Biomedical Signal Processing
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Lecture - 05
Biomedical Signal Origin and Dynamics (Contd.)

So, now let us continue the topic.

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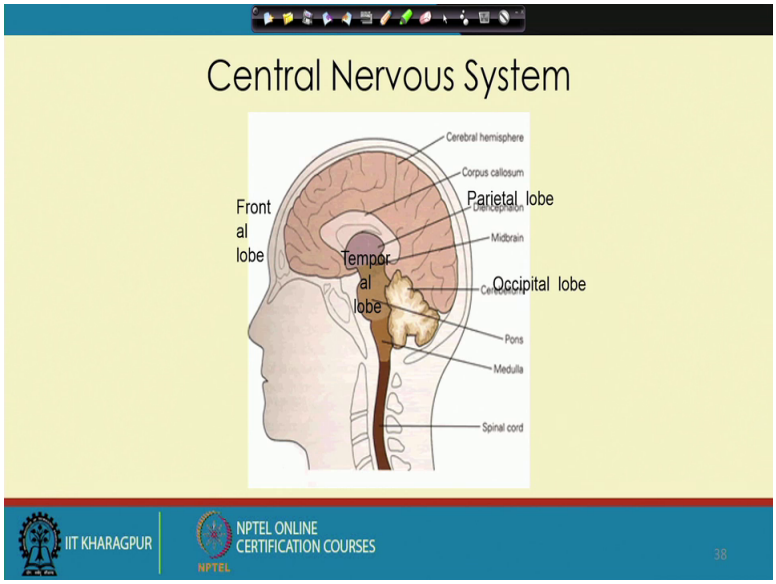

First let us get into the Central Nervous System: central nervous system that it contains the maximum number of neurons within a human body. Out of 12 billion neurons, 9 billions are there in the central nervous system and central neurons system consists of the vein and out spinal cord. So, these two they form the central nervous system and the neurons are there, they are actually within this they are called the intern neurons. And different part of that the central nervous system or this that brain they are responsible for different work.

The frontal part, this frontal lobe that is responsible for intelligence, that occipital lobe that is for the vision parietal lobe for sensation and our the moto reaction, then medulla it is actually looking for the autonomous different kind of actions like breathing that our contraction or regulation of our heart. So, different part is responsible for different kind of activity, and it is encased in a very safe way that we have the skull covering this, and we have the spinal cord is also actually within encased in the bones. However, that does

not make it disconnected from the outside the sum of the cells they are for example, the motor one, that they have the connection that is going out and the same way from the sense organ, that the neurons they are getting in and terminating in the spinal cord.

So, that is the way it actually collects the signal throughout the body and it can also that control the actions throughout the body. And that this interconnection of neuron they have a lot of interesting features; in the experiment it is found that if one part is damaged then slowly the other parts they take up that responsibility or start doing that job. So, it is peculiar that what we call that healing up. Actual healing may not happened in the brain, but part of the other part of the brain is reprogrammed to do that activity of the impaired region. And that is why it is told that our brain a very small part of it only we are using for our work and it has enormous capacity to actually store the information, to process the information and to give commands.

So, that is a brief overview about that the brain and the signal what we get out of it we call as EEG or electroencephalogram.

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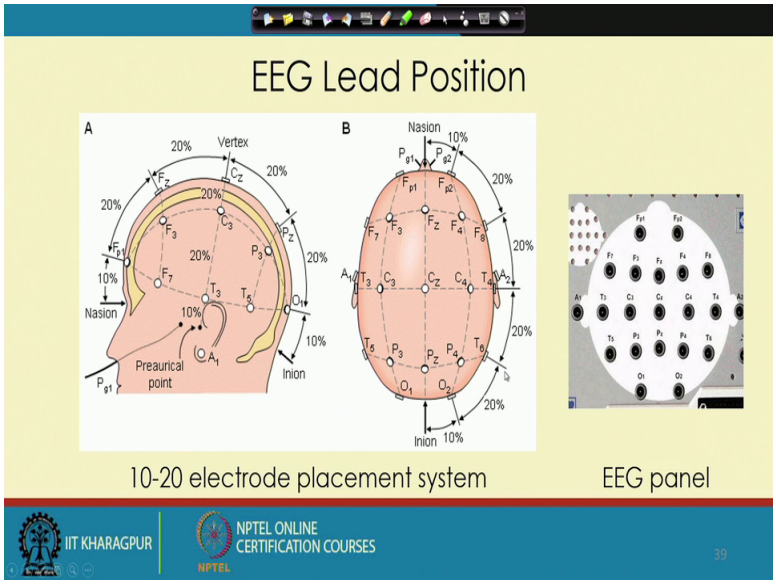

Now, let us go for the connections that how we are actually going to collect this signal. So, here we have given a that template, that a template is given here on the board that how the cords are connected to record the signal, and in the same way we have some points here. The two ear lobes they are marked as a 1 and a 2, they acts as a reference

and if you look at this is the skull we call this electrical that collections systems it is called 10 20 electrode placement system.

So, why this name if we look at that how the configurations are that if it take two axis are there, one axis is passing that from the left to the right ear lobe, from that left to right that is one axis another axis passing from the nose tip to that that this point that back of that inion that back of the that brain. So, that is another axis. So, in both the axis we are actually placing some electrode. So, if we look at first that that the end point of the nose to that inion after 10 degree. So, this this 2 if we take a it as a hemisphere. So, this is about one 8 80 degree apart.

So, after 10 degree we have a electrode placed then after 20 degree apart we have another. So, this is a way that we have the electrodes are connected. So, and they this is the way that looking at the length that after that 10 percent then 20 percent then 20 percent in that way the electrons are placed. Same way in between the distance between the two ear lobes, that if we take that like this if we go like these both the side just like a headphone. So, the connections are done in that way again and if we look at side wise also, that 10 percent 20 percent that proportion is maintained and these two axis they form a grid.

And those grid points we place the electrode and they are marked as that that F or T or C different names they are given. So, that is the way they are marked; this is the EEG panel where the signal are acquired for that one patient. So, when we are talking about the EEG signal. We need to talk about also we need to specify that what lead we have used to collect that signal otherwise that the description of the EEG signal remains incomplete.

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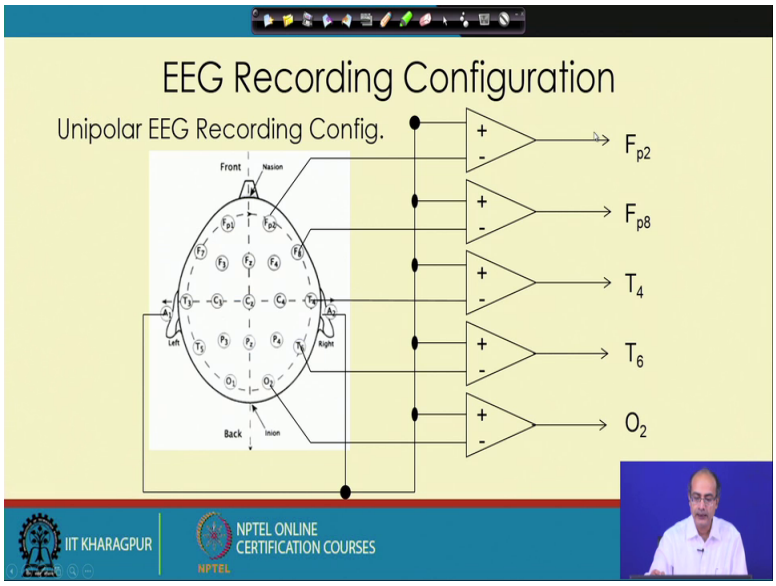

Now, let us look at some configuration first we look at the unipolar EEG recording configuration. In this configuration that we know unipolar means that we are taking one pole for that connection here it could be O 2, it could be here it could be O 2 or it could be that F 8. So, it could be any of this point and the reference is taken from the two ear lobes. The mid potential of the two ear lobes are taken as the reference and they are fit to the amplifier to collect the signal. So, we would tell that that unipolar configuration O 2 we have collected or we have collected it from F P 2 or F 8 in that way the signal would be marked.

So, what it can give us? It can give us the global activity of the brain and how they are varying from point to point. Because we know that different parts of the brain they are doing different job through this connections, we can find out that which part of the brain is getting activated when we are listening, which part of the brain is actually getting more active when we are visualizing a scene, which part of the brain is becoming more active when we are thinking or processing the that information. So, different part of the brain will actually get activated for different kind of that activities.

So, that can be detected or marked for using this kind of system.

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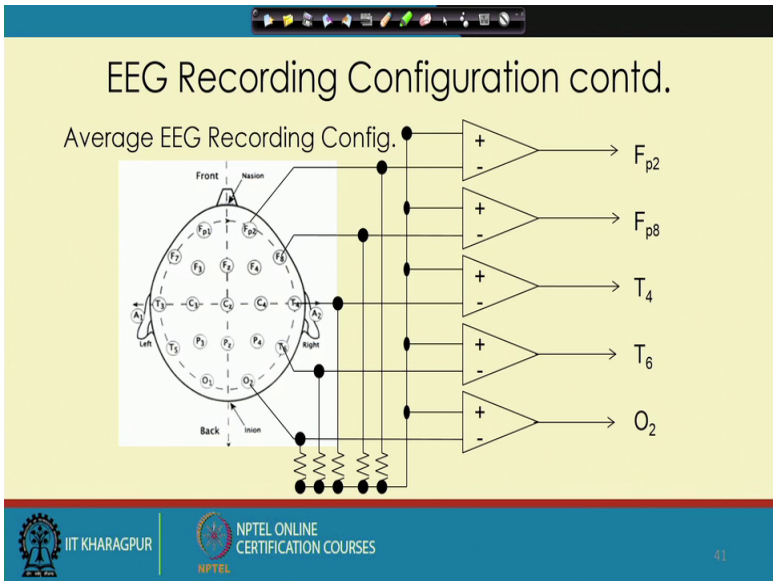

Now, let us look at average EEG recording configuration. In this case that we get the reference is taken not from the two ear lobes, but we connect actually all the points which we are taking for the study. And they are connected through some resistance and the midpoint of that resistance is taken as a reference and with respect to that again we have the unipolar leads, that is connected to one point we call that signal depending on the point where the that unipolar lead is connected that is F P 2, F P 8 or depending on that place. And here we get actually more uniform reference, because now the potential is the reference potential is the average of all the points.

So, with from a different reference we get the recording, but the nature of the signal would be similar to the previous unipolar connection, but as a signal would be different and to defeat that fact that we have the reference is the average of all the leads, this is called as average EEG recording configuration.

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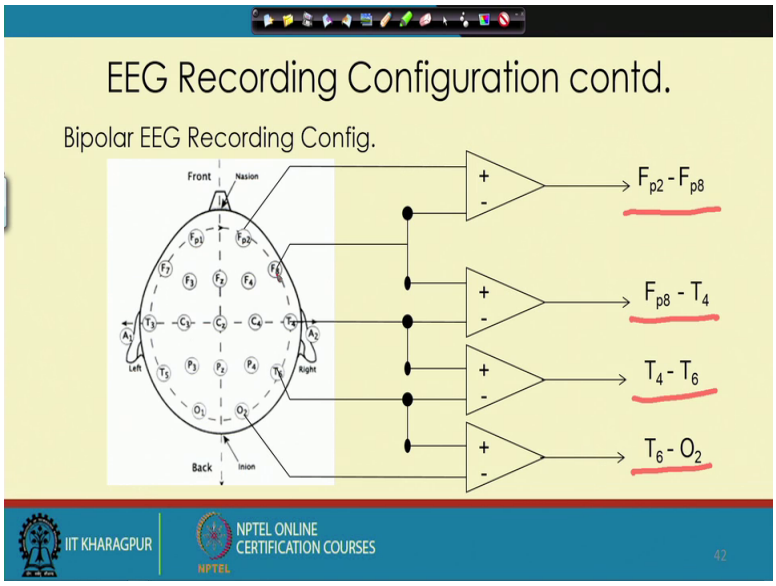

Now, let us look at a one more different configuration, this is bipolar EEG recording configuration. In this case the simple two actually leads are taken positive and negative and as we connect at two points as marked by the 10 20 system, we get the potential or the potential difference of these two points. Like here the first case it is a difference of potential of that F P 2 and F P 8.

The next one is in between F P 8 and T 4; the third one is in between T 4 and T 6 here the T 4 and T 6 are there and here it is will between the T 6 and O 2. Now the question could be that why do we need to take so many configuration. The reason is that they defect actually different kind of theme in the brain, that when we have some local activity, the local activities can be detected more easily using the bipolar leads. For example, a tumour has actually grown in part of the brain.

Now we can detect that with bipolar lead not only the detection we can get that locality of it using the bipolar leads, because the two leads are close to each other. And we know that the within this space the signal is coming, which that kind of the quantization or the localization is not possible using that unipolar lead or the average lead configuration. So, for diagnostic purpose the bipolar lead, it sometimes is more useful.

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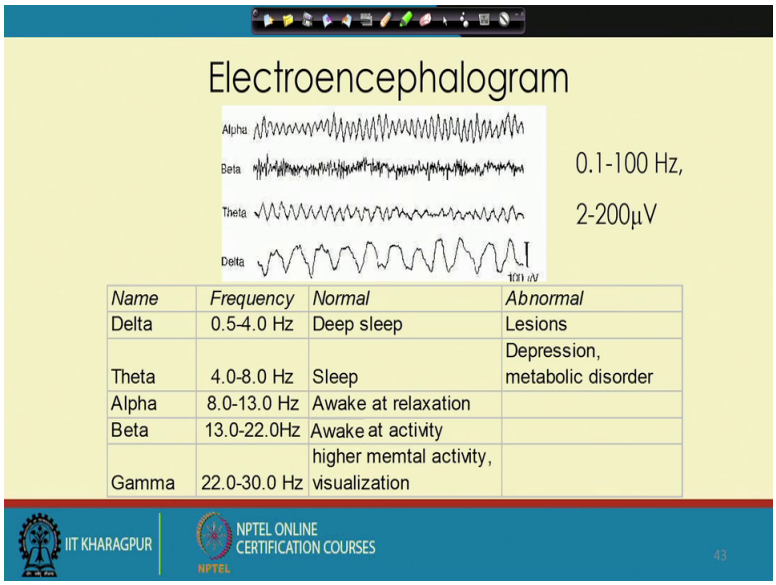

Name	Frequency	Normal	Abnormal
Delta	0.5-4.0 Hz	Deep sleep	Lesions
Theta	4.0-8.0 Hz	Sleep	Depression, metabolic disorder
Alpha	8.0-13.0 Hz	Awake at relaxation	
Beta	13.0-22.0Hz	Awake at activity	
Gamma	22.0-30.0 Hz	higher memtal activity, visualization	

Now let us move ahead and see that how the EEG signal looks like. The first thing that to note that when we told about the EEG signal, EEG signal is having much higher strength it was in millivolt range, now the EEG signal it is coming in microvolt range. So, these are much more weak signal, but we see that the signal bandwidth is also little more and that signals they do not have nice clean shape like the EEG signal. So, primarily that the EEG signal the its classified in terms of the frequency band, just like in our electrical engineering we use the band per signal. And we tell that within this band we have the signal that is the way that EEG signals are depicted.

In the lowest level we get the delta wave that is in between 0.5 to 4 hertz usually we get it in the deep sleep. So, if you get into the deep sleep we will get the signal, also when a person is awake we may give the delta wave if there is some abnormality like a lesions has developed. What we call as mass is known as or termed as lesion in a medical science and the next band we get that is the theta wave. It is in between the 4 to 8 hertz and we get it in sleep. Also it can come in depression or for metabolic disorder if some of us are put under the EEG and this theta wave is detected; that means, either we are sleeping we are not doing our job or we are having some kind of disorder like depression.

Next we get the alpha signal, where the signal predominately is from 0.8 to 13 hertz. Now what it means that within 8 to 13 hertz the maximum energy of the signal would be

located it does not mean no signal energy would be there beyond that, but the primary concentration of the energy maximum amount of energy would be there within this boundary 8 to 13 for alpha, and when we are awake at relaxation. So, we should emit alpha wave. Now, if the electrodes are connected on our brain, we are supposed to give actually alpha wave, some of us who are processing the signal at more carefully; may also give the beta wave that is in between 13 to 22 hertz; that means, within this band we will have maximum energy of the signal. If you are awake at activity we are doing the processing of the signal we are thinking. So, then it can emit the beta wave.

The next part is that we get the gamma 1; the gamma 1 it starts from 22 to 30 hertz in higher mental activity or visualization. So, if you try to visualize anything. So, the mental processing not only increases, but it gives rise to increase in the frequency of the signal it emits. So, we get the actually gamma wave. So, from our electrode if we get the gamma wave, we can also get that at this moment we are not listening to the lecture, but we may be visualizing something else. So, this is the broad description of the EEG does not mean that there is no pattern is detected in the EEG signal there are patterns, but these are the primary the classes of the signal.

This signals that alpha beta then theta delta gamma. So, this five they are the main classes, and apart from that for different kind of special activity, we can have some actually signals where we can get some shape and those things we will cover later.

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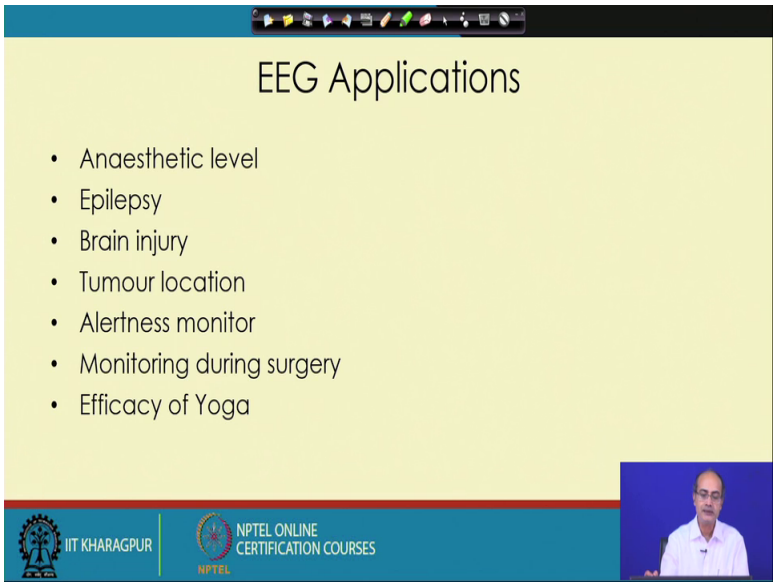

Now, let us look at some of the application of EEG or in other words why at all we would look at the EEG signals. The first thing is anaesthetic level; during the operation it is very important that the patient should be sedated. So, that the senses are not working otherwise due to the pain of the operation the person may expire. The person may not be able to bare that amount of pain and due to that shock the person may actually expire.

So, it is very important to know that the person is sedated sufficiently, but at the same time we need to be carefully that the person should not be sub due to that level, that it cannot be actually that person cannot be recovered back. That means, after the operation is over again we need to get rid of the actually that anaesthetic and the person should again come back to his senses or her senses; so that also is an important part. So, we need to very carefully monitor and control the level of the anaesthesis, and that can be done by the EEG. We know that at deep sleep it gives that delta wave. So, we can look at that that how much percentage of the total signal, it is in that delta wave through that we can get that level of actually the anaethesis and we need to control that and monitor that throughout the period of operation.

Next we look at epilepsy; now epilepsy is a disease which commonly known as that the person they have a tendency to collapse and that it could be very dangerous, specially if the person is driving or on the roads or very near to a moving machine. Now that because we need to be careful and diagnose that person that why that the person suddenly lost the senses and again he is recovering that the senses and becoming normal. So, that tendency can be found that looking at the EEG. In the EEG if we get some spike that suggest that this person has a tendency to have epilepsy or epileptic tendencies we can say.

So, that again EEG can come to the rescue, it can tell us that whether this person as a epilepsy tendency or not and if the that person is medicated, we can expect that those tendency should go again instead of waiting till that person again gets fainted and have an another risky affair we can monitor that using the EEG and get the number of spikes whether that has reduced and has become minimal and the patient is safe enough to do the day to day activity. So, that is another application.

Third is the brain injury; sometimes the people have accident while driving or some other way. Now whether the brain is working properly or not. Each of the lobe they are responding to the stimulus or not, that can be checked through the EEG. What could be

the task for example, one patient is lying that if we want to get that whether that their listening comprehension is working fine, we can ask that person to count the number of actually the bells so that the lobe responsible for listening, hearing that bell would get actually activated and the vein will be legally waiting again when that signal will come.

Now, there could be a little more change in the activity there could be two kinds of signal, one could be of lower frequency another for higher frequency and the patient may be asked that you count only the one which is having the higher frequency. Now the patient has to not only listen to that they need to process that thing that whether it is high frequency or low frequency, in that relative scale through his or her senses and then count it and also decide that whether in this case you will increment the count or not.

So, that in case of brain injury that such kind of function if it is effected, we know that that particular lobe is getting effected and injury is limited there. Next thing could be tumour; again when the tumour grows it actually affects that activity of that region. So, through the experiments of stimulus we can get that the other thing is that we can use that bipolar lead configuration and detect that when the person is awake, whether we are getting the delta wave that also can help us to find out that location of the tumour or lesion.

Again we can think of other activity like alertness monitoring. The alertness is very important for any task whatever we are doing we need to be alert and attentive. Now in some work these become even more crucial for example, a truck driver is driving a very good big truck. If that person becomes drowsy they may actually get into the pavement and kill so many pedestrians or think of a pilot actually is on that fighter aircraft. Now every moment they have to so many actions and monitor so many signals; if the person cannot take that load becomes fatigue, then we can actually have accident at any time.

So, in those cases it is important to monitor the alertness level of the person and that is possible through EEG. Next comes monitoring during surgery, that if it is a brain say surgery if the surgery is going in the brain, then you may be interested that whether the functionality of that part is maintained or it is getting impaired by your operation. So, what can be done that you could give the signals and monitor the EEG to know whether you are getting the response or not. Because the person is sedated the person would not

be able to tell that yes I can hear the bell or so, but EEG will tell that the human senses they are able to get some signal and that is actually that has reached up to the brain.

Again as it can look at the different functions of the brain, it can help us to quantify the effect of the exercise like yoga. In case of yoga the claims are that our mind becomes more thank full and peaceful we enjoy more. Now all this things are the claims made by the people who practices yoga, if all on a sudden one new person start that he would not be able to get that benefit immediately. And thereby it is difficult to quantify or ascertain in a quantitative way that is there any benefit of yoga or whatever the claims are made are they true or false. Now as EEG acts as a probe to get the brain activity, we can actually get that whether through yoga or through meditation we are getting more peace because some of the lobes become more activated when we are enjoying something.

So, using that EEG, again we can do that and that thereby we can actually monitor the efficacy of yoga or as an individual we can say that, how much benefit we are getting out of the meditation or yoga. So, that is about the application of EEG now.

Thank you.