Biomedical Signal Processing.
Prof. Sudipta Mukhopadhyay
Department of Electrical and Electronics Communication Engg
Indian Institute of Technology, Kharagpur

Lecture – 19
Event Detection (Contd.)

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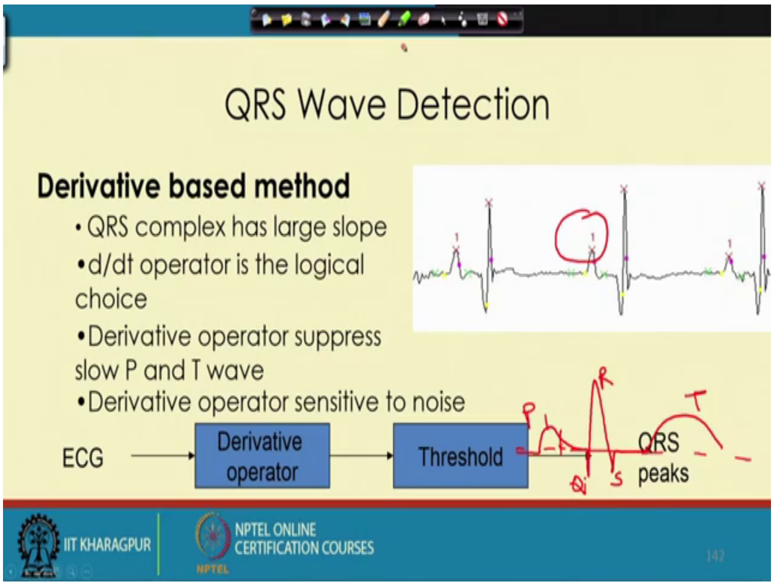

So now, let us look at that how we can get the ecg signals? How we can detect the different events? Now when we try to get the event, that first point of attack, is naturally the QRS complex, because it has that the high magnitude, and it has that large slope, and already we have seen that that if we take a gradient operator, and that helps to actually boost the high frequency signal, that becomes a logical choice actually for the detection of the QRS complex. So, the idea here is that first we will attack or detect the QRS complex, and if we look at the ecg signal, that we know that P wave would be preceding the QRS complex T, wave would be actually following the QRS more complex, and after T there would be a long time, before the next QR square that ecg cycle starts, there would be the isoelectric line. So, if we can catch the QRS complex, with respect to that we can find out the other event.

So, first we look at the QRS complex, and that we take the derivative operator for that, but one thing we need to keep in mind that derivative operators also, that amplify the noise so, we need to be a little careful about that. So, if we look at that all the algorithms, which are designed for the QRS wave detection, the basic block diagram is like this, that the ecg signal it is passed through fast a derivative operator, followed by a thresholding the job of the derivative operator is to, suppress the other part of the signal and boost QRS complex. And then followed by the thresholding we can get actually the QRS peak here so, that is the basic design.

So, now, let us see that the couple of, actually the methods proposed for the QRS complex detection.

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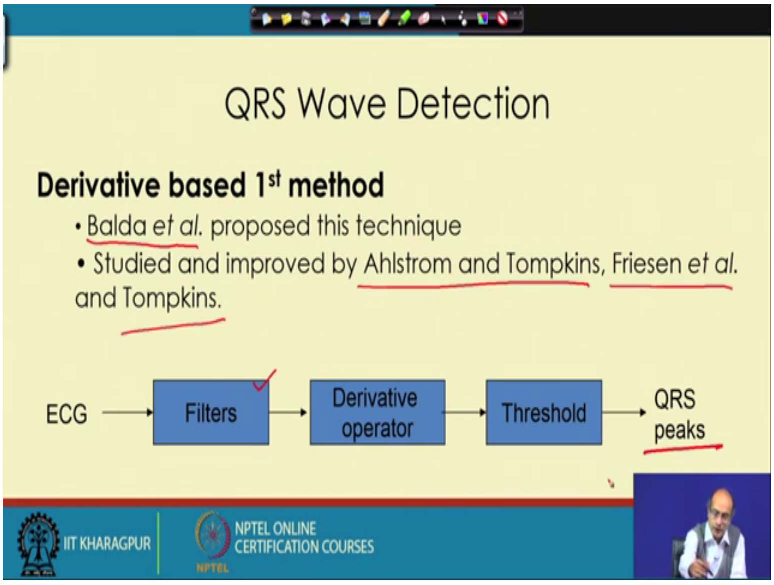

Here we get the first technique for that purpose, it was presented by first that the balda at all, and then it was improved by number of actual researchers, that Ahlstrom and Tompkins, then present at all, then again, the Tompkin in his book he has proposed some more changes so, they have improved this technique, and we are going through this improved technique here. So, in this technique that the first thing we do that ecg signal is passed through a filter here, the reason is we know that derivative operator which is would be the next block, it is sensitive to the noise so, first we would like to actually reduce the, that no amount of noise or improve the, snr of the signal before we pass it through the, the derivative operator. And derivative operator one good thing that it is, actually robust to the low frequency noise. So, the filter is primarily responsible for actually suppressing the, high frequency noise if we do that, that will be good enough, then it is followed by the thresholding operation and we would get the QRS peaks.

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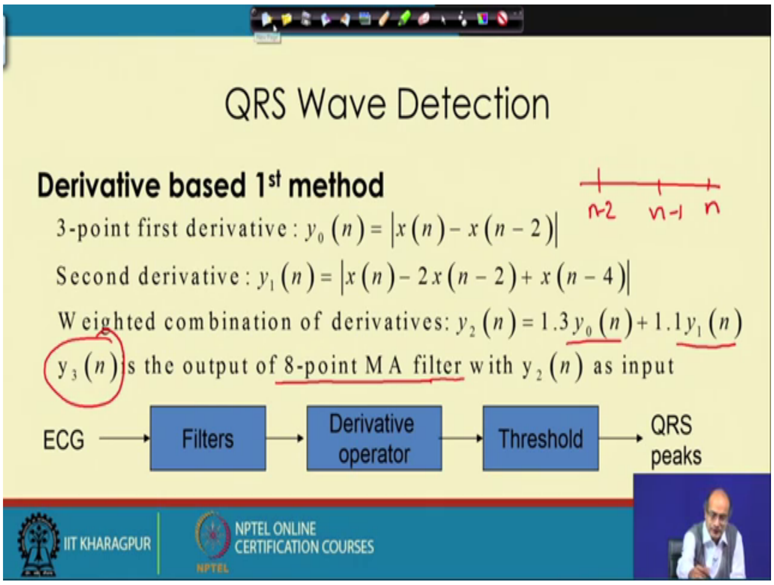

So now let us see how this simple scheme works here. In this case that what they have suggested, to take the 3 point first derivative, the 3 point first derivative means, that we have a signal xn, we have the point n n minus 1 n minus 2 so, if we take this is the central point with respect to that, the 2 points n and n minus 2, that we take the difference of these 2, and take the absolute value we get the amplitude of the first derivative to be more precise, and also in the same way the second derivative is taken, what we can do simply that, we can make use of this formula that xn minus xn minus 2, and if that gives us some output, we can actually take that derivative of the signal using the same form. And that gives us the second derivative, and here for the purpose of presentations the absolute value is taken, because if we do not take the absolute value, then we have to take 2 thresholds 1 is the, that the threshold above 0, another is below 0. To make it simple we take the, that absolute value which helps us to do the job, with only a single threshold.

Now, after these 2 derivatives are taken, they are combined that first derivative that is y 0, and y 1 that they are combined and a weighted average actually is taken, now these weights the researchers have found actually empirically they found that, if we take a unequal contribution from both these derivatives little more contribution from the first derivative, and a little less from the second derivative, and they are combined in an additive way, that what we get, that signal is actually better for the detection, and that part is actually passed through, a 8 point ma filter, that 8 point ma filter; that means, it is having actually uniform weights, that the 8 consecutive values of y 2, that is combined or average we can say, and we get that output y 3, which would be actually send for the purpose of the thresholding. So, let us see that how this technique works with the help of an example.

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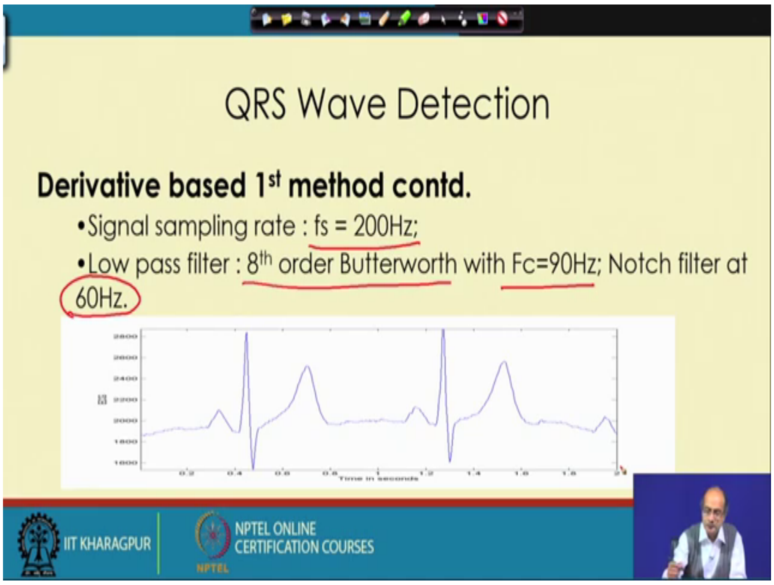

Here we have taken, a ecg signal which is sampled at 200 hertz, that sampling frequency is 200 hertz, and at that sampling frequency 8 order butterworth filter, with cutoff frequency 90 hertz is selected, that will help to actually reduce all the, that noise above 90 hertz and also there is a notch filter at 60 hertz ok.

So, the signal is collected in north America where the power frequency is at 60 hertz. So, that power frequency and the high frequency noise that is above 90 hertz, that is eliminated with the help of this low pass filter and the notch filter. So, this is the signal we get here, that example is taken.

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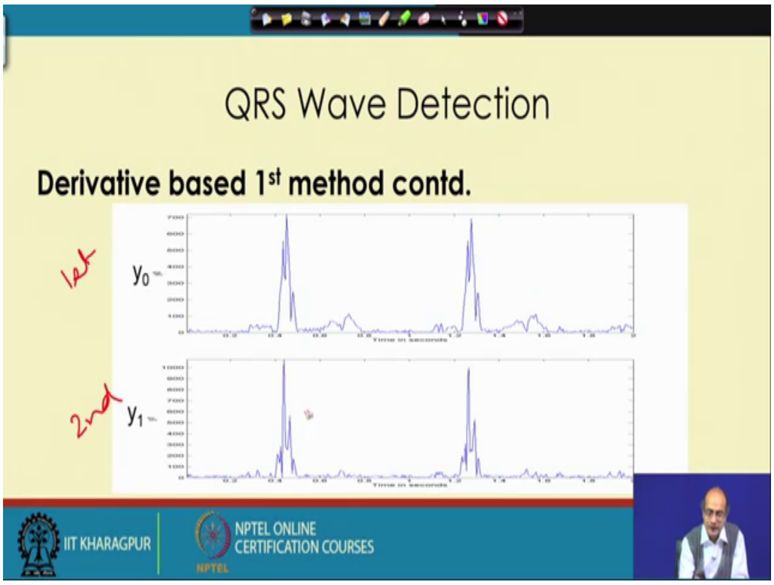

And then the next operation will start, we have to compute the first and the second derivative, and their amplitude is presented with respect to the time, that they are that y 0 that is the first derivative here, that we have the this is the first derivative, and this is the second derivative, y 0 and y 1. So, we get that the signal what we get out of them, that amplitude from the amplitude we get they are actually very much jagged. So, they have multiple actually local peaks in them, and when they are combined, that should help actually to get a better representation of them.

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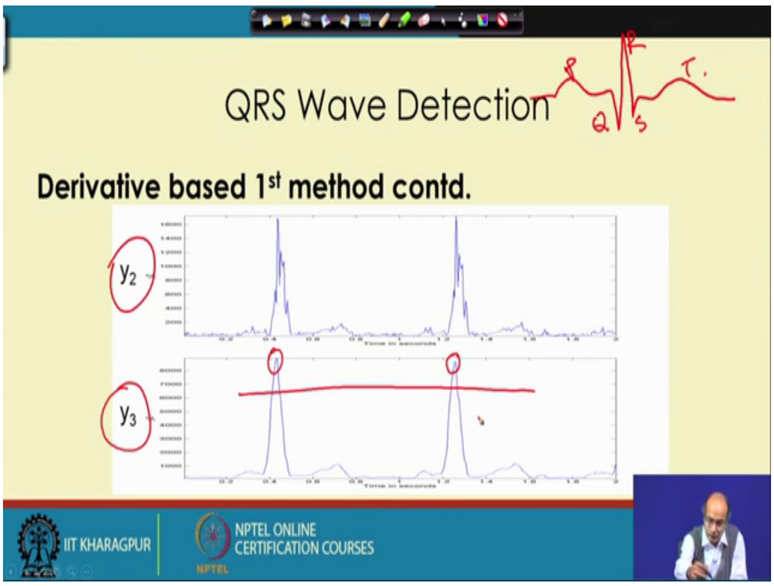

That we get after combining this, y 0 and y 1 with the weighted averaging, we get this signal that is y 2, we get it that we get that it becomes less jagged. Oh, but still we see a lot of local peaks are there, it is not very prominent that which one is the location of the that are.

So, what is done in this case, that it is passed again through that 8 point ma filter, and we get the y 3 and you see now after taking these averaging, all the that the jagged edges of the that the signal they have got smoothed out they merge into a single peak, for each QRS complex and now with the help of thresholding, we can actually pick the that the point that where the QRS complex is located, and these are location of r is usually taken that the tip of that signal. So, that also called as a bit, and it helps us to get that how many bits of ecg actually we have gone through. So, this is the simple way we can see that, even the that very simple technique using the derivative, the first the technique the which is initially proposed by that the bother at all, that that works and that gives us a reasonable output.

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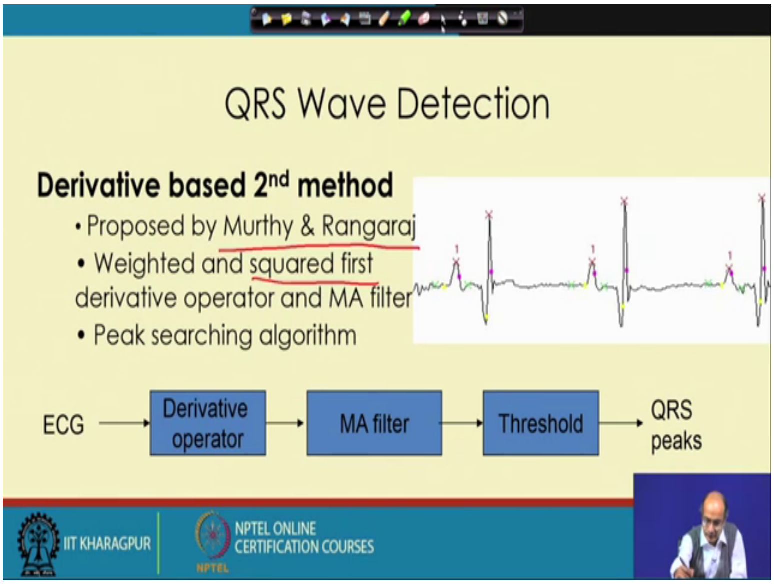

Now let us look for that more actually sophisticated technique, the second technique it was proposed by, that Murthy and Rangayan that Murthy and Rangaraj, they have actually proposed this technique.

So, they are approach is, that after the derivative that, it is weighted and squared, they have used the squaring operation of the first derivative. And then that you that there is that the ma filter, for doing the smoothing followed by that threshold in, to find out the peak. So, there is a difference that instead of taking the absolute value, they are taking the square, and the squaring actually serving the 2 purpose the first thing that it makes that signal positive. So, that one thresholding one threshold will do to find out the peak, the other thing it does that it emphasizes the, the high the signals more than the that low amplitude signal. So, it gives a transform which helps to emphasize the, the high amplitude signal.

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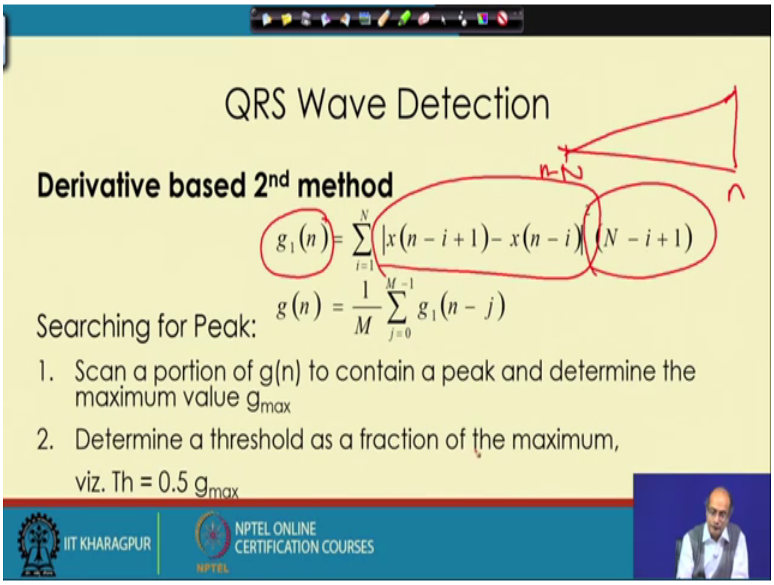

So, let us look at that form of the derivative first, that the first thing what they have done they have taken a weighted sum, because the signal after taking the derivative, accentuates the contribution of the noise. So, in this case that when they are taking the derivative and taking the square of that for each of these term, they are added and added in a weighted manner, the weight is if you look at carefully it is a tapered weight so, if this is the instant n that it is actually decreasing in the past. So, we are giving the maximum weight to the, that the latest actually that, the difference and for the other the previous the derivatives, here we get actually n minus n it becomes, e to the weight would be become 0.

So, for all of them, their weights will decrease or contribution will decrease. So, that is the way that we get the derivative, and that the weighted derivative what we get as g 1, that is again pass through a ma filter for further smoothing, and after that we take a threshold that is data driven. So, how it becomes data driven? The first operation is that for this signal g, will look for the maximum or the peak, and we mark them as g max, and for these g max what is done that we take there is a reference, and 50 percent of it is taken as a threshold. That 50 percent of the g max is taken as the threshold, if the signal is above that threshold, we tell that presence of them that r web is there or the QRS complex, has is present there at that position, and if it is not then QRS complex is not there.

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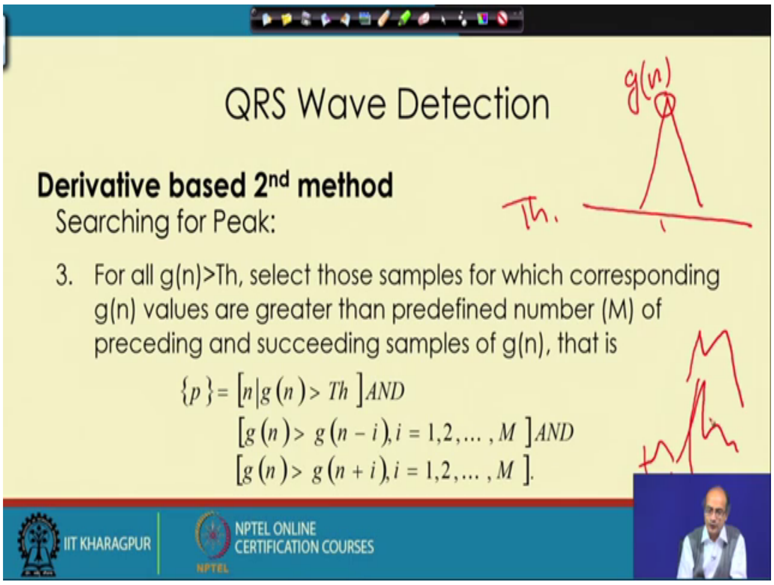

And to ascertain that there is no that spurious peak, they have taken, another actually care here what they have done, that they have added one more condition, the condition is that the peak what we are talking about these that in gn, that should be above that threshold Th, this peak should be a prominent peak what we mean by that, that if we look at both the sides of the peak there should be sufficient number of points, to be more specific here that they have taken a predefined number, that m points in both the sides which should be lower than these actually peak value; that means, the peak should not be just like that, a king kind of thing that it may be a peak, but there is a lot of kings.

So, in that case if we do not have sufficient number; that means, m points that preceding or following, that peak above the threshold then we cannot take that as a that the true peak. So, that is a way that we find out the, the true QR speaks and that is the way we get the output of the second derivative-based technique.

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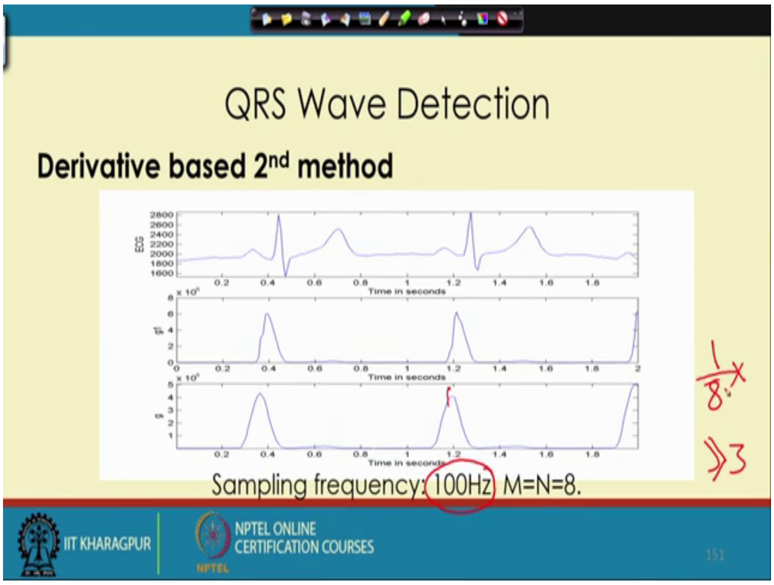

Here we see one example of it, that signal that sampling frequency is 100 hertz so, that is done intentionally; that means, that when they have selected the, that sampling frequency as 100 hertz, it must be preceded by, a low pass filter to avoid aliasing that helps actually, to take out some part of the signal and that high frequency noise from the signal. So, if the sampling frequency is 100 hertz, the maximum frequency of the signal present, in the that after the sampling that is 50 hertz, and that is lower than even the that power frequency, of that north America that is 60 hertz. So, that is why in this case there is no notch filter, there is no low pass filter is added here. Because before the sampling actually all the high frequency terms and the, that the power frequency noise they are eliminated.

So, after that that once we get the ecg signal, that the g 1 is calculated and we get g 1 is already pretty smooth, which becomes smoother after actually taking the that the ma filter, and the order of the ma filter in this case is 8, as well as that the number of actually the points preceding, and that following that peak, that that it should be lower than the peak, that is also taken as m, the choice that that m is value is 8. The choice of the that the ma model order 8 helps for the implementation, in terms of a integer filter. Because we know when we have to calculate the average, we have to compute the one 8^{th}, what we can do we can simply do it by 3 times right shift, and thereby we can actually give the effect of multiplication with 1 by 8. So, that is a reason for this, actually choice and that is how we get another very simple, yet effective actually derivative based that QRS detection algorithm.

Thank you.