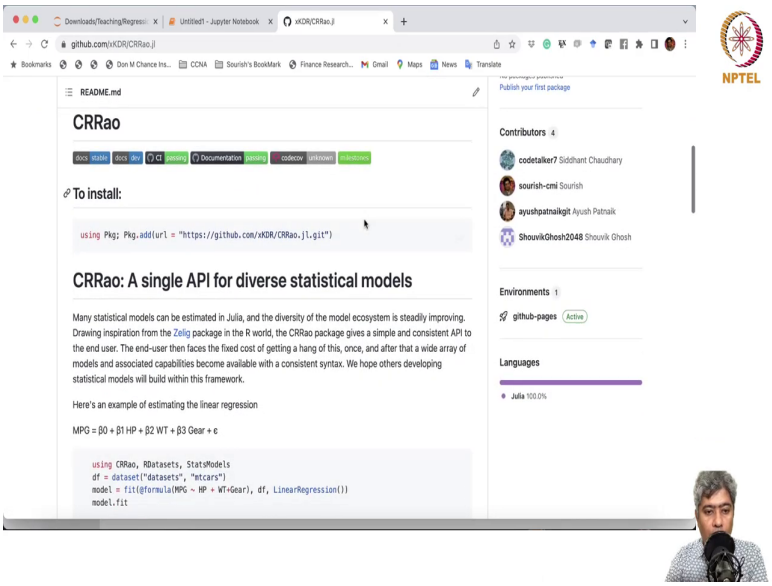

And. so, I will give you the. So, here is the, it is a complete open-source development, we are doing it in GitHub. If you, there is a lot of detail that we are doing, we have given.

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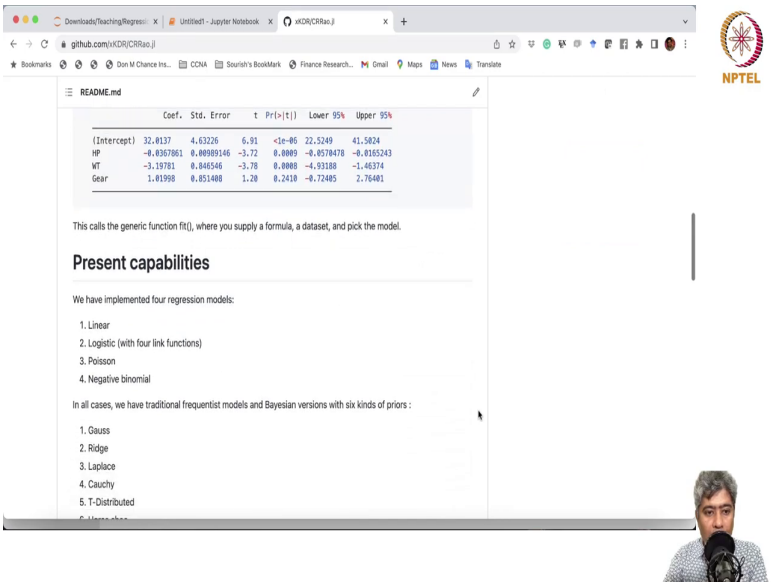

So, CRRao is a package that essentially all of us in based in CMI, well Ayush and other, Ayush is in the partly Bombay, partly Delhi.

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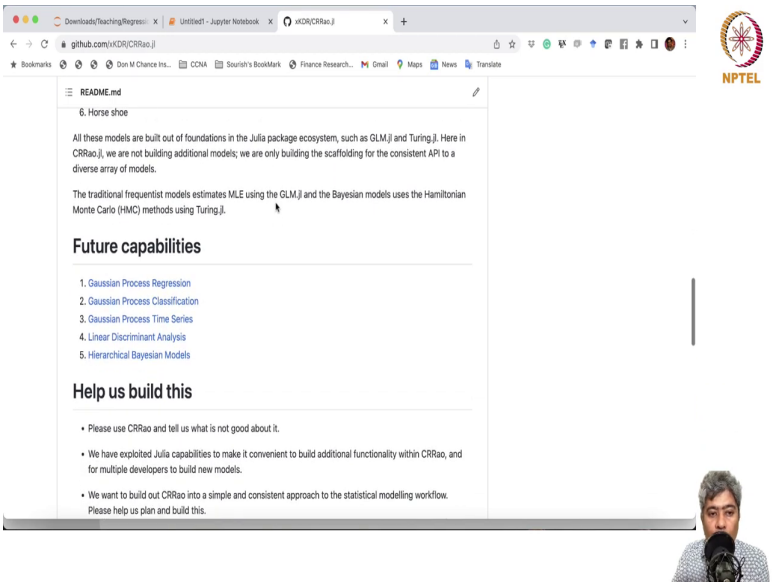

So, but we all are associated with CMI. And, these are the current capabilities, it can fit linear regression, logistic regression, Poisson regression, negative binomial regression. Whatever model we are going to do in this course, all these problems, all these models are now part of this package.

Now, in along with, you can implement some of the Bayesian models also, which is beyond this course, but at least you will know that, that if you want to fit a linear regression with Gauss prior or Laplace prior or Horse shoe prior, you can very easily do that. And, then automatically CR Rao will figure out whether you want to do a frequentist model or Bayesian model, automatically it will do that.

In future, we are trying to, you are trying to do, a you know, implement the mixed effect models, Gaussian process model, hierarchical Bayesian models. So, lot of, you know, development activity is happening.

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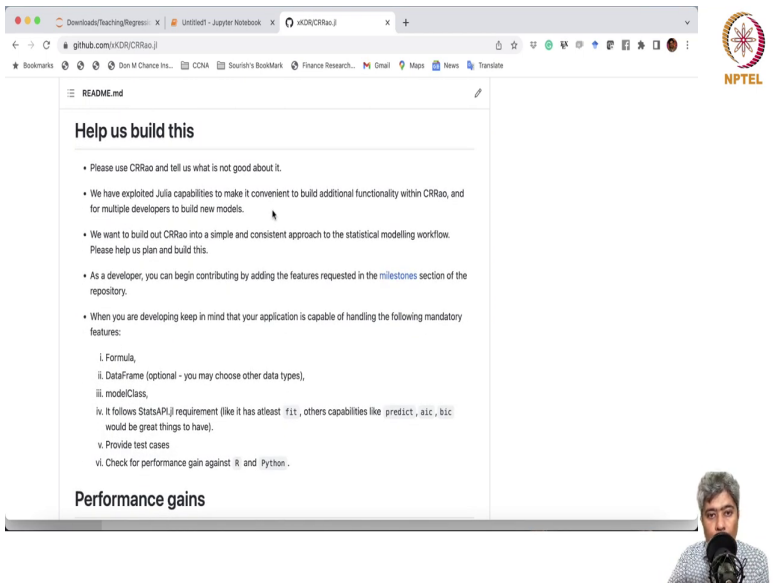

So, you can please help us building this package.

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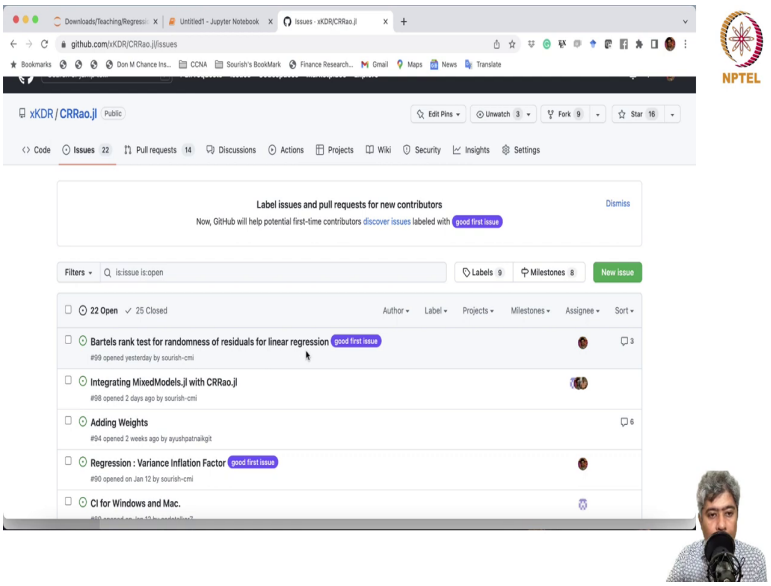

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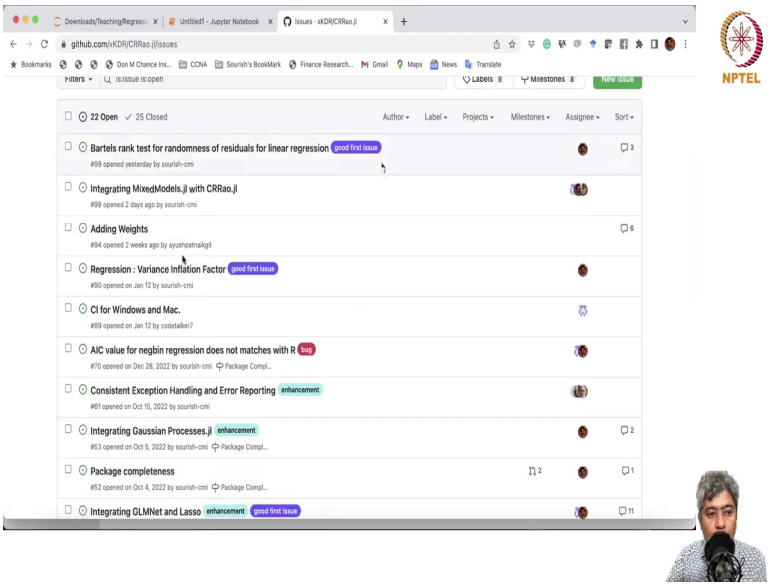

You can just, easiest thing will be like, you know, if you go to the Issues you know, there are some good first issues I have mentioned, you can try to implement those issues. Then, or you can raise the issue, if you can use this and you can raise issues to, you know, report bug. So, that will be this, how that is how you can help us with this package.

If you like this package, then please hit the start button. It is like that will help us encourage us to do more about this package. So, to develop more about this package, if you do not like, then some feature of the model package, please write in the issues that, ok, I do not like this package or issues or this feature, can you make this feature available or something like that. And, definitely, we will try to do that. If you can help developing, that will be even awesome.

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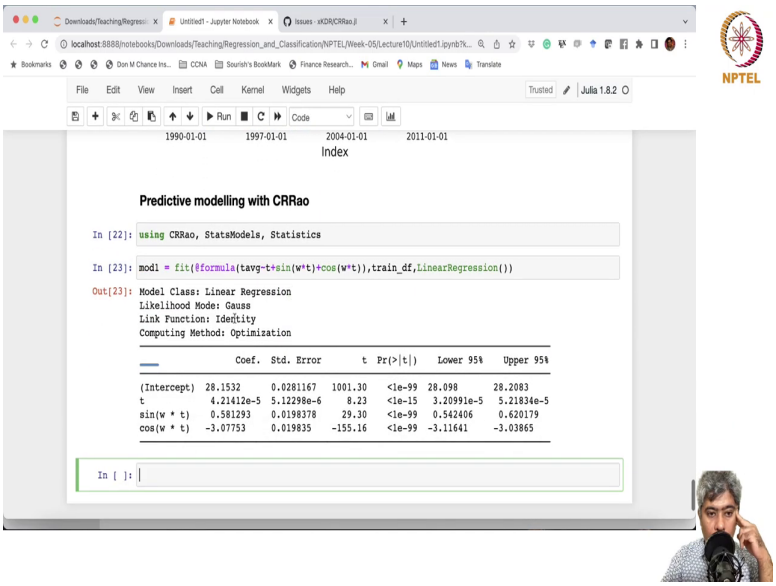

So, I am going to call using CRRao and some more things, stats models. So, I am going to, from stats model, I am going to use formula and statistics, ok. So, let me call this, ok. Now, so, the first model perhaps, we can try this particular model, we have discussed here, maybe. Ok. So, why not?

So, the first model is model 1, fit, at the rate formula, tavg t plus sin w times t plus cos t times w times t. This is the formula, then train; we have to provide the dataset name, train data frame and then, we have to say, which model class. In this case, it is linear regression. So, if you want to fit a logistic regression, then you have to say logistic regression. So, like this only. Ok. So, let me Run and here is the fitting of the model. Ok.

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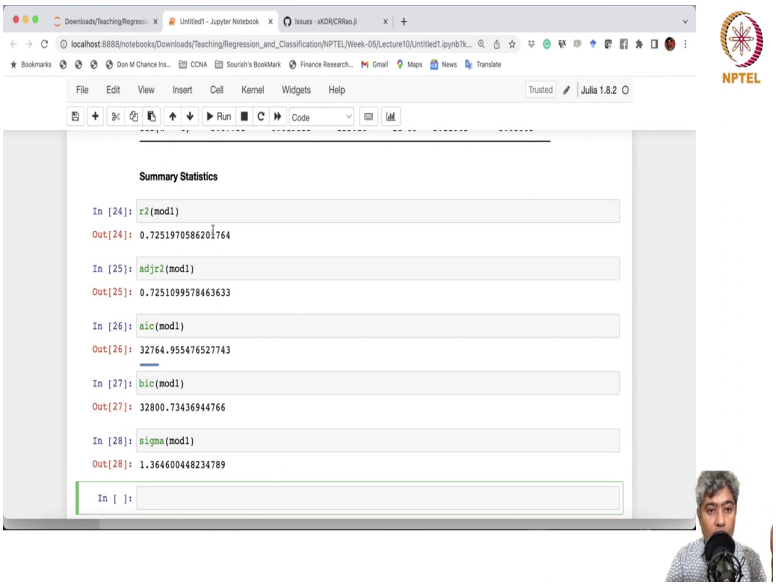

So, some summary statistics, we can pull. Summary Statistics, maybe r2 of mod1 is the r square, and then adjusted r2, I think, adjr2 mod1 will give me adjusted r square. So, I can then aic will give me the aic of the model, then bic will give me the bic of the model. Then, if I call sigma, that will give me the standard deviation or residual standard error of the model. But these are all in sample summary statistics. Ok.

Now, if we try, we will do out sample statistics, but we want to bring another model, maybe a little bit more complex model, few more Fourier terms.

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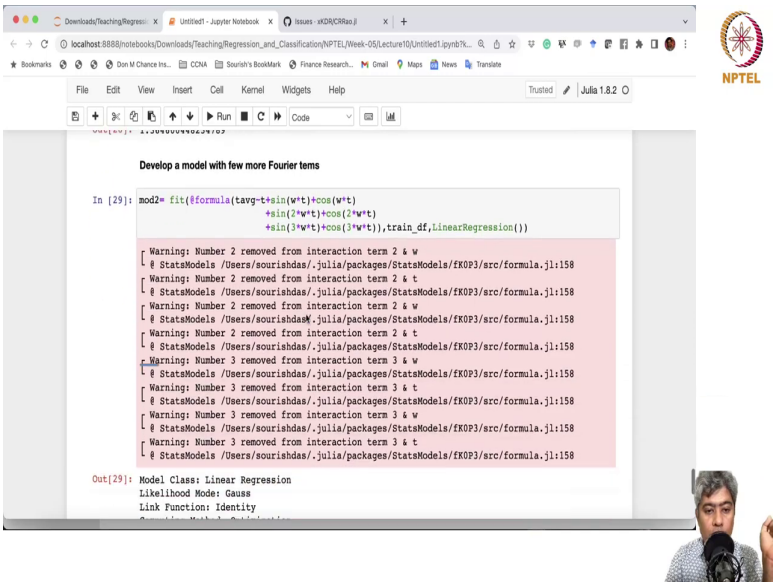

Develop a model with few more Fourier terms, develop a model. Develop a model with few more Fourier terms. Ok. And then, this is the second model. So, and what I am going to do, I am just going to copy this, and just add this here and say, sin 2 omega t cos 2 omega t. Maybe one more Fourier, 3 omega t cos 3 omega t. Ok. 3 omega t cos 3 omega t and, else, everything is same.

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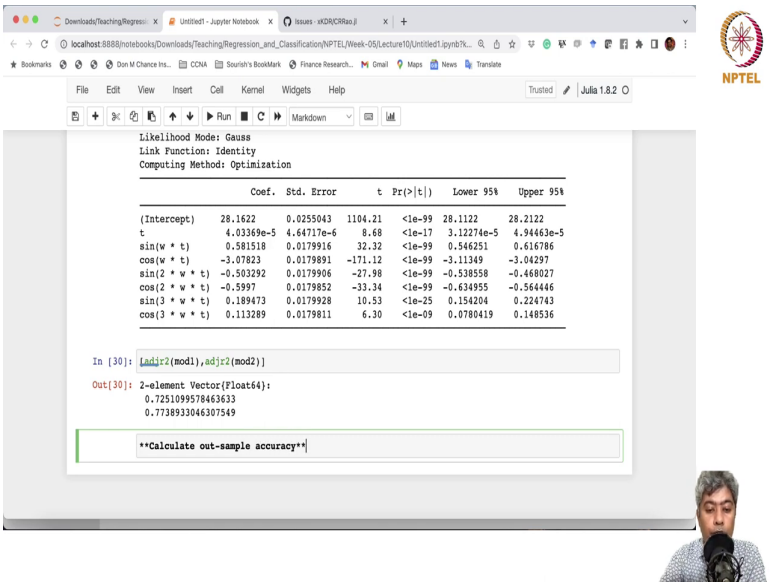

So, let us Run. It gives some warning, but I think all of them are significant. The time do have effect and all these Fourier do have effect. And what we can do? We can just compare the, maybe adjusted r square of model 1 and adjusted r square of model 2 as a vector, let us see.

So, first model has a 72 percent accuracy; when we add second and third, these two Fourier terms, it jump up to 77 percent. But these are both of them are in sample accuracy. So, we will calculate the out of the sample accuracy. So, let me just calculate out sample accuracy.

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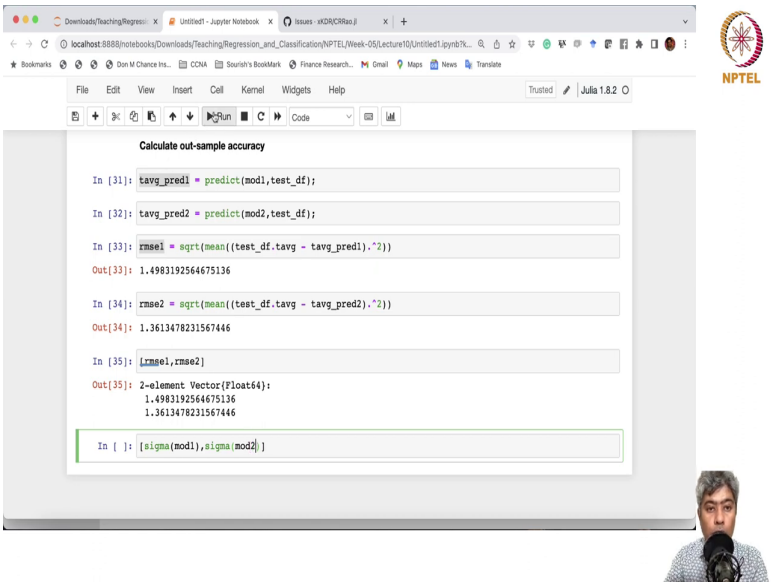

tavg predict 1 equals to. So, what I will do? I will just predict mod1, and I have to give test data frame test data frame ok. And, maybe I will just calculate the second one with second model. So, this gives me the predicted value of averaging the test data frame. Now, what I am going to do, I am going to calculate the root mean square error, root mean square error.

So, rmse1 equal to square root mean of first from test, oops, sorry about that, test data frame, you calculate t average just for it, extract t average, ok minus, you just take the first prediction from the first model and yeah, square. So, this is a broadcasting operator, and then it should work. And, then let me just Run it. So, you have 1.49 and then, this is the second one, rmse of the second one. So, this is 1.36.

So, now what we can do? We can just compare the rmse1 and rmse2, which is in sample, sorry, out of the sample rmse1 and out of the sample rmse2, the second one is clearly much

better. And, then also we can calculate the sigma, which is in sort of in sample rmse mod1 and sigma mod2.

So, clearly in both cases rmse of course, out of the sample rmse slightly more than the in sample rmse, but this is definitely better. I mean, in second model is definitely better in this case. Our model accuracy is doing reasonably ok, about 77 – 8 percent accuracy we are getting; even if in the out sample probably we are getting little, maybe around 70 percent accuracy.

Now, still we have to do some model checking, model assumption checking. So, check the assumptions and at least if it is doing normality on going well or not.

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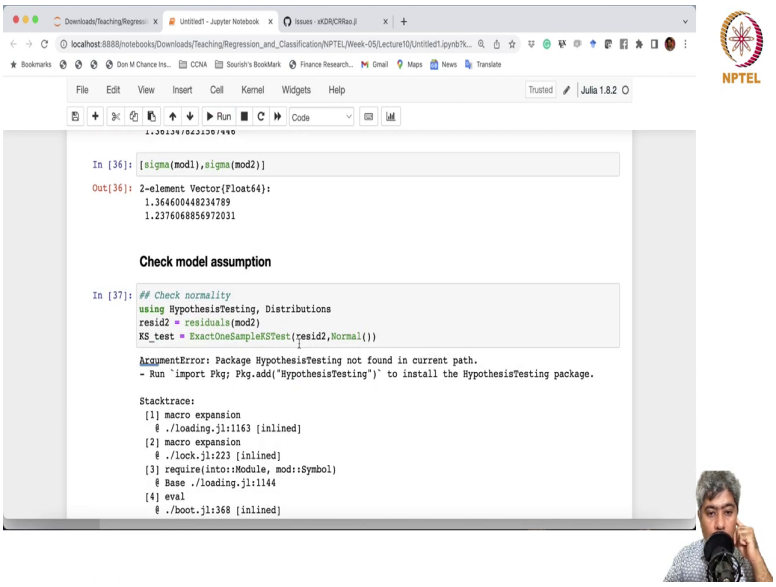

Check model assumptions. At least first thing we have to check this model assumption oh for the second model, we just we do not need to check model because we are going not going to use the first model in any way. Second model is significantly better than the first model. So, we will just do the check the model assumption of the first model.

So, let us check first normality, check normality. So, what we will do? We will just run a Kolmogorov – Smirnov of test for normality using hypothesis testing is a package and distribution distributions, ok. So, KS test is ExactOneSampleKSTest and we have to give residuals ok. So, what we will do, we have to first. So, resid2 from the resid2 will help me imagine ok this is from the model 2 resid residuals from mod2.

Sorry, mod2 and this needs to go to a Kolmogorov – Smirnov of test with normal distribution the test will be against normal distribution. So, let me just Run this ok. It is saying that I do not have the hypothesis testing. So, let me just pause the video if I just run this piece of code, it is saying that it will import the hypothesis testing. So, let me just pause the video and I will come back once I will install and I will come back, ok.

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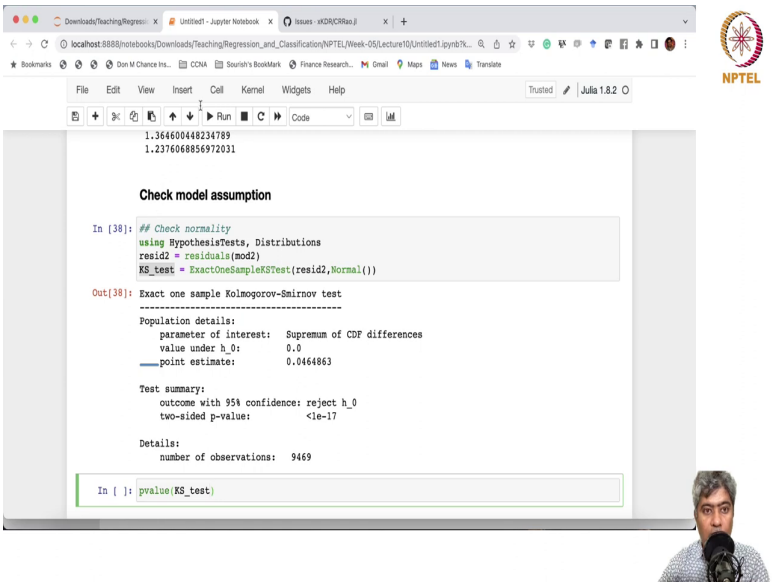

Ok, I realized that the spelling there was a spelling mistake it should not be hypothesis testing this should be hypothesis tests. So, that is what the issue, I think. So, let me just run it yeah and its can and for two sided p test, the p value is really small. In fact, if you just want to see what is the pvalue if you just provide the test itself it will extract the pvalue and print it for you. So, it is like really small p value. So, it cannot really test the model.

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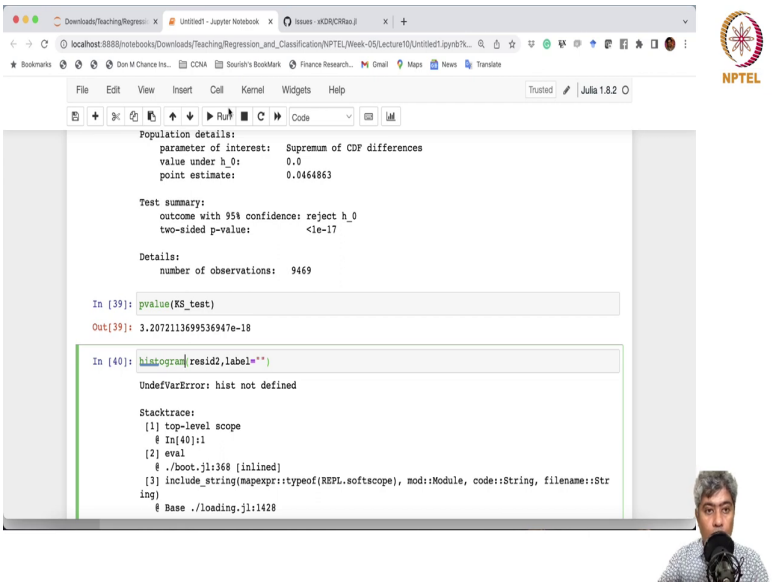

So, what we will do we will just also check how the actually this residual behaves. So, is it really bad? Let me just do residual resid 2 with no level maybe. Histogram I have to sorry I have to just write histogram.

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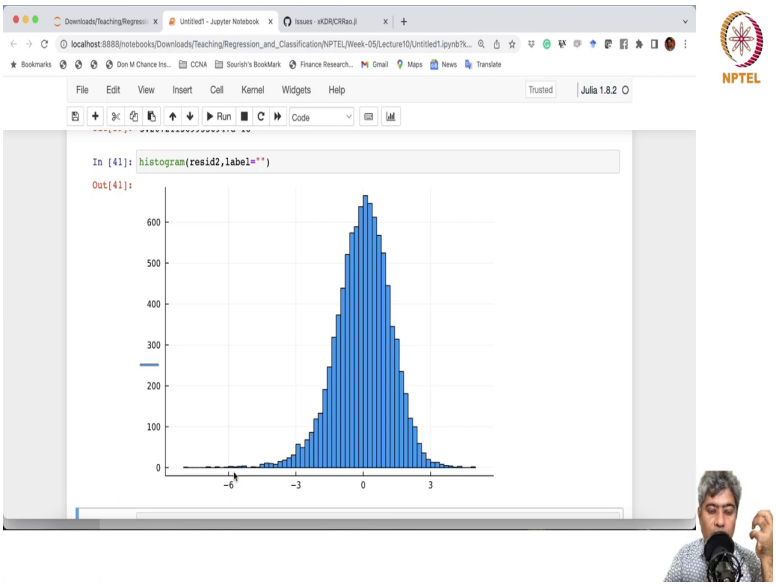

So, ok this is the histogram of the residual, it is not bad. It is almost like a bell-shaped only thing it has a bit of a long negative tail. So, that means, that it has a essentially it means the way if you see it looks like it is underestimated, it is doing some underestimation probably.

So, like an underestimation happens when probably if a model is saying that ok it will be 30 degree Celsius and turns out to be it is 32 or 33 degree Celsius. So, naturally there will be a negative of the negative residuals and that residuals we are seeing here. There quite a way almost 6 degree difference in the predictions and that has also happened.

So, let me just stop here. So, that means, normality is an issue model is models predictive accuracy is reasonably ok almost 70 percent, 78 percent. So, we cannot if we want to go and say that ok this is beyond reasonable doubt that you know. The problem main problem that we will face is here and I will tell you what the problem is saying.

So, based on these analysis when we are running this model based on these analysis the coefficient of t over time is positive, it is increasing and p value is really small confidence interval does not include 0.

Now, the problem now we are facing is, so, based on this Chennai's temperature is increasing. Now, somebody can come and say that well your underlying assumption is that your residual follow normal distribution your normality assumption does not hold good ok clearly normality assumption does not hold good. Kolmogorov's – Smirnov test reject that assumption.

Therefore, you are in where therefore, your these inference that temperature on an average temperature of Chennai is going up over the last 20 years 20 almost 30 years is not correct. It is not correct because your underlying assumption is wrong and what is the probability that it will be correct? The way to solve this issue is very simple we know that we have to run bootstrap regression. Residual bootstrap regression does not or even paired bootstrap regression does not rely on assumption of normality.

In fact, it assumed that any residual follow any probability distribution with some mean and variance and looks like this is fine. The mean zero is assumption is fine and some variance is also fine. So, we will we can implement this model using bootstrap regression. So, I am leaving this to you as we have already studied bootstrap regression, I am leaving it to you. Try to write the bootstrap regression and implement this.

I will share this Jupyter notebook in the NPTELs forum and in the NPTEL's platform in Swayam platform. Please go there, download this notebook and also the data will be available there I already shared the data with you. Please go ahead, download this notebook and implement the bootstrap regression using CRRao package ok.

So, CR Rao package has not implemented the bootstrap regression yet. But I think you can do it very simply, quickly by yourself we have done it in R you have seen basically you have to translate that code into bootstrap regression.

So, with that I will stop here. Thank you so much. Take care, bye.