Biomedical Signal Processing
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Lecture – 24
Event Detection (Contd.)

So today, we will summarize the event detection and first we look at the derivative based techniques. Primarily, when we look at the derivative based techniques, it is looking into the fact that the signal has high change of rate or a rapid change is there and there we make use of this derivative based filter. The best example of it could be the QRS complex; QRS complex provides a high change in the intensity in the signal. So, that is a very good candidate for the, that derivative filter.

However, one more thing we need to keep in mind that derivative filter being actually a high pass filter it is prone to the high frequency noise. So, whenever we are using the derivative filter, you have noticed that we are doing some preprocessing to suppress the noise and at times, that we need to suppress that power frequency also and after that derivative filter also, we need to use some sort of again low pass filtering to take care of the fact that we may get actually multiple peaks to actually merge them to get a single peak to catch that the single event that has occurred. So, that is about the derivative based filtering.

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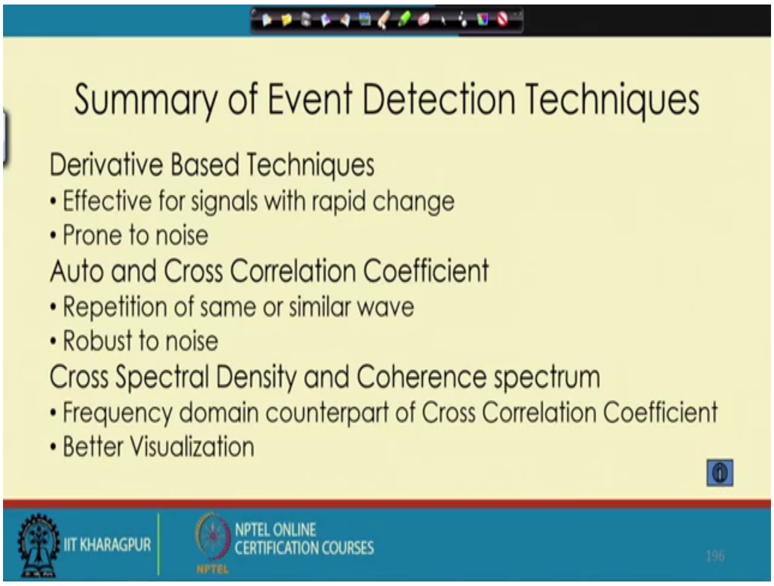

Next, we have covered the auto and cross correlation coefficient. The correlation coefficient for that, actually we need that a similar wave, a whether it has a fixed waveform or not. A similar wave need to be present, only then actually this kind of actually technique is effective. When we take that filter, that means, we take that pattern from the same signal, then we call it is a auto correlation, otherwise we call it a cross correlation and when we are taking it to the cross correlation coefficient that means, we are normalizing it with the energy of the 2 constituent signals.

So, that makes it easy for quantitative analysis, even otherwise if we are visually actually judging that map, that cross correlation and auto correlation can give the same piece of information. However, when we are talking about quantitative analysis, that means, we want to write a program and want to determine that, whether that we have that signal present or not then we need to define a threshold and at that time that normalization helps because then the value gets restricted between minus 1 to plus 1. So, that is the advantage of going for that cross correlation coefficients or auto correlation coefficient.

The next technique that we have taken is cross spectral density. Now, spectral density and the, from there we have taken there something called coherent spectrum, again we are normalizing it with the energy. Now, it is actually a frequency domain counterpart of that cross correlation coefficient we can say, that cross correlation function or auto correlation function, if we take them in the frequency domain, we get the cross spectral density or power spectrum.

So, this is actually that one way of looking into the same thing, what is present in the signal and when you look at the examples we find, that when we are looking into cross spectral density or PSD, it is better for the visualization. So, let us go back to some of the examples what we have taken, I think then we can recall them better.

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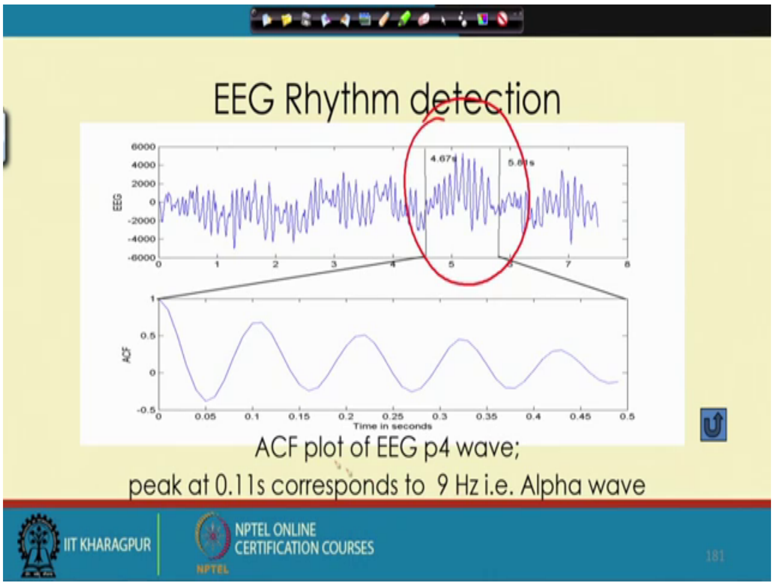

Here in the P 4 wave, we are looking for searching for the presence of a pattern. What we have shown in between this place that ,in this area we see a pattern and it seems that it is repeated and it seems to be like alpha signal; alpha wave. So, we are looking into that and auto correlation coefficients also tells us that we get a repetition of that wave we get high peaks. So, we get that our alpha wave is present in this signal.

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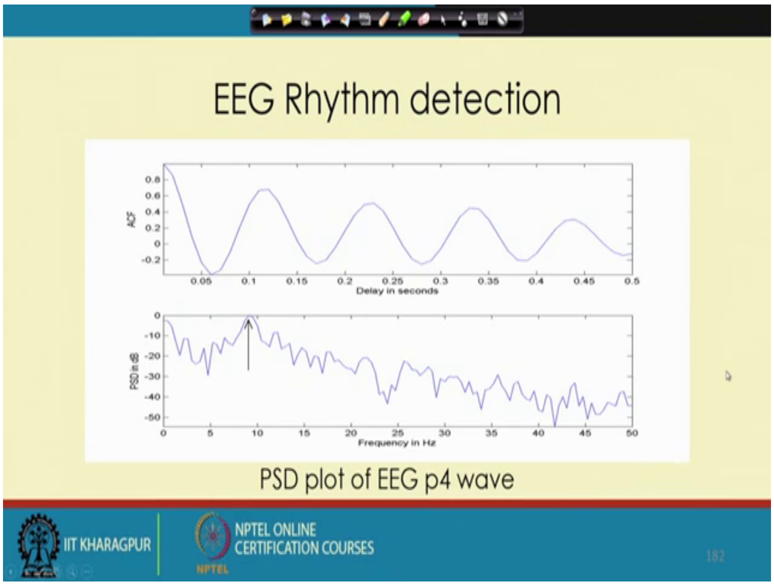

Now, we take from that auto correlation coefficient, we can take that PSD and we get a peak at 9 hertz. So, that clearly indicates that we have the alpha rhythm present there.

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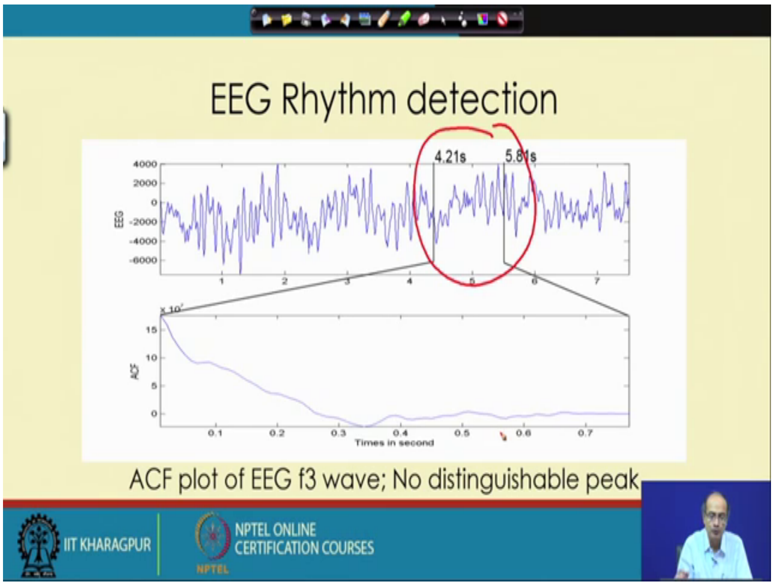

So, next example we look at again, that we again suspect that alpha wave is present in between 4 to the 4.21 second to 5.81 second and then we take the auto correlation coefficient of this part, that 1 signal is only this part, another is the, full actually f 3 wave. So, when you take the auto correlation coefficients, we get a actually drooping characteristics there is no prominent peak, which suggests that there is no that repetition of the that alpha wave or whatever the signal was present there.

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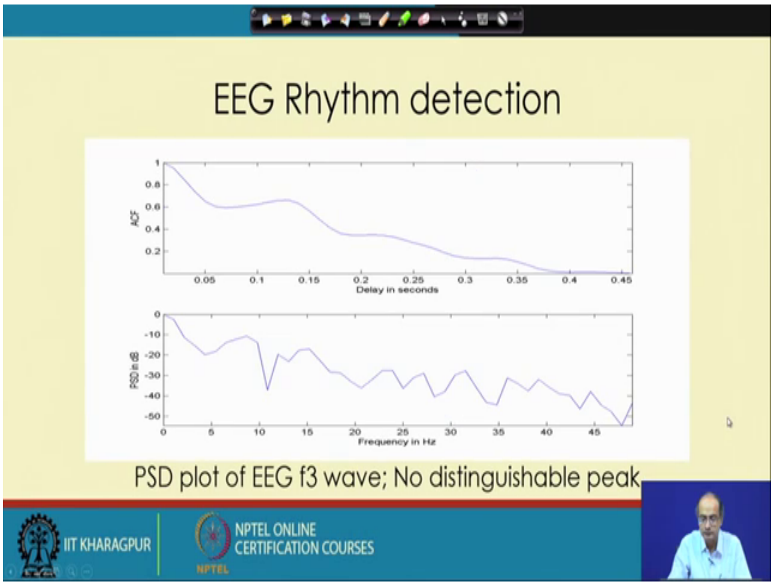

And then, we have calculated the PSD, to see the same thing from the auto correlation coefficient and here also we see we cannot get the, the peak as we have seen in the previous case. So, this also tells us that there is no distinguishing peak. So, we cannot tell that the signal what we have taken that is getting repeated.

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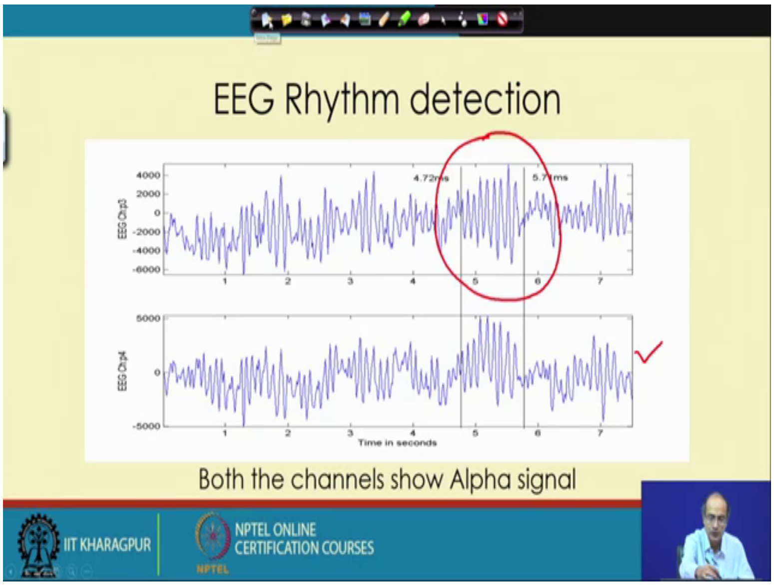

Next, that we have taken a that 2 signals, one is that P 4 and another is that P 3, the 2 channels that is taken, that we get similar kind of actually signal in between 4.72 millisecond to 5.71 millisecond. About 1 millisecond that the gap we get same kind of signal, so we want to know that, whether that it is repeated in both the places and that looks like a alpha 1.

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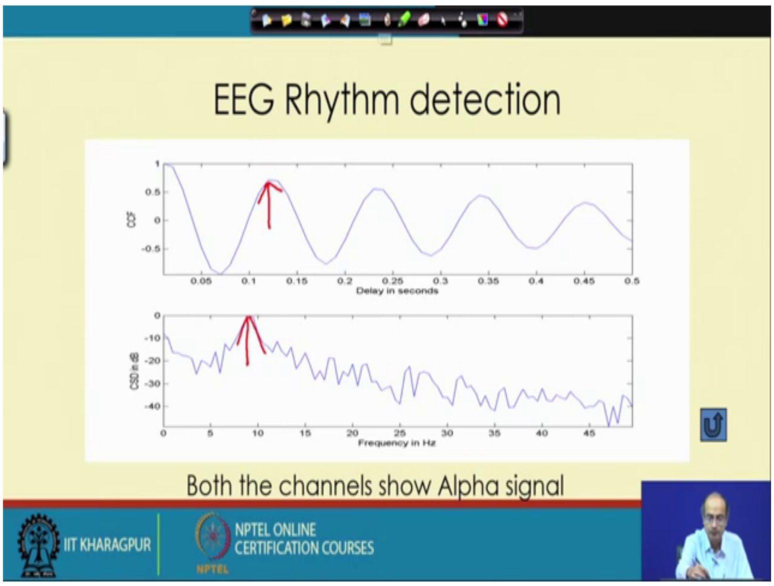

So, let us, look at that whether we are getting the same signal. So, first a cross correlation coefficient is taken from 1, that we have taken the patch, that means, what we have taken, that we have taken say, this part as the x and the other one, this one is taken as the y.

So, that gives rise to cross correlation coefficient. So, here we have taken the cross correlation coefficient and we get a peak here and we get similarly a peak here in PSD. So, which tell, that tells us that, that there is the signal is re getting repeated in that channel and because that peak is at 9 hertz it is alpha wave. So, we can get that thing that easily and we get that cross spectral density and that our, that CCF, they are giving us the same amount of information only thing, the visualization is much more easy in, when we are going for the frequency domain.

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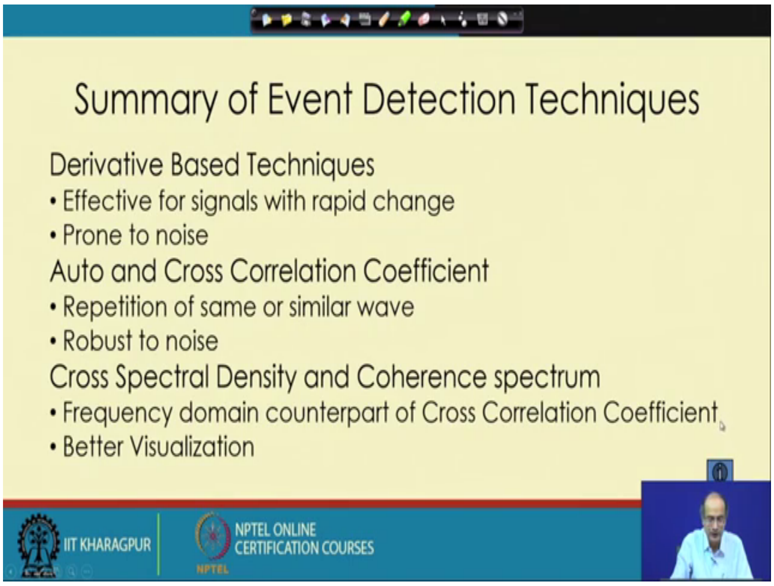

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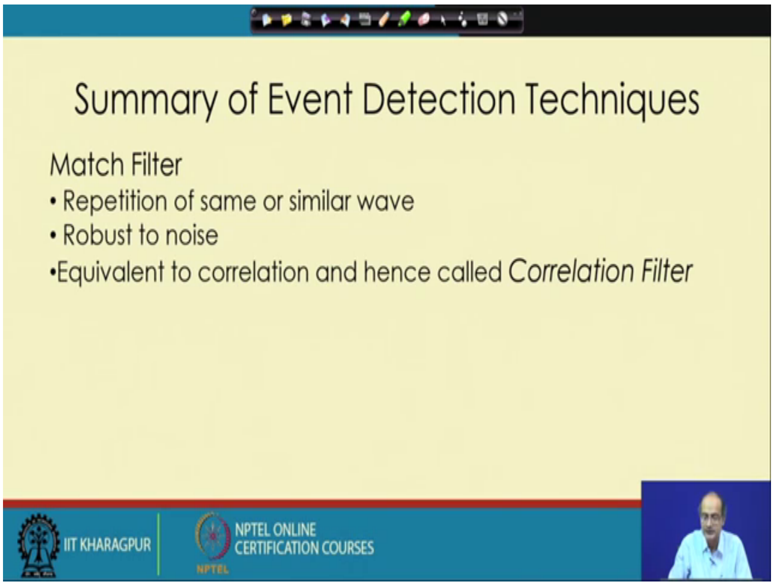

Now, let us look at that, the other technique what we have learned here that is match filter, again match filter is based on the philosophy that the repetition of the same or similar wave and again that, this match filter we find that it is robust to noise. Only the first one, that is derivative based filter, it is prone to the noise all the other techniques that is auto correlation or cross correlation coefficient that cross spectral density and match filter they are robust to the noise and they are what we get one more thing, that match filter it is a different way of performing the same thing it is equivalent to the correlation and hence it is also called as correlation filter.

So, essentially what we are doing, that we are actually performing the same correlation, but we are, we can actually we are taking starting from a different point we are taking it as a impulse response of the filter and then we are performing the task. So, that is about the techniques what we have taken, apart from that we should look into the fact, that what we have actually learnt from this chapter.

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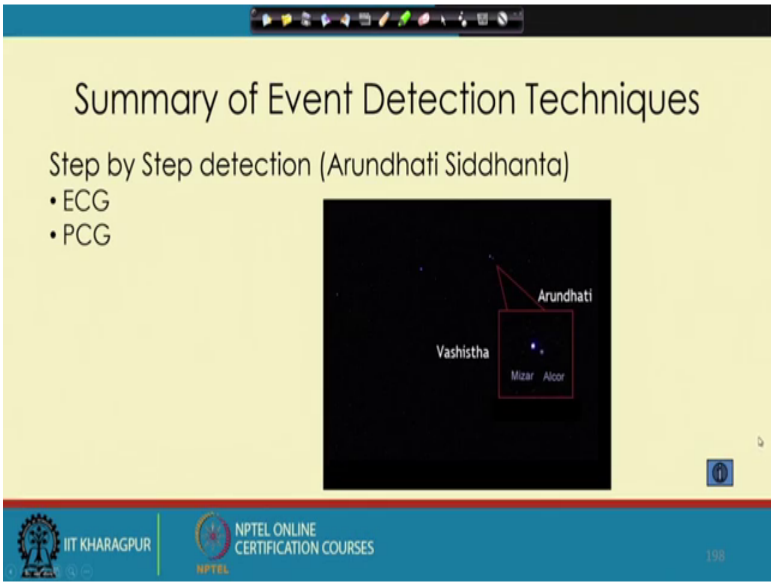

Here, one of the very important thing that what we have learnt is that step by step detection, which is actually called as Arundhati Siddhanta in Indian philosophy. Let us, first start with that and ignore that and then get back again into the our examples, that when you look at the north sky that is north pole and there is the most, actually prominent star that is a north pole, what we call it is known as that Vashishta. Actually, when we look at that star, that beside that there is a small twinkling star, the western names are that Mizar and Alcor of that.

Now, if someone is asked that small star that is known as Arundhati, actually these 2 names that came the Vashishta was a very well known sage for his knowledge and austerity and his wife's name was Arundhati and the story goes like that, that even after their death, they could not be separated and they are staying in the sky very near to each other and this the star Arundhati, if someone asked to find it out, that it is impossible to actually figure it out in the sky because there are so many stars are there.

Now, the way to get that, is first you need to find out the that most prominent star in the sky in the north sky, that is the Vashishta and once you look into the vicinity of it then you can get a very small twinkling star and that, thereby you can get actually with the reference of Vasishta, that what is the star Arundhati and from there actually the Indian that logic system or the experts they have given the name Arundhati Siddhanta.

That, it is a way that when you cannot directly detect it or find it out you go fast through a strong reference and once that reference is established, with respect to that you can find out the weak phenomena. If you look at that, our approaches here we are actually following that technique without taking that name, for the ECG, for example, that we are looking at that, all the time that the QRS complex .The reason is, that QRS complex is the most prominent one, but you will see, that our that P and the T waves are also important and other segments are also important.

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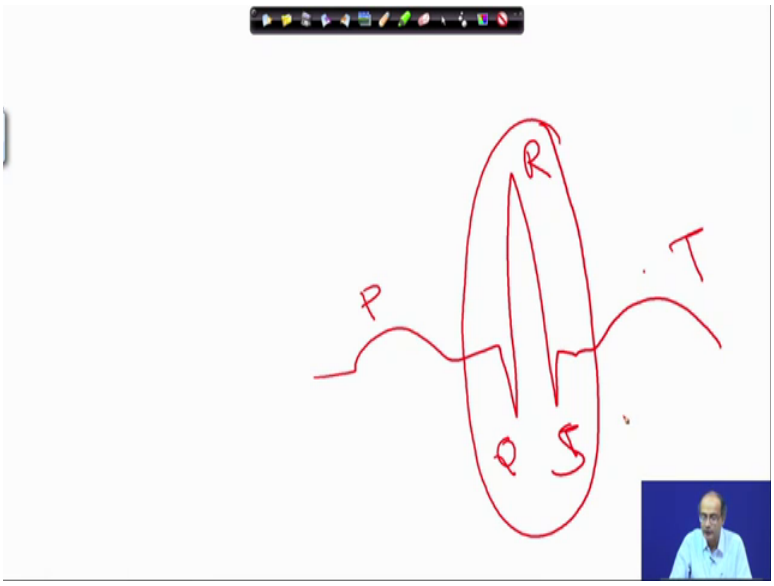

Here, we have not actually try to find it out, in fact, if we need to find out P or T or other segment, what we do? We find out first, the most prominent phenomena that is the QRS complex and once we can actually find it out, we know there is a relationship in time that how far the T wave could be or how ahead the P wave could be. With respect to that, then we localize that and then we can find out the P wave, T wave or S T segment, which is already buried in noise.

What kind of noise? The way we have drawn that curve you will not get that in that way, because we have a high frequency noise all the time, we have power frequency hum. So, by processing we can reduce their effect, but it is not possible actually to completely eliminate them. So, will have the noise all the time and there we need to detect that.

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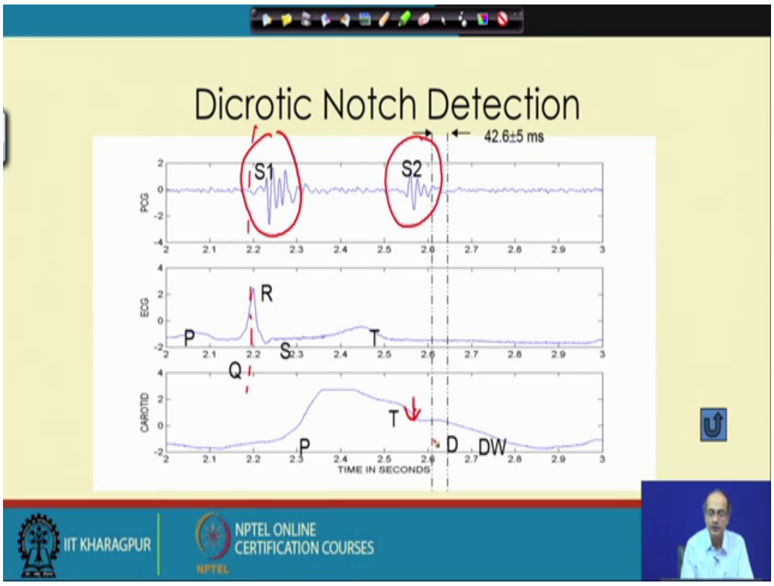

Next, if we look at the example of the PCG signal, the situation is more complicated. That the PCG, the signal that we get the actually that Phono Cardiograph, what it is a full form. It means, we are looking at a sound of the heart. Now, this sound is coming out of multiple thing, that the blood is actually flowing from one chamber to the other chamber of the heart, then it is coming out of the that heart through the arteries and it will be, it is a turbulent motion, so it will give rise to actually noise.

Next is, that there could be some constriction that for example, that if there is some Stenosis, that means the arteries are getting narrowed, so that will increase that noise. If the valves which are helping to do the unidirectional flow of the, that blood from one chamber to the other or from that the heart to the artery, those valves are not operating in a proper way. For example, they are not closing properly, so there would be a leakage, a backflow of the blood, so that will give rise to the noise. If the valves have been actually Calcinated, that means calcium deposition has happened and what will happen it will become hard.

So, it will not actually press properly on each other, it will lose the proper actually contact of the surface and instead of that it will make a metallic sound. So, that will also get exhibited in that, the vibration of the PCG signal. Now, out of that, we have 2 actually phenomena, 1 phenomena is S 1, again the way it is shown here it is a clean signal, the way we are seeing it here, you will not get it. In that way, when the signal is acquired there would be a much more high level of noise, that everywhere you will find the power frequency harm and the high frequency noise. So, these 2 phenomena S 1 and S 2 will not come so clearly and for that we need to actually localize them in time, even to figure them out that where they are present.

Now, S 1 wave is created, when the, that ventricles are getting contracted and when the blood is coming out to the, that arteries and fortunately at that time we have that ECG signal. So, as we directly cannot get that reference from the PCG, if it is buried in noise. Then what we do, we take the help of the ECG signal, where the QRS complex is very actually prominent phenomena and with the help of that we know just after the, that QRS complex the S 1 wave will come.

So, taking that as a reference, so we can find out that where the S a wave is starting. Now, if we look at S 2, it is actually followed by the T wave. The T wave indicates that, the ventricles they are relaxing and because of that, the of valve which was so far open, allowing the blood to flow from that ventricles to the arteries that is getting closed, making sure that there is no backflow of the blood and the pressure is actually retained in the arteries to ensure the flow of the blood throughout the body.

Now, because T is not a actually, that very clear signal. So, we cannot take the help of that, instead we go for the carotid pulse, which also rises. Actually after the QRS complex, there is some delay to get that pressure transmitted up to that point and once the valve is actually closed, then what happens? There is a sudden deep in the pressure, again as the valve is closed the pressure cannot drop it regains.

So, there is a notch created. So, we try to find that notch in the, that carotid pulse and with the help of that we know there is some time relationship, there is some actually time difference between S 2 and these carotid pulse. So, with the help of that we can find out the S 2. So, these are very nice examples that we are actually taking the help of the other references, sometimes other signals. In this case, completely 2 different signals that is required to get actually the location of S 1 and S 2 and we can then actually that find out that these 2 events. So, that is another thing we have learnt as bonus in this chapter. So, with that we complete that chapter of that detection of events.

Thank you.