Affective Computing
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Week - 07
Lecture - 03
EEG and Emotions

Hi friends. So, in the last module, we looked at the emotions in the GSR signal. A very popular physiological signal to observe the emotions. Now, in this, we again looking; we will again look at, a very common physiological signal and very very popular, which has become very popular in the recent years, is the EEG signal or as it is known as the electroencephalography signal.

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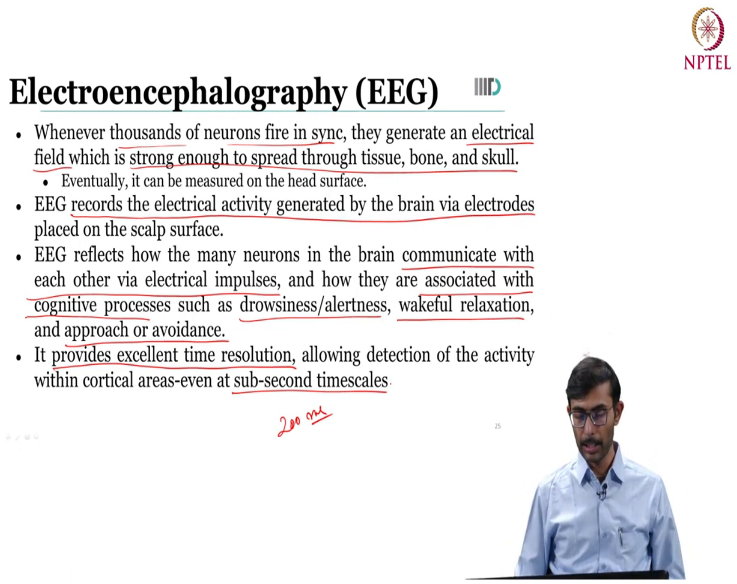

So, you may, you already know that our brain, it consists of millions of neurons and it turns out that in order to communicate with each other. They, these neurons, they fire in sync in order to do the communication. So, it turns out that whenever there is a firing of thousands of neurons together, then what happens that, they generate an electrical field which is strong enough to spread across tissue, bone and more importantly the skull.

And that is how we eventually measure the electrical activity of the brain on the head surface. So, this is what essentially is EEG. So, EEG is what? It records the electrical activity generated by the brain and how it records of course, with the help of certain electrodes that we place on the scalp surface.

So, we will see some example. And so basically, as I was saying that the reason, that the neurons fire in the brain, because they want to communicate with each other via some electrical impulses and this communication, it turns out that its not a random communication that happens, of course. So, these communications, they are associated, they have been shown to be associated with certain cognitive processes, such as drowsiness, alertness or intern, that is what you call as a kind of engagement, how engaged you are.

They give a sense of a wakeful relaxation, that whether you are in a relaxed state, even though when you are wake. And then of course, more importantly, they also tell you about whether there is an approach or avoidance attitude in response to something by looking at your brain activity.

So, then because of this reasons you know, that we are able to understand let us say, lots of emotional information of about the individual, such as the engagement, such as the cognitive, different cognitive states that an individual is in through the brain activity. And that is what it makes it very very exciting. Other important feature about the EEG signal is that it provides an excellent time resolution.

What it means, that first thing the response time of the EEG signal is pretty fast, is somewhere around 200 millisecond. So, basically from the onset of the stimulus, it takes around 200 milliseconds for the response to occur in the EEG signal. And hence, it allows the detection of the activity at sub-second time based scales.

As I said, within milliseconds within 200 milliseconds, you may have the response and so within a second, its a time-scale itself, you can analyze the activity that is happening, right. Activity in the sense, the cognitive activity that is happening inside the brain.

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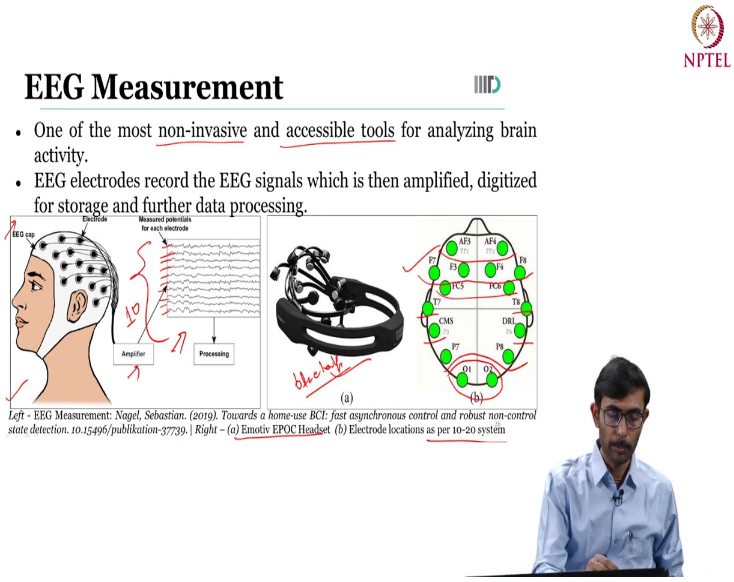

So now, having understood that, let us try to understand how can we measure the EEG signal. So, it turns out again, its it is; its not so in the due to the advancements in the variable technologies. Now, it is not. So, invasive sensor and tools that are used to analyze the brain activity.

So, basically, in this what we do? We put the EEG electrodes, such as the one that you are seeing on the left screen here. So, basically, this is a one diagram, where we are looking at how do we do the EEG measurement. So, basically, the EEG electrodes, this is what is the EEG electrodes.

And these are the EEG electrodes, they are put on the scalp, surface of the scalp using a in the form of a EEG cap, just to make the life easier, you know when you are putting it in the form of the EEG cap, it makes the replacements and all a bit easier. And then, what happens, then whatever signal that is, this electrodes are capturing.

Of course, it turns out that these are again very, very small minuscule voltages of course, because you are not a transformer, the human brain does not generate a lot of current or voltage thankfully. So, basically, whatever the voltage, whatever the electrical activity that the electrodes are capturing, then of course, that electricity is usually pass through an amplifier, which then amplifies it.

And then, of course, then it is sent for the further storage and for the further processing for these different electrodes. So, for example, here you can see that there are different number of waves, there are n number of waves. So, for example, in this case, this is 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. So, basically, there are different number of waves, that are representing the electrical activity as captured by the different electrodes.

So, for example, if there are 10 waves here, so basically, they are representing the activities of 10 different electrodes, right. So, as many number of electrodes you will have on the EEG cap, as many number of waves you will get further processing and for the further storage and the recording purposes.

And it turns out that nowadays, as I said, because of the advancements in the variable technology, there are many even more non-invasive and portable kind of headsets, such as this Emotiv EPOC headset that you are seeing on the right side.

So, you can see that the EEG Emotiv EPOC headset it constitutes around, it constitutes 14 electrodes. And among those 14 electrodes, you see that its not a kind of a in a cap structure, it is purely; it is a Bluetooth headset. What it means? That it simply captures the data through the electrodes and then it simply makes use of the Bluetooth to transfer the signals in a wireless fashion to the nearby computer or wherever you are trying to collect the data.

And it turns out that, you know like all the 14 electrodes that are there is being depicted on the this particular diagram. So, this is the locations of the electrode of the Emotiv EPOC as per the 10-20 international labelling system. So, basically, in order to understand this thing.

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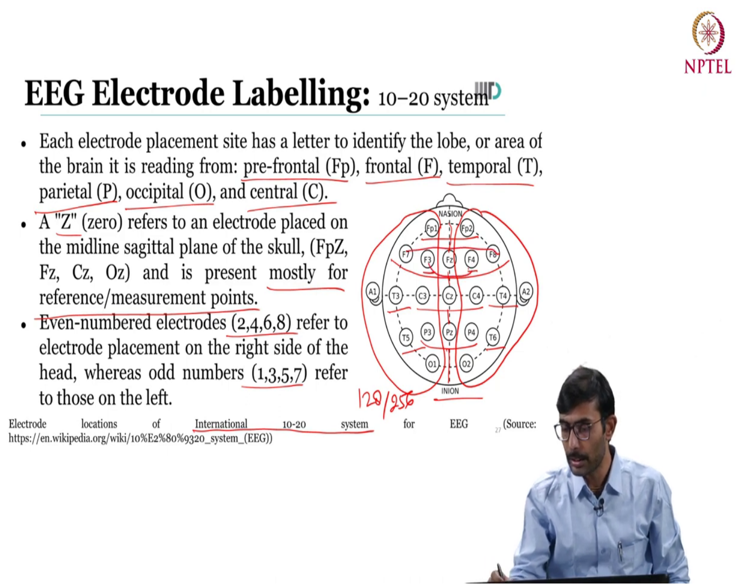

Let us try to understand what is the electrode labelling 10-20 system. So, basically this 10-20 international system, it is a international system to label the placement of the electrodes in an uniform fashion. So, basically, what it has, as you can see on this diagram, it shows you the electrode locations of the international 10-20 system for the EEG data.

Now, if you look at here, the electrode placements in general on the surface of the scalp is a defined in certain different areas such as prefrontal region. So, for example, if you look at this these two, so for example, basically this part is what is known as the prefrontal region of the surface.

Similarly, then you have the frontal region, so its not hard to imagine that why this becomes the frontal region. So, basically prefrontal and then you have the frontal region of the scalp. Similarly, you have the temporal region. So, basically, this is what is the temporal region of the scalp. Then you have the parietal region, so basically, this is what is the parietal region, you can very well imagine this is the parietal region.

And then you have the occipital region, so basically occipital region is at the back. And then of course, you have the central region and then that is what are the different regions in which the placement site on the surface is divided as per the 10-20 international system.

Now, apart from this placement reasons, there is a 0 that is often attached with a electrode and the 0 refers to as the midline sagittal plane of the skull. So, for example, if you look at this midline sagittal plane that is what is; that is what refers to the electrodes that are placed on this midline sagittal plane. And then accordingly they have becomes Fz, so electrodes placed on the frontal cortex, they become the Fz.

Similarly, on the central they become Cz, similarly on the parietal region becomes the Pz, right. And mostly, the electrodes that are Fz, Cz and Pz, they are mostly for the reference or the measurement points. So, the real data is not used in the analysis, but rather it is used to understand the baseline or understand the reference points of the EEG data, right.

Now, it turns out that as per the structure, as per this labelling system, the even numbered electrodes such as you know 2, 4, 8, 6 and so on so forth. They refer to the electrodes placed on the right side of the head, similar right. So, these are the even numbered electrodes, they refer to the electrodes placed on the right side. Similarly, the odd numbers such as these, they refer to the electrodes placed on the left side of the human scalp, right. So, scalp, so that is how is the placement of the 10-20 system looks like.

Now, of course, you know like these are not the only the number of the electrodes that can be represented, that you can have in a EEG system. Of course, you can have very well even 128 or even up to 256 electrode systems are very very popular. Well, are common, not so uncommon to have but nevertheless you can imagine the more the number of the electrodes, the more the density increases and hence what we call it as the special resolution increases with the more number of electrodes.

So, we will talk about the special resolution in a bit. And of course, you can very well imagine that with this what happens and that the precision of the data that you get it increases. Nevertheless, also it adds to the cost, it adds to the more intrusiveness, it adds to the complexity of so many different things, right. So, now having understood the 10-20 system, let us try to look at the electrode locations for the Emotiv EPOC.

So, if you look at this thing, so you have this AF3 and the AF4, what is this? Basically, these are representing the prefrontal cortex, prefrontal electrodes. Similarly, you have these frontal electrodes, right. These are the frontal electrodes, but which are more related to the central parietal. Similarly, you have the temporal electrodes; these are the reference point electrodes.

Similarly, you have the electrodes in the parietal region and these are the electrodes in the occipital region, right. So, that is how all together you have 14 electrodes in the Emotiv EPOC system, which is nice system, it is a portable system, its a wireless system and on the other hand, you can always have this kind of a; you know, the EEG caps that you are seeing on the left hand side.

Nevertheless, no matter what type of device you have, all these types of device, they make use of usually this international 10-20 system for the placement of the electrodes on the surface.

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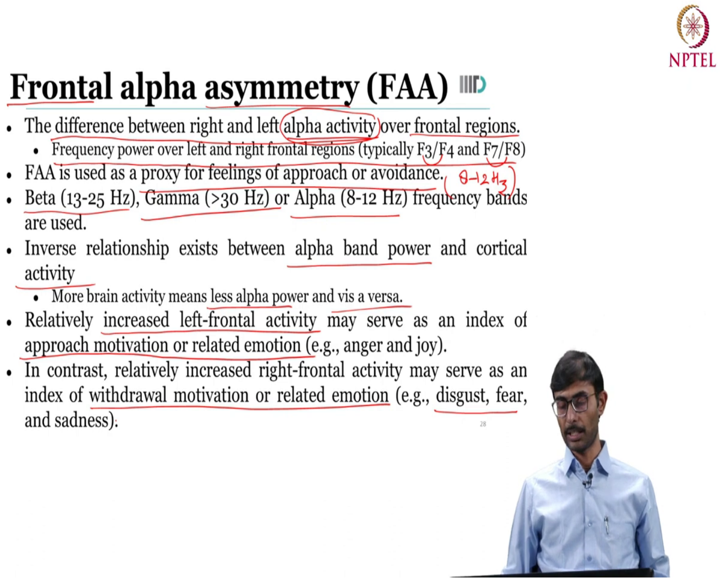

And it turns out that all these different reasons of the human brain, they represent then information about different areas, right. So, without going too much into the neuroscience, we will simply try to now look at the different features of the EEG signals that are related or correlated with the emotions rather than trying to understand the EEG data as such, right.

So, basically one of the very popular feature with respect to the EEG signal is known as the frontal alpha asymmetry. So, the frontal alpha asymmetry as the name itself suggest, basically this is what this is the difference between the right and the left alpha activity over the frontal region.

So, let us try to break it down. So, basically this is what, this is the difference between the right and the left. So, basically you have of course, you have a right hemisphere and you have a left hemisphere not hard to understand over the frontal regions. So, we already understand there is a prefrontal cortex and there is a frontal region. So, basically what you have of course, alpha activity we will try to understand in a bit.

Basically, what it says that it says the difference between the frequency power over the left and the right frontal regions and we talk about the left and the right frontal regions. So, basically you have several options, you can have either the F3 or F4 as a pair. F4 representing the right hemisphere, F3 representing the left hemisphere or you can even have the F8 and the F7, right.

So, basically you can have a pair of these two or you can have a pair of these two and in turn what you try to do, whenever you take the difference between the spectrum power of these electrodes that is what is known as the frontal alpha asymmetry. Now, where does the alpha comes from? You already understood the frontal; you already understood the asymmetry, basically the difference between the frequency power between the band power. Now, alpha where does the alpha come from, so let us try to well.

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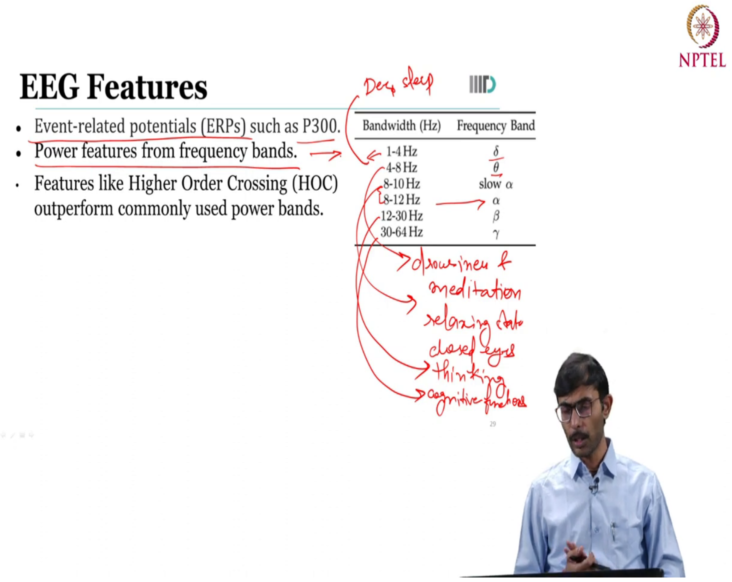

So, alpha is basically turns out that you know the EEG signal it can be categorized into the different bands as per the frequency ranges that it has, and so basically roughly speaking we have this we call this delta, delta is the frequency band that is representing the 1 to 4 hertz commonly and basically this particular region it represents the electrical activity when then individual is in the deep sleep state.

Similarly, you have the theta, so basically this is what this is representing the deep sleep state. Similarly, you have the 4-8. So, basically 4-8 is what? 4-8 is known as the theta region. And this theta region basically theta region the activity in this theta region that is the electrical activity within the 4 to 8 hertz of the EEG signal, it mostly represents the drowsiness and it also represents your condition let us say when you are doing the meditation, right.

Similarly, then you have the 8 to 10 hertz. So, basically 8 to 10 hertz and this 8 to 12 hertz these 2 are combinedly this is known as the alpha band. And basically, in the alpha band it is basically the activity electrical activity of the brain, when mostly you are in the relaxing state and many times when you have this closed eyes, right.

So, basically that is what is the these 2 are representing together and then you have the beta band. So, basically beta band is the electrical activity, that happens between 12 to 30 hertz and this beta band it mostly represents when you are in the state of let us say concentration or when you are doing thinking. So, it represents the concentration and the thinking.

Similarly, when you look at the 30 to 60 hertz, this is the gamma band. And in the gamma band basically what it represents, it represents different cognitive functions including the workload, cognitive workload that you may be experiencing, right. So, these are the different bands in which corresponds to the different sets of activities that the individual is involved in at least the with respect the cognitive state, right.

So, having understood that, now let us try to understand. So, now, you may have understood that ok, what is the alpha activity? So, basically alpha activity is what, you are trying to look at the frequency power in the alpha band. Alpha band is that 8 to 12 hertz frequency roughly speaking, right. So, basically you are looking at the difference between the F3 or F4 or F7 or F8, but of what of this 8 to 12 hertz frequency power for the EG signal.

Its not hard to understand again frontal, is the frontal electrode asymmetry is the difference and then alpha is basically you are looking at the alpha activity the 8 to 12 hertz and then when you talk about the frontal pair they are on two usually you take two pairs two sets of possibilities are there, either you take the F3 or F4 or you take the F7 and F8, right.

And it turns out and that is frontal alpha asymmetry, it is used as a proxy for the feelings of approach or the avoidance. What it means? So, when you are looking at an stimuli, when you are looking at an activity or when there is an external event towards which you are feeling engaged or you are feeling as more interested.

So, you are approaching that and then; so that particular experience or in the same way the experience of when you are feeling boredom, when you are withdrawing from the interest of a particular activity or an stimuli that is being represented by the FAA signal. right.

And as I said so, mostly we use the alpha band here, but many a times this gamma band which is the greater than 30 and this beta bands are also equally used. But more importantly this FAA is the most commonly used activity. Now, there is an interesting phenomena here, that it turns out that there is a inverse relationship that exists between the alpha band power and the cortical activity.

What it simply means, that if there is more brain activity happening, then there is less alpha power and vice versa. It means when there is more alpha power it means there is less brain activity happening. So, I hope that this is clear, again I will repeat. That when there is more brain activity happening, when there brain is actively involved in something or when certainly particular part of your region is of your brain is actively involved, then you will find that the alpha power for that particular region is less and vice versa.

So, now if you combine these two what it means, it simply means that when there is an increased left frontal activity, when there is an increased left frontal activity, what it means that it serves as an index of the approach or the motivation or the related emotion, right.

So, increased left frontal activity, it means you will have less alpha power here, when you have less alpha power in the left; in the left frontal region it means that you are feeling an approach motivation or let us say related motivation which in this case could be of the anger as well, which is an exception when it comes to the positive emotions.

Similarly, when there is an relatively increased right frontal activity, which means when you have a less alpha power in the right frontal region, then it means that there is an withdrawal motivation; withdrawal motivation see you are sort of experiencing a negative emotion and then you are trying to withdraw from the stimuli or from the event, which is in turn representing that you are feeling disgust fear sadness and so on. so forth, right.

So, now you can see how beautifully the frontal alpha isometry, again I will summarize it. So, basically the frontal alpha isometry it is used as a proxy or as an indicator of approach or withdrawal or approach or avoidance, in order to calculate the frontal alpha isometry. You simply look at the alpha band power that is the band power that is the power in the range of 8 to 12 hertz, in the F3 region or F4 region or F7 region and F8 region.

You take (Refer Time: 20:33) of 2 pairs and then you simply take what is the band power there and if you have increased left free frontal left frontal activity, which means you have less alpha power here, then it means there is an approach motivation there is usually a positive emotion, of course anger is an exception here you may be experiencing anger also.

And we have increased right frontal activity means when you have less alpha power in either F4 or F8 then it means that you are experiencing an a negative emotion which is an indicator of the withdrawal motivation or for example, disgust, fear or sadness, right. So, this is a very very important feature that you may want to look at.

And it turns out that it has been very commonly used in trying to understand, whether you are liking something or for example, whether you are disliking something right, and then quite easy to calculate.

Now, apart from these frontal alpha asymmetry there are different; there are other there are other features that are very very popular. Of course, again you have to understand this is again a time series signal. So, when you have a time series signal you can do the analysis in the time domain, you can do the analysis again in the frequency domain, you can do the analysis in the time frequency domain and so on so forth.

So, basically it turns out that the way we have event related potentials or event related skin conductance response for the GSR signal, in the same way we have the event related potentials in the EEG signal and there are different types of ERPs that we have for the EEG signals. And for example, one that is very popular we are also known as the P 300 what it means. So, basically the number 300 here it represents, the that there is an response within 300 millisecond from the onset of the stimuli, right.

So, that is what is for example, the event related potential and again you can calculate lots of statistical feature on it and the domain or the community uses a lots of statistical features on this P 300. Similarly, as I said I was suggesting you can definitely use the power features from the different frequency bands, you already know that there are different frequency bands for the EEG signal.

And then within those different frequency bands you can simply calculate the power and then using those power you can understand what exactly is happening in that particular region, right.

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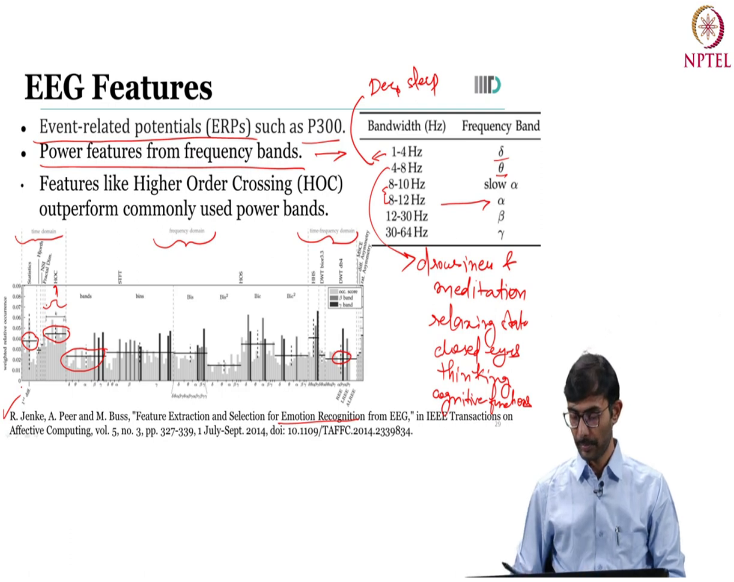

So, that is the power feature from the different frequency bands. And then it turns out that you know like there is a very interesting paper that for example, there is a very interesting paper which was presented by researchers in 2014 which nicely represents that what are the different features, that are related to the EEG signal in response for the emotion recognition.

And then it turns out that there they have shown that for example, advanced features such as you know higher order crossing. So, for example, if you look at this is the; this is what is representing the higher order crossing. So, for example, higher order crossing is what? Higher order crossing is simply the number of times, the waveform is crossing the axis, right.

So, basically you count the number of times the waveform is crossing the axis and you take some differences you take the difference of that, right. So, basically this HOC is for example, what the researchers have shown here, that this HOC this is the weightage sort of it is representing the weightage in among the different features when it comes to the for the emotion recognition.

So, you can see that these advanced features like the HOC for example, it is outperforming the commonly used for example, the power band features. So, this is what is representing the power band features. And similarly, it is even you know outperforming many different features which are even including let us say you know these are the DW2 feature which is discrete wavelet transform features.

Similarly, for example, there is other this statistical feature and so on so forth. So, without going too many too much in detail, again here you can see that here in this particular paper the researchers have tried to analyze and understand the different features of the EEG signal in time domain, again in frequency domain and again in the time frequency domain and then if you look at this particular diagram, it gives you very nice representation about the weightage or the importance of different EEG features with respect to the emotion recognition.

I will definitely invite the audience which are going to look at the emotion recognition from the EEG signals to have a look at this very interesting and nice article perfect.

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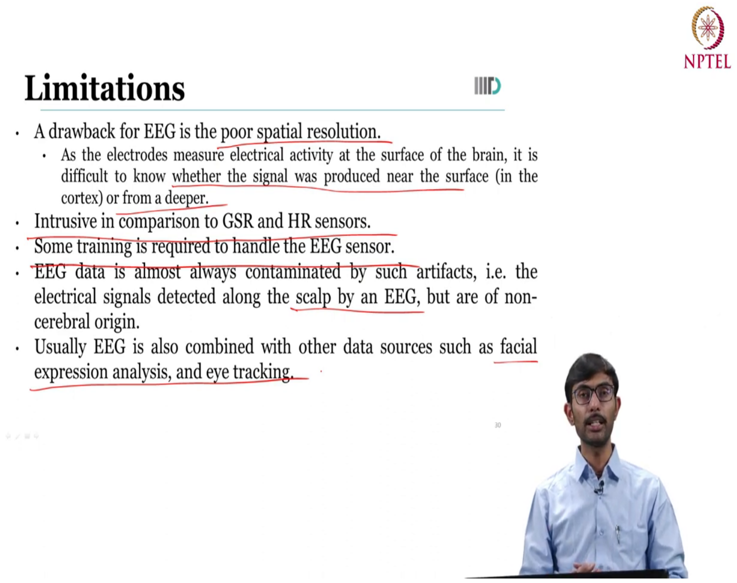

So, now we have already understood about the EEG signal and then we already are a bit excited. I hope that we are a bit excited about the use of the EEG signals. So, with that we have to also understand that there are certain limitations again associated with the EEG signals.

So, one limitation that is associated with the and it is very common with the EEG signal that it has a very poor special resolution. What it means? That while it has an excellent temporal resolution, it can it is very fast responsive signal and within 200 milliseconds it can give you the response to an external event or the stimuli.

You really do not know that whether the signal that is being produced is produced near the surface that is from the cortex or it is being produced at a much deeper level. So, basically you know there are different ways to and this is what we call it as the source localization problem in EEG domain to address this source localization problem of course, one way that you may have rightly guessed that is to make use of multiple electrodes, but now you can understand the more you have the number of electrodes.

Of course, it sorts of gifts you an hint, but then also there is no proper way to understand this source localization or to understand to resolve this special resolution for the EEG signal. Nevertheless, I think it is also very easy to understand, that while there is an availability of while there is availability of the portable and the mobile portable and non-intrusive devices, wireless devices; such as, Emotiv EPOC and there are others also in the market.

Its a bit intrusive. Actually, its a bit intrusive in comparison to the GSR and the heart rate sensors that we saw earlier. Nevertheless, it provides an excellent time resolution. Its a very, very effective sensor, but to handle this again you need some sort of training you know about the how to place do the placement of the electrodes on the human scalp.

And the skull and then at the same time you know how to you know perform the analysis of the signal that you are capturing. It requires a bit of understanding of the signal processing in order to understand how to do the analysis.

Of course, but bottom line is nowadays there are lots of tools which are available online and then at the end as I said like we will have a demo of certain tools, certain methods, methodologies which will definitely help you a lot in doing the pre-processing or in doing the analysis of the this physiological signals.

So, you need not to worry about it. Of course, its always good to have a background in the signal processing for this thing. One very important problem that is associated with the EEG data that; is it is almost always contaminated by certain artifacts. Such as, the electrical signals which is detected along the scalp of an EEG.

So, for example, as simple as that, so you know when you are capturing the EEG signals, as many times there is going to be a blink or an activity in the eyes, in the eyes, you are it is going to be reflected as an artifact in the EEG signal. So, you have to understand that when these artifacts are occurring and of course, accordingly how to remove them.

Again, it turns out there are tools which can do this job for you. Again, as I said so EEG while its a very interesting signal to have and it gives you a lot of information, many a times EEG signal again is combined with the facial expression analysis and the eye tracking to have a multi-model view of the emotion that we are trying to analyze and understand, right.

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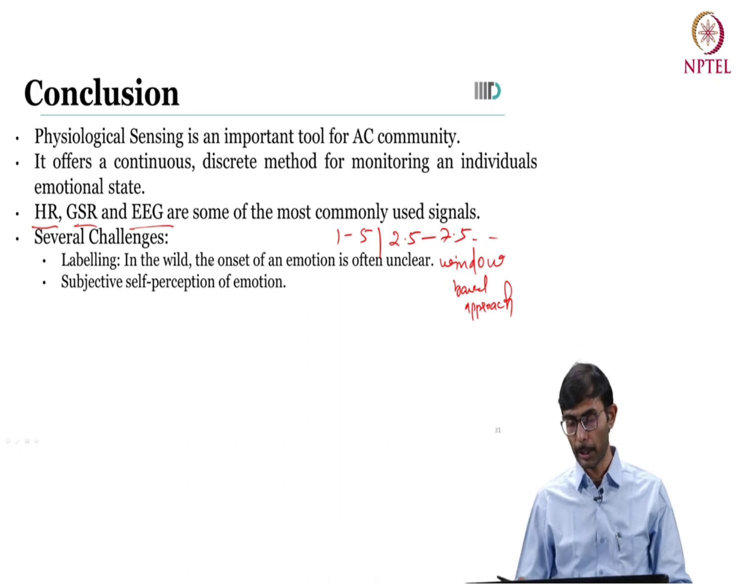

So, now we already understood about the emotions in the EEG signals. So, let us try to conclude and after that we will go for a demo on the how to process and analyze the physiological signals. So, it turns out of course, what we understood first that physiological sensing is an important tool for the affective computing community, more importantly because it gives you unaltered form of the emotion. It is it cannot be faked and hence it is sort of represents the pure emotions that are occurring in the humans.

Other important thing that physiological sensing in contrast to other form of sensing that is available, it allows you to have continuous and discrete monitoring of the individual's emotional state, right So, basically when you are trying to analyze the; let us say when you are using the self reporting to understand the emotional state you cannot really do a continuous monitoring over there, right.

So, you it cannot really ask every second, every millisecond that ok, how are you feeling and so on so forth, what is your emotional state, right. What it turns out if you have the sensors which are variable, which are portable, which are wireless then of course, you know you can with the help of those sensors you can really do a continuous monitoring of the emotional state.

Among the different physiological signals, what we also saw that the heart rate, GSR and the EEG signals are the signals which are most commonly used for the emotion recognition and the emotion analysis. And with this you know like among these physiological signals comes lots of challenges. Such as, of course one we talked about the labelling or the annotations. So, we saw that ok in the wild, the onset of an emotion is often unclear.

While you know when you have a very laboratory settings lab like conditions, you have a lot of control, you can really mark when the stimulus is being presented when there is an onset of the stimulus. But there is usually not much resources available when you want to do these experiments, when you want to collect the data in the wild. And then for the same reason there is this there is something known as windowing here.

So, window based approach. So, basically in the window based approach, what you do? Basically, rather than trying to analyze the signal every second, let us say or every minute you create a window of let us say 5 seconds, 5 minutes or something like that. And you try to analyze the emotion within that particular window and then you sort of you know moving window you make use of a moving window and then you let us say if there is a 5 minute window you move it with 50 percent interval.

So, then the first signal that will appear from the 1 to 5, similarly the second signal if there is a 50 percent overlap, may appear from 2.5 to let us say 7.5 and so on so forth. So, you got the idea right. So, this is known as a 50 percent overlap of moving window. So, you try to analyze this emotions in a window segments and then you try to do this moving window to capture to help you analyze the emotions without even precisely knowing the onset of the emotions.

So, other of course, the problem is the subjective self perception of the emotion. So, what I mean by the subjective self perception of the emotion. That of course, whenever you want to analyze the emotions, you need to get the ground truth of the emotions from the humans only and then it turns out that the emotions are very very subjective.

So, the same thing one individual may feel happy about, another individual may feel sad about and then it turns out that emotions itself are very very complex and then there are of course, defined well defined emotion models, but then you really need to make the participants understand those emotion models like in advance and to whatever extent you can.

So, that you know they can give you a good a perception of the emotion in terms of the models that you are trying to analyze or use.

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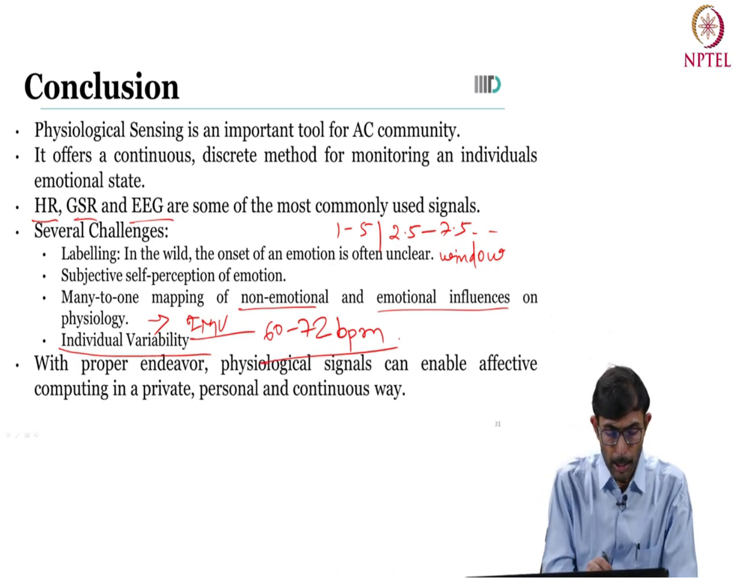

And this is something that is not, and let us say is specific to the; to the physiology signals, but it is common to all other modalities as well. This is interesting actually, so basically apart from this thing you know like it turns out that there is many to one mapping of the non-emotional and the emotional influences on the physiology.

What it simply means? That for example, while there may be response in the physiological signals, in response to an emotional stimuli, the same type of response in the physiological signals may also happen due to some physiological some physical activity as well.

So, for example, as simple as that if I sneeze at a moment; at this moment right now. Maybe you know just my sneezing itself will increase my heart rate to certain extent and it will make some changes in my physiology, which may not be related to the emotional state that I am feeling or it will not relate it will not be associated with the emotional state that I am in, right.

So, and it turns out that there is a many to one mapping here. So, basically you have non-emotional actions, you have emotional influences and for the non-emotional and the influence emotional influences you may have same sort of a physiological responses. And it turns out that it is a bit tricky problem when you want to analyze the emotions in the wild.

Of course, that is here you know people have used for example, you people have used different types of sensors again to understand how to differentiate among these two and one very popular kind of sensor is the for example, IMU sensor which is the initial inertial measurement unit sensor. So, basically the IMU sensors, what it they; what they do they try to observe the emotions.

So, the emotions of the human body while you are trying to observe the emotions making use of the physiological signals. So, of course, when there is a emotion detected by the IMU maybe you may not want to consider the physiological responses in that particular segment right, or you may want to be a bit careful while analyzing that.

So, that is one very important and interesting challenge that we have; again, one challenge that is very very common across all the modalities and maybe a bit more pronounced in case of physiological signals is the individual variability. So, what is individual variability?

So, basically individual variability is as simple as that; there are variations in the individual's expression of physiological signals. As simple as that for example, your baseline heart rate may not be the same as someone’s, else's baseline heart rate, right. So, for example, there is a range usually even for the healthy individuals if I am not wrong the heart rate the healthy heart rate looks like 60 to 72 beats per minute.

So, there is a reason that there is a range, right. So, because there is a individual variability 65 is also ok, 70 is also ok, 60 is also ok. And so, it turns out that you need to know this variability the baseline for the individuals in order to understand what is the change in the physiological activity for that particular individual in that particular sensor or signal, right.

So, this is also very interesting limitation that is there. But nevertheless, bottom line is like there is a lot of research and lot of work development that is being done, with respect to the analysis of the emotions in the physiological signals and it turns out that with the proper endeavour, right.

So, with the proper efforts it turns out that if you are looking at the right sensor, if you are looking at the right setting and if you are looking at the right type of analysis and machine learning and deep learning and signal processing techniques, then these physiological signals can enable very affective can enable affective computing in a very very robust fashion and which is private.

Of course, you are not it is some in many senses the data of the individual is private, you are not its kind of anonymized, you are not really looking at the identity of an individual so that is in that sense its quite private. Of course, its quite personal, again for the same reasons you are not trying to identify the individuals in that case, rather than you are simply trying to identify the emotions that individual is having.

And other thing that is very very important and that is not offered by many different modalities is that you can do the analysis of the emotions in an continuous fashion, which is not possible with the several of the other modalities and it turns out that it is a luxury when you combine this private personal and the continuous method attributes together, right.

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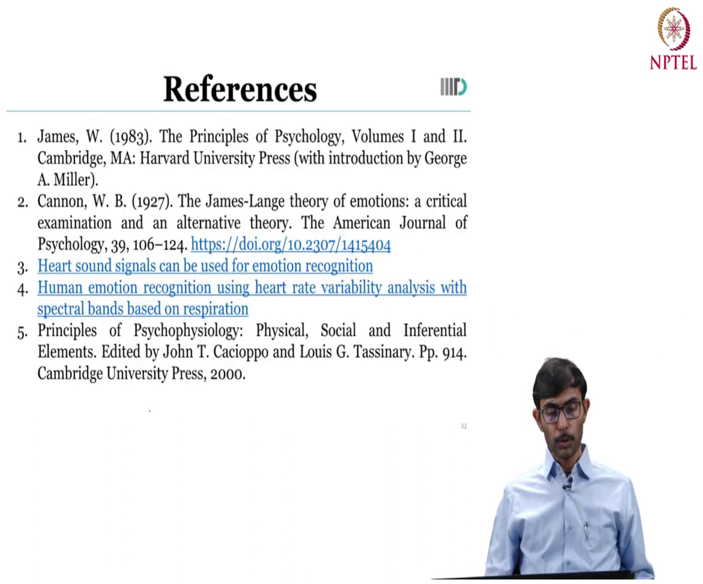

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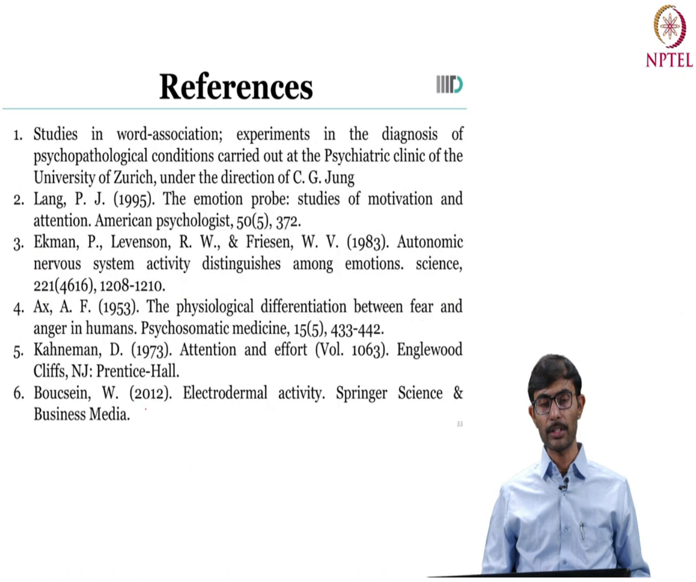

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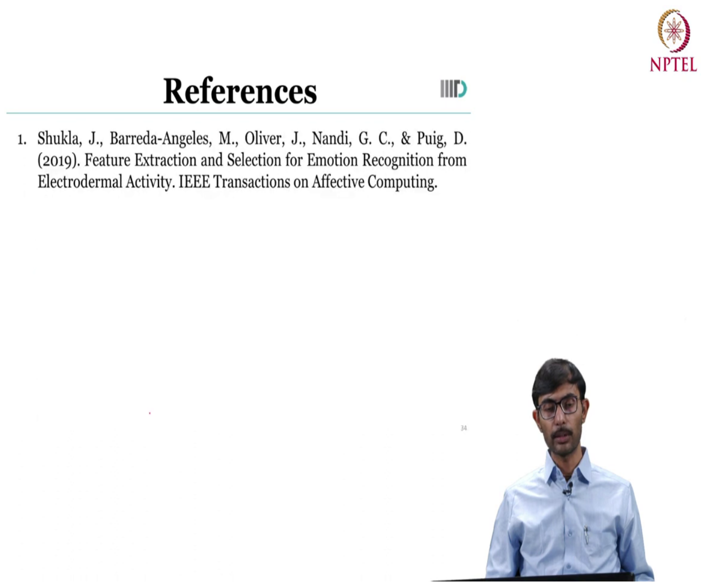

So, with that then there are lots of references that we used while trying to come up with this lecture. But that is all of course, we will provide the references you are to you and now we will try to look at the demo that we are talking about, that how to do the processing or the analysis of let us say particular physiological signal to understand the acquisition reprocessing may be feature engineering and then the classification ok. So, with that see you at the demo.

Thanks.