Biomedical Signal Processing
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Lecture - 62
Tutorial - IV (Contd.)

Now, we will start the 6th assignment of the tutorial 4. So, here we are given a that ECG signal, having a lot of PVC S ok, that the number of PVC S include the episodes of bigeminy; what we mean by that? That we have alternate cycles 1 cycle is big, 1 cycle is small and why that is happening? It is happening because of premature ventricular contraction or PVC which is giving rise to the ectopic beats ok.

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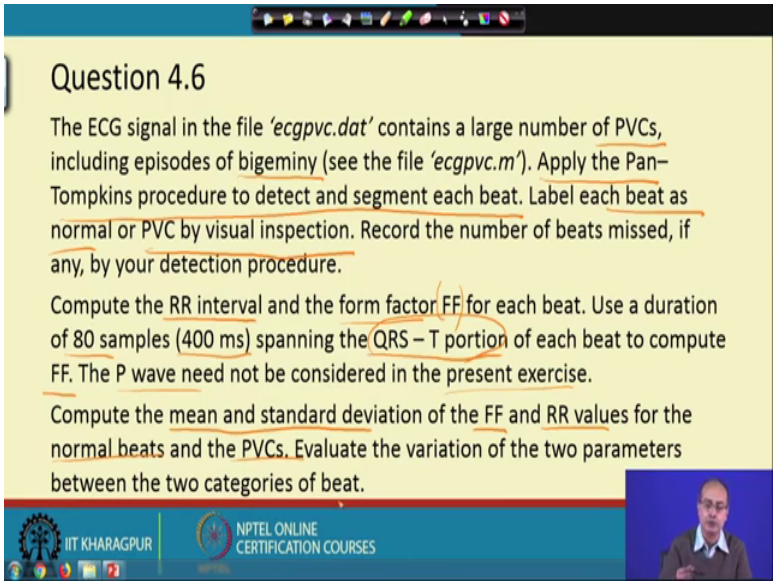

So, we are given such a signal, with lots of ectopic beats they are actually PVC s. Now what we are asked that apply Pan-Tompkins algorithm to detect and segment each beat ok. So, we get that idea that how Pan-Tompkin algorithm is successful, in actually creating those that the QRS complex; to detect them and segment those beats then level each beat as normal or PVC by visual inspection.

Once they are actually the beats are labeled, then it is possible to actually suggest that which cycle is normal, which cycle is PVC and record the number of beats missed if any by your detection procedure ok. So, if any beat was missed that is also should be noted. Next compute the RR interval and form factor; form factor is given as FF for each beat

ok. Use a duration of 80 samples that corresponds to 400 millisecond, spanning QRS-T portion of each beat to compute the, that form factor.

The PVC S P wave need not be considered in this present exercise ok. Many times P are not present properly and because it is ventricular contraction. So, QRS and T that portion is most appropriate to look for that analysis and that is why we have taken that portion that QRS-T this portion ok. Next is compute the mean and the standard deviation of form factor and RR value for the normal beats and PVC s.

Evaluate the variation of the two parameters between the two categories of beats; that means, that how the mean and the standard deviation varies for the RR interval as well as that form factor for the normal beats and the PVC s, that is what we need to compute.

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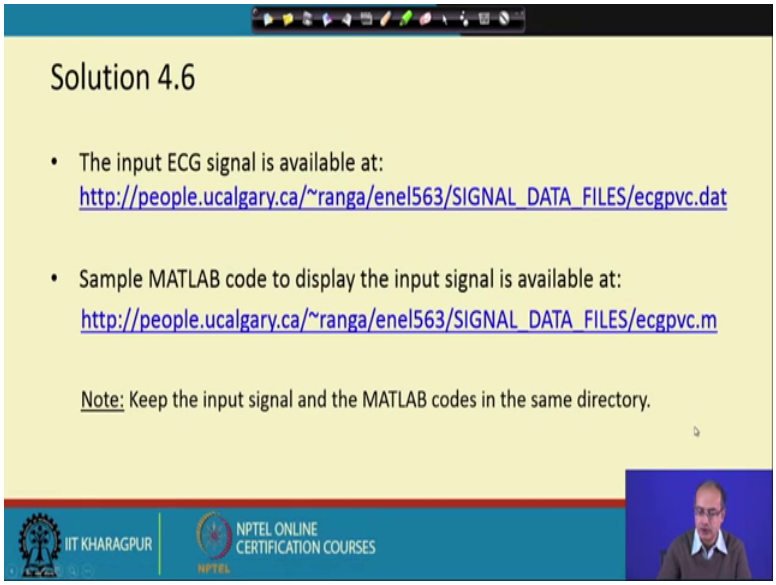

So, let us proceed to get that answer the first job, like any other assignment is to collect the data, collect the MATLAB file recur to read it and we need to put the input signal and the MATLAB code in the working directory of MATLAB.

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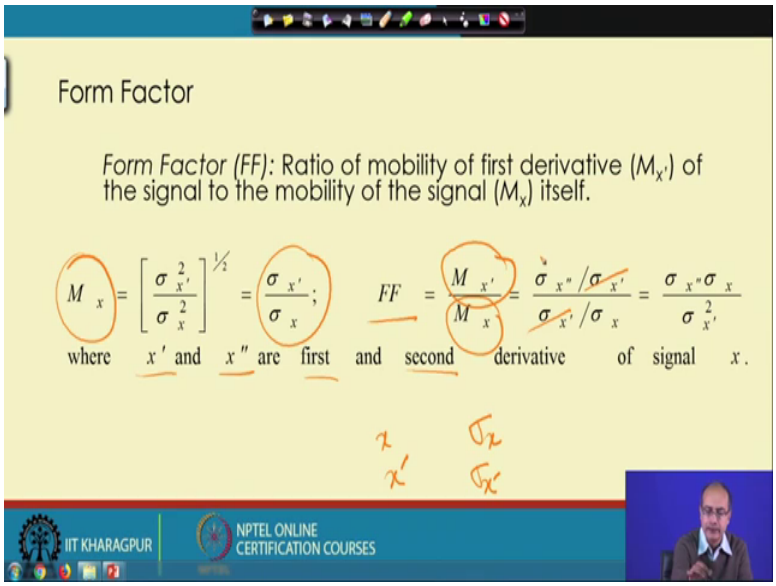

Once that is done we proceed to do the work; first let us do some brush up. That if we look at the signal x, then if we take the standard deviation of x; that gives us the activity of the signal. Now if we take the derivative of the signal x dashed and corresponding standard deviation of that is a sigma x dashed; ratio of that gives us the, that mobility of the signal.

Now, if we take the mobility of the signal and mobility of the that first derivative of the signal and the ratio of them, that gives us the form factor or in short FF and now we can simplify that what is M x; it is nothing but sigma x dashed by sigma x. Same way that mobility of x dashed is sigma x double dashed by sigma x dashed whereas, double dashed is the second derivative and x dash is the first derivative of the signal x.

So, after the simplification what we find that these two terms they cancel each other and or no I they are not cancelling each other. So, they are coming here square. So, what we have that we have that sigma double derivative into sigma x divided by the standard deviation of the, that derivative of the signal square and; that means, we can say the variance of the first derivative of the signal.

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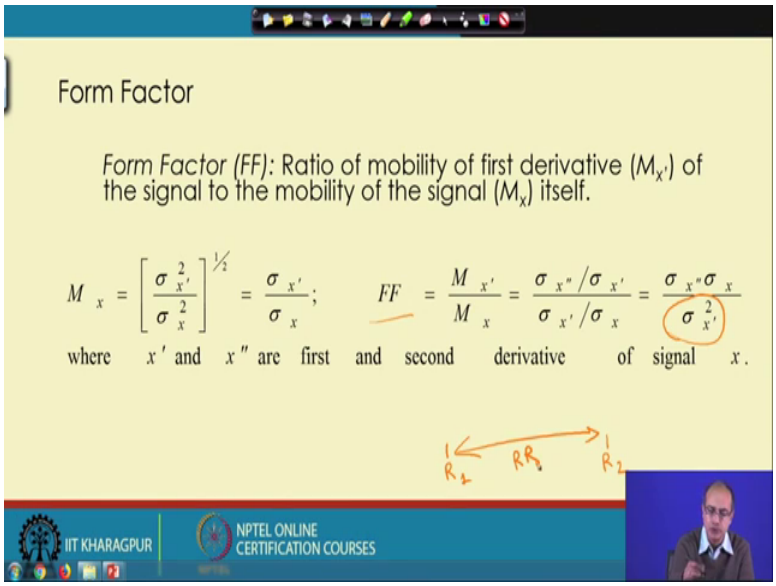

So, that is the form factor; what is one of the thing we need to compute and we know that when we are getting the that QRS complex if this is the first peak R 1 this is the second peak R 2 this interval is called the RR interval ok. These are the two things we are asked to compute in this case.

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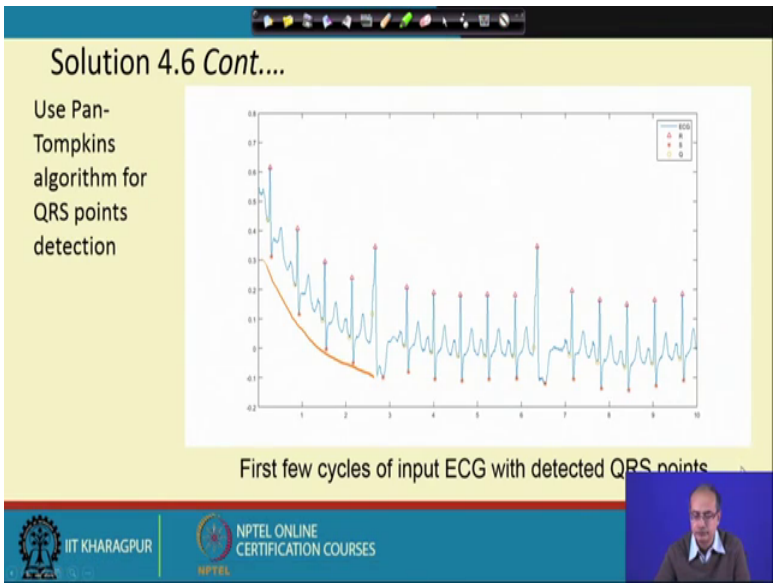

So, first let us apply the Pan-Tompkin algorithm and let us see few cycles of it. Now, if you look at this signal; the first thing what we notice that we have a baseline drift we see that the way the signal is changing we have baseline wondering, but our Pan-Tompkin

algorithm is successful to get the R waves ok. So, first few cycles we could get in this way.

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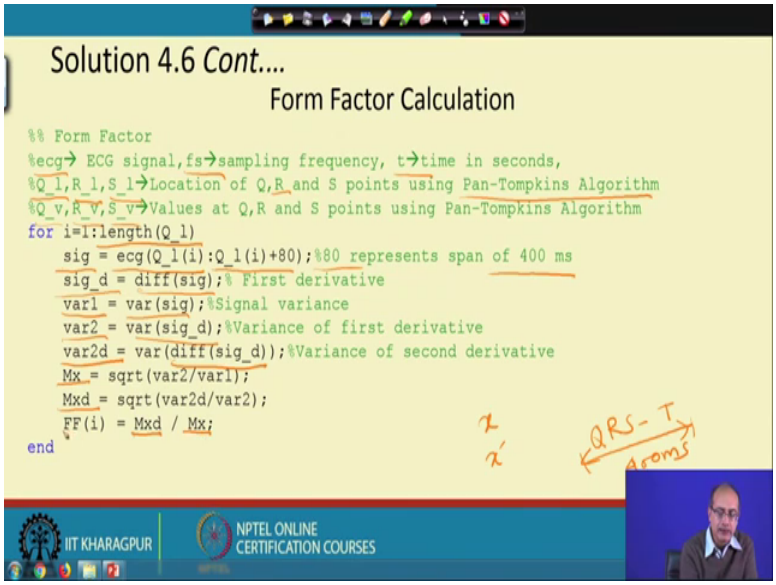

And then once we have that the QRS complex detected and after R we could get actually that Q and S. So, we start the calculation of the form factor. So, here are a couple of things we are mark that ECG is our ECG signal, fs is the sampling frequency, t is the time axis, Q 1 is the that location of that Q underscore l is the location of the Q R underscore l is the vector containing the location of R and S underscore l is the providing the location of S points and all of them we get from the Pan-Tompkin algorithm.

Actually we get R and taking that as a reference we find out the location of Q and S and the corresponding value of a those points we also get ok. Once the location are there; now what we are doing that, we are going through that length of the, that number of cycles we have. If we take any one of them that Q underscore l, R underscore l, S underscore l all of them they have equal number of actually the points because this is giving us the count that how many times we could get the QRS complex. So, that length essentially is giving that so many times we could find out that cycle.

So, in this case that we go through that, actually that vector and we are taking that a part that starting from the Q to 80 samples more after the location of the Q. Now, why 80 samples? Because in this case 80 samples represents 400 milliseconds; that is how we got that number 80, because we are told that we need to take 400 millisecond of QRS

and T segment, 400 millisecond of these ok. We are asked in the question that 400 millisecond we need to take.

Now, once we have that, so this is our signal; so in the equation what we are talking about that that is x. Next thing we need to find out x dashed ok, so we have created that that sig underscore d is the first derivative. So, var1 is giving the variance of 1; that means, square of activity var 2 is giving the variance of the derivative signal first derivative. So, that is the square of the activity of the derivative. So, that now to form that form factor we need the double derivative. So, we are taking the derivative of the first derivatives and then we are computing the variance of that ok.

Next what we are doing? We are computing the mobility of the signal and mobility of the first derivative of the signal and taking the ratio of the mobility of first derivative of the signal and mobility of the signal to give the that form factor of that particular cycle ok. So, that is a way just using the formula we have computed the form factor for each of this cycle.

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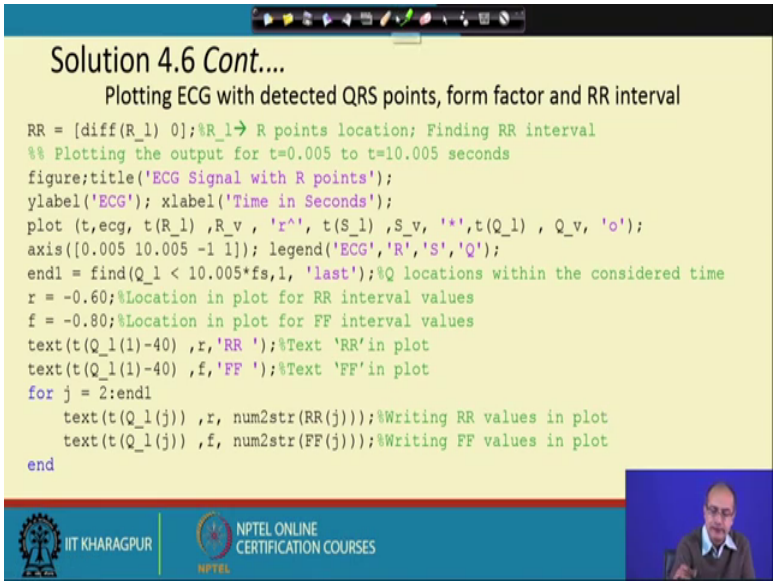

Next is we have to plot it and we have to show that each of these location that that in the ECG signal where is the location of R? Where is the location of S? Where is the location of Q? And below that we are writing actually below that we are writing that in the text that where is the RR? Where is the FF plots are there? Ok. So, we are writing the value

of the RR and the FF there. So, let us proceed to see that output which will help us to understand that that what we are doing.

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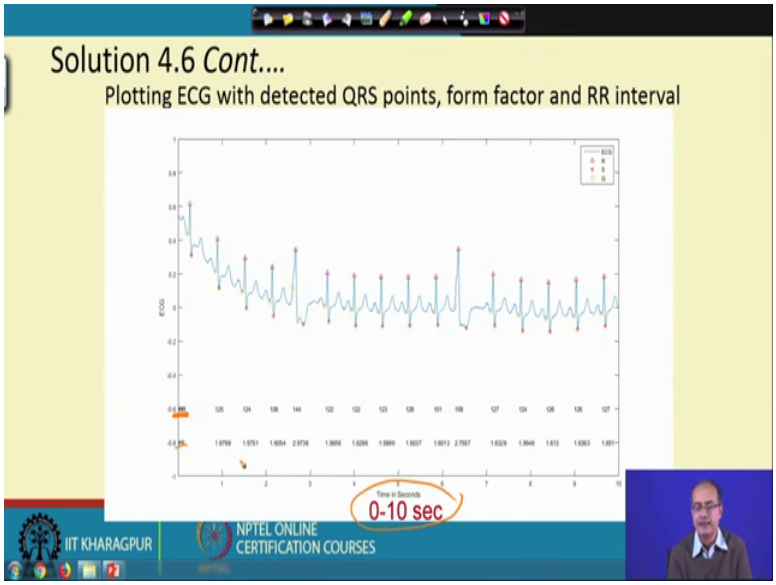

So, we have the first 10 second of data on the ECG data; shown here and below that we are writing in this line that, what is the corresponding RR intervals and below that we are showing that what is the FF intervals ok. So, these are the things we are showing to make it easy to read the plot and this is a way we go ahead to show that the different periods of the signal instead of showing the whole sequence at a time we are taking them part by part for ease of understanding.

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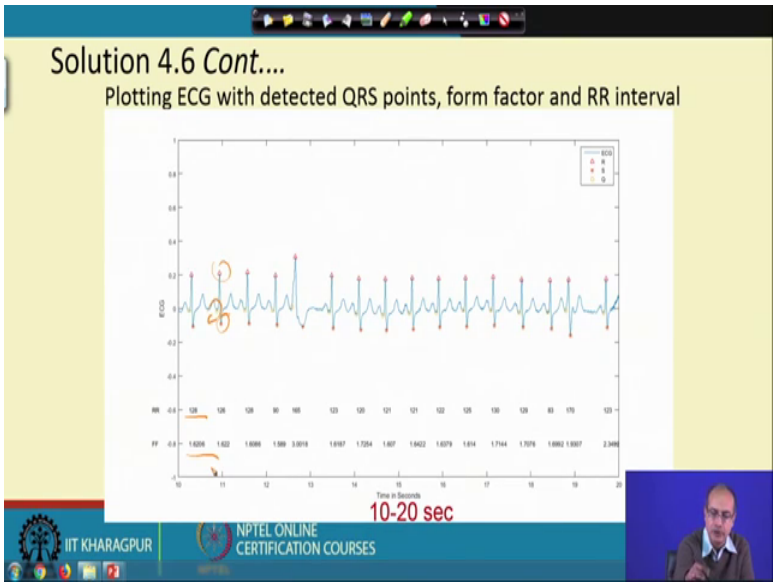

Next we look at that 10 to 20 second again for the ECG we have marked that the R, then Q this part and S and corresponding that RR values and the F values we have given below.

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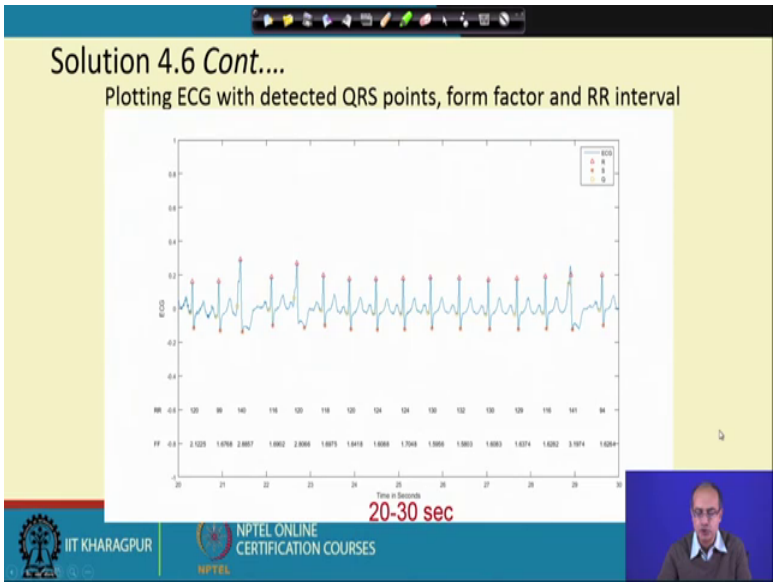

Now after that we look for the next segment going 20 to 30 second. So, every actually plot we are covering 10 seconds; so in that way we could show them clearly.

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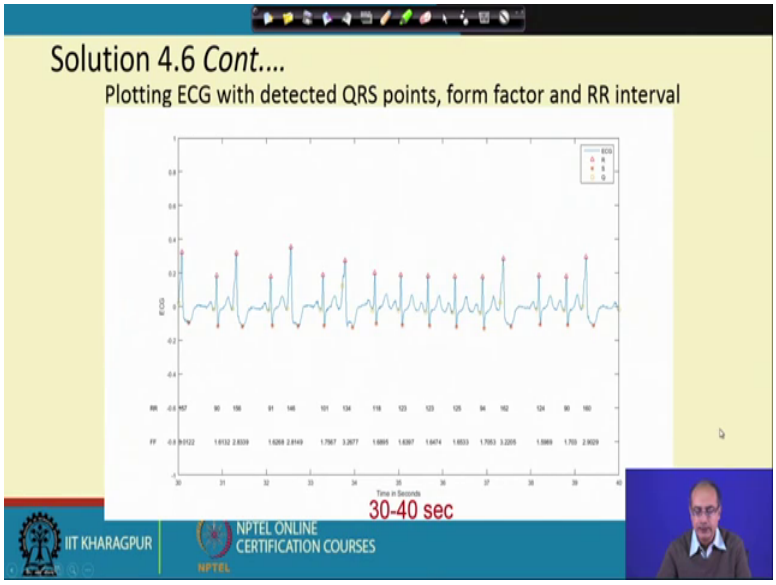

Then we go for that the 30 to 40 second, so in the same way we are showing the location of the R, Q and S and also the value of RR and FF for each of these QRS complex.

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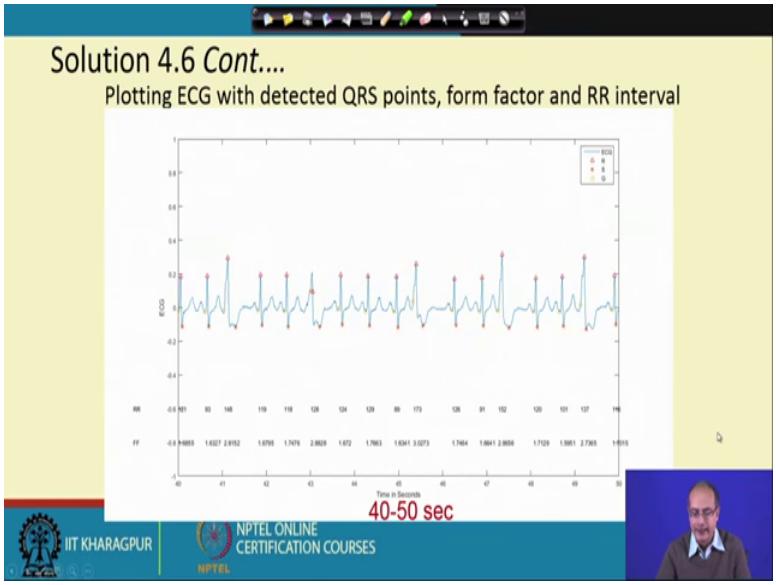

Then we are showing it for 40 to 50, so by that we are actually completing that part and then we look at that what are the abnormalities in the signal.

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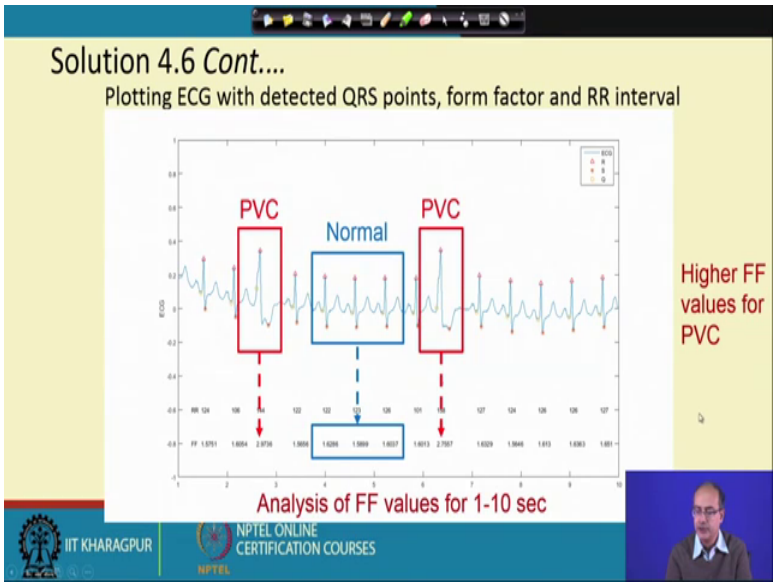

In fact, each cycle we have that; in this case we get actually the two kinds of waves are there, first we would like to draw your attention that we are getting that PVC s ok.

Here one here another in between we get that few cycles which are normal; how do we get that these are PVC s? Simply looking at the height, look at that that height is bigger, the width is also bigger. If you look at the width of the QRS complex, that is bigger than the normal. So, that really gives us that these actually QRS complexes are abnormal and they are affected by PVC.

Now, how do we get that more objectively; so for that we look at first that RR values get in the first cases it is 144, here it is 158; compared to that when you look at the RR interval of the normal cycles we get it is in between 120 to 126. So, there is some variation in among in that normal beats also, but RR interval still they are much smaller for the normal beat.

Now, let us look at the, that form factor for the first cycle of PVC; we get the value is 2.97 almost near 3. Next one is a little bit less 2.7557. So, what we get both of them are close to 3, on the other hand if we look at the normal beats that what we are marked here it is in between that 1.58 to 1.63 the values are much less ok.

So, that gives us some idea that, how to separate them out; we get the range of the FF values which can help us that to discriminate the normal cycles and the PVC cycles ok.

So, armed with that information or knowledge we proceed what we note first that higher FF value for PVC, with that we are taking here a chance, that what we have taken that from the observation we have taken that if we take a threshold at 1.9 above that value if we have FF then this should be a PVC beat below that value it should be a normal beat.

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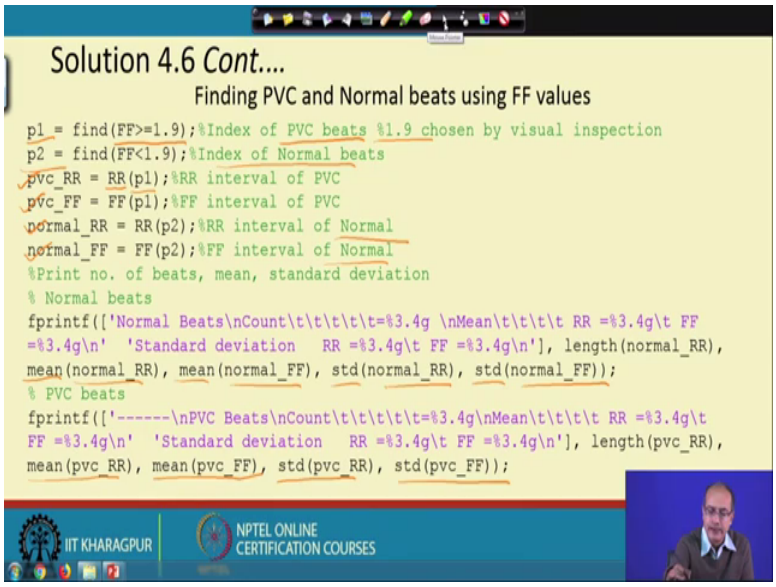

So, we have using this find command we get two sets, one is p 1 and p 2; p 1 is giving us all those actually cycles that which are having PVC and p 2 are giving us those cycles which are having the normal cycles. Next what we do we can take actually that the RR value for the PVC s so using that index p 1, we take the corresponding RR values we put that in a variable here and corresponding the form factors also for the PVC s. Same way we put the that RR value of the normal and the FF value of the normal bytes. So, this way what we do that we get the output, that we get the two sequence separated and that helps us to do the next few things that we can compute the mean of the normal RR, mean of the normal FF, standard deviation of the normal RR, standard deviation of the normal FF.

Same way we get the mean of the PVC, RR intervals that the mean of the FF value of the PVC cycles and the corresponding the standard deviations. So, we print them all of them ok; so that is the next task we have.

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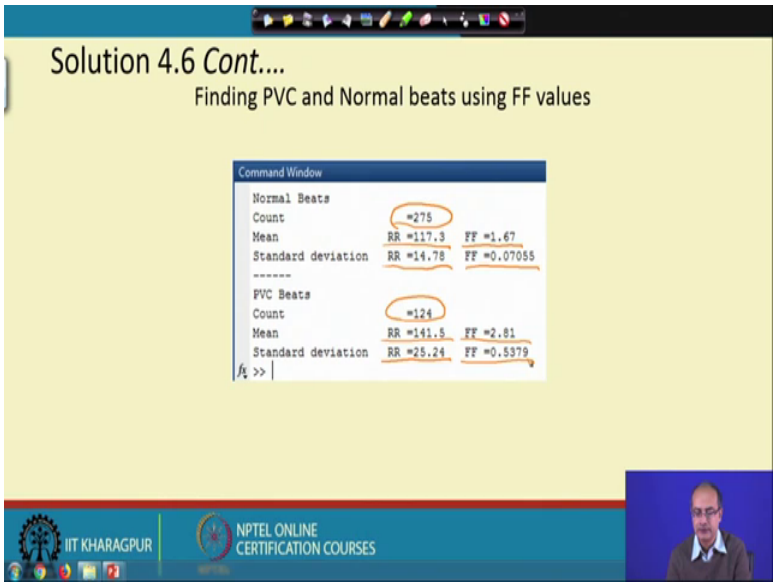

So, here we get the result that that is printed in the screen, that we get the number of normal beats are 275 compared to the number of PVC beats 124 ok. So, we have more normal beats almost more than double and then we look at the mean value of the RR, for the normal beats its 117.3 whereas, the mean RR value for PVC is 141.5. So, what we get that the RR interval is much bigger for PVC and if you look at this corresponding standard deviation we get for the normal cycles, it is 14.78 that standard deviation for the RR of the PVC cycles is 25.24.

So, the standard deviation is also increased; next we look at the FF value, the FF value for the normal cycle average is 1.67 and the standard deviation is very less it is in the second order place of the decimal, but for the PVC the FF value is much higher it is the mean is 2.81. So, difference is more than 1 of the average value and though the, that standard deviation is less it is in the first order of decimal it is 0.5 ok.

So, we get that that form factor for the PVC is much higher, not only that the variation is also bigger in this case. So, that is the actually observation we make out of this experiment and let us collate all the observations what we have.

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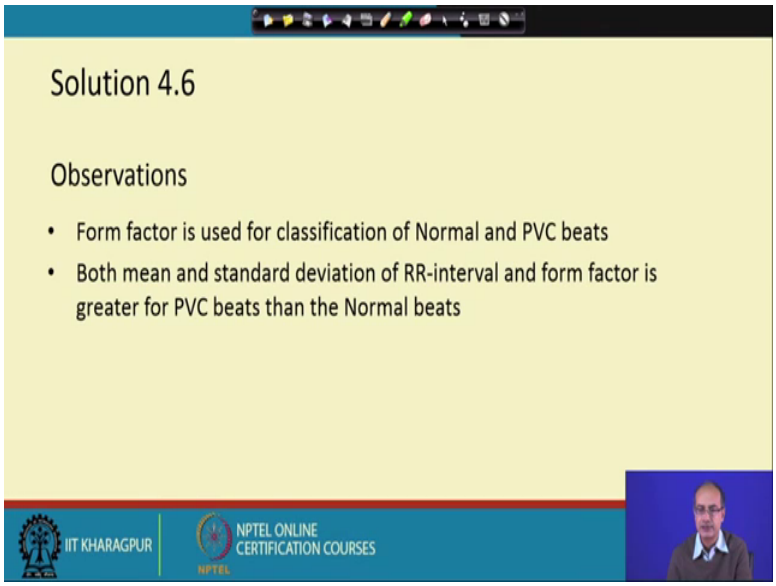

In this case the form factor is used successfully for the classification of the normal and the PVC beats and both the mean and the standard deviation of the RR interval and form factor they are greater for the PVC beats than the normal beats. These are the two observations we could make from that exercise.

Thank you.