Neuroscience of Human Movement
Department of Multidisciplinary
Indian Institute of Technology, Madras

Lecture – 48
Primary Motor Cortex Part – 12

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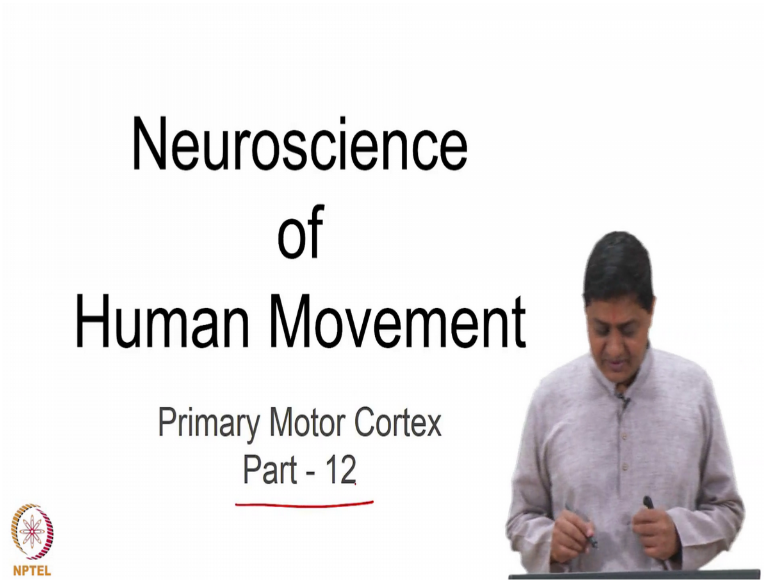

Welcome to this class on Neuroscience of Human Movement. So, this is part 12 of our discussion on a Primary Motor Cortex. So, we have been discussing recently about lesions and how the motor map is dynamic, how plasticity can be helpful or the possible role or possible exciting role of plasticity in improving brain function or improving motor function in people with compromised systems.

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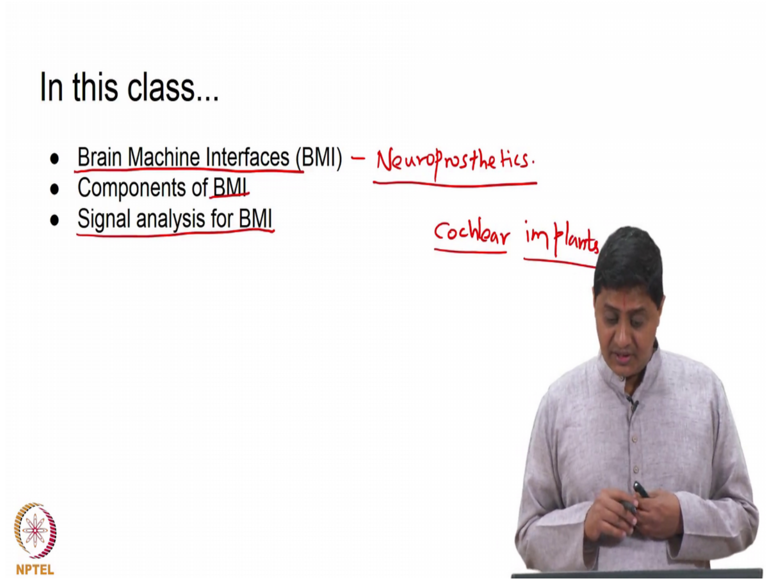

Another way to help patients with neuromotor disorders is brain machine interfaces. So, if you go to neuroscience conferences, there is this regular neuroscience that gets discussed in the regular neuroscience sessions and then you go to the neuroprosthetics, nanosymposium. For example, in society for neuroscience meetings, right.

It is hot, it is that particular place that is absolutely glamorous. It is that place where you know these individuals are going to stand and listen to talks. It is the everywhere else there will be a lot of chairs that are free, in any other nano symposium or symposium a mini symposium any other talks that are going to be charged that are going to be free because not every therefore, that room is designed for you know a larger audience, but usually just enough audience fill that rooms. But when it is neuroprosthetics the room will be full there will be people sitting on the floor and then there will be people standing on the floor. Why? Because this field is hot, super hot, right.

The other topic of interest is of course, neuroeconomics I do not want to get into that. So, this topic is neuroprosthetics and there are several components of this brain machine interfaces and how to perform signal analysis from brain machine interfaces.

Fortunately a substantial amount of progress has been made within prosthetics, not necessarily in the movement generation field, but in a different field. This is in the prosthesis of the auditory system for example, cochlear implants; substantial in my limited view in my humble view in my limited reading. I believe that cochlear implants are auditory prosthesis has made substantial progress within the neuroprosthetics field. Signal processing algorithms are very advanced, instrumentation for measuring and for implanting and for stimulating or very advanced are at a stage and it is very already commercially successful.

When compared with other for example, we compare this with other forms of prosthesis what are the other forms of prosthesis, movement related prosthesis or you know for example, I you know relatively limited success relatively limited commercial success relatively limited establishment of algorithms and instrumentation. However, in cochlear implants there has been tremendous success.

So, if we are to proceed at least in my view, if we are to be successful in improving brain machine interfaces for movement then we must learn the lessons from this field from cochlear implants. So, let us, but we are interested in this course on movements and improvement of movements. So, we will continue our discussion on how this can be achieved using brain machine interfaces.

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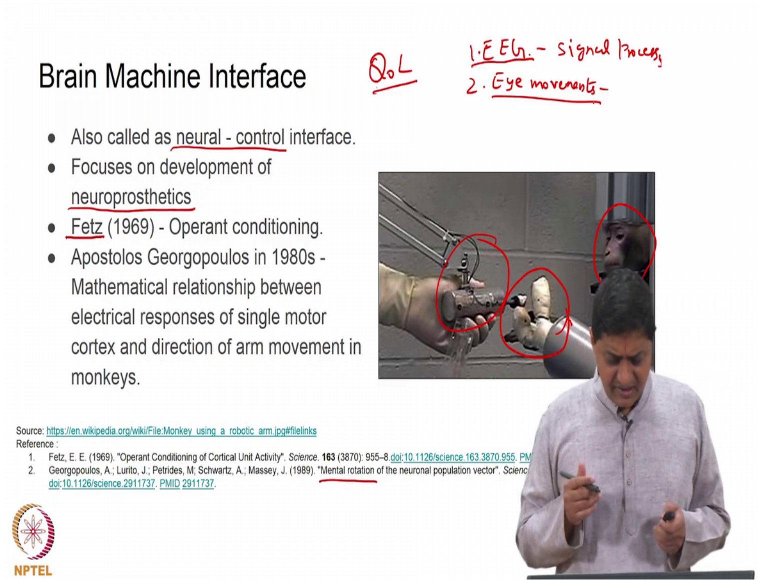

So, what is the goal these are also called as a neural-control interfaces. So, the goal is to develop prosthetic devices, right. It is possible for monkey an animal to be conditioned right, this was shown earlier much long ago by a Fetz and his colleagues right, and it is also possible to come up with a specific relationships between individual neuron our population linear populations of neurons to particular movement. So, this particular movement is elicited by this population of neuron, and this particular for example, population of neurons encode the direction in which the movement is going to happen we saw this from the work of (Refer Time: 05:00) for example.

And there are other things it is also possible for us to you know perform mental rotations, right mental rotations of the neuron population vector, brilliant study those who are interested must check that. So, it is possible to change all these things. So, a question is and the hot topic is can I move or can I perform movement for prosthetic limb, but a robotic arm by mere thinking. So, I am thinking like I am going to move and let us suppose some electrodes or recording electrodes are implanted in my brain and they could record the activity and perform movements using a robotic arm. The answer is yes technology is available today to convert thoughts into actions, right.

So, that is what this monkey is here is doing. So, here is the monkey that is seeing, right it is seeing the activity. It is not the monkey's hand you see this is the robotic arm this is the robotic arm, right. So, these are the robotic arms, right. So, the picking up of the treat for example, is achieved by the monkey by mere thought, right. So, with some training which say this, this is this would give you the idea wow, so this can be done so easily no there are several challenges along the way that have been overcome already before this monkey can actually achieve this that are not presented in this picture. So, those challenges that have been overcome are the lessons that have been learned have not been discussed as part of this, but at least that the main result the core result is that it is possible to achieve what we want in terms of. But why do we want that a question is why do, we need that is it. Does it even have any meaning? The answer is yes, there are individuals who cannot make movements who cannot perform movements even to communicate system movement system is completely compromised.

And we and they live for relatively long periods, no it is, because of improved medical care that is available that is good fortunately unfortunately. They will have to live with the disease. So, then the question then the problem that is challenge that is presented to us as scientists is how do we improve their living conditions or how do we improve their quality of life. If we can produce devices, if we can produce devices that perform activities of daily living for these individuals it is a huge step.

What do I mean by activities of daily living? The basic activity is such as buttoning up once own shirt or such as brushing your once own teeth or such as grooming oneself, right. Things that healthy normal individuals would take for granted, but for these individuals for individuals with compromised systems it is huge challenge and it is also greatly depressing for them when somebody else they have to depend on somebody else for drinking from a cup of water and they have to depend on somebody else to come at a particular time. So, they can brush and comb and dress themselves huge difference.

And by the way there is also depression due to clinical factors. So, these individuals are having multiple problems. One is that they have a compromised system that is causing a deficit or a huge deficit in movements, the other is that this compromised system also causes you know clinical depression and the fact that they are not able to perform even simple activities of daily living they have to depend on somebody else to watch themselves are to use the restroom has huge implications for their mental health.

And you know these individuals are going to live how do, we improve their quality of life, what can we do, that is the question. So, to that extent can, we come up with devices which can provide them basic movements at least. For example, buttoning once own shirt unfortunately, buttoning once own shirt trivial as it may seem involves you know relatively complicated mechanics, it is not a trivial problem. It is not like you could button your shirts with trivial mechanical the mechanics involved continues to be quite complicated.

So, there are multiple challenges in this field. In the good old days are the first approach towards this was towards achieving an acceptable prosthetic devices was performed using mainly using EEG non invasive technique still being continued its a hot field this is still being continued. And another approach was eye movements, (Refer Time: 10:00) challenges exist in these.

For example, EEG if you see is the activity that is recorded at the scalp level, right. There are about 6 layers from where the recording is where the recording is made to where the actual activity is originating; the activity, the neural activity is originating in the brain, but the recording is made at the scalp there are several things you know we know what is between the scalp there is scalp; scalp, dura mater, parameter, subarachnoid mater, cerebral spinal fluid, then the surface of the cortex and then the activity may be deep. If it is too deep then EEG may not be able to pick up. So, there are several challenges.

Yet advanced signal processing algorithms are available to classify this, but from these can be performed relatively complicated movements. It is an open question, this remember this is an open question. Similarly with eye movements there are multiple artifacts that could happen either with the EEG are with eye movements multiple challenges exist in terms of how to use this for you know real practical brain machine interfaces. So that is a huge challenge. People, there are groups of people who are studying these and improving algorithms improving instrumentation in these fields, but the hot field is the following can we record directly from the cortex.

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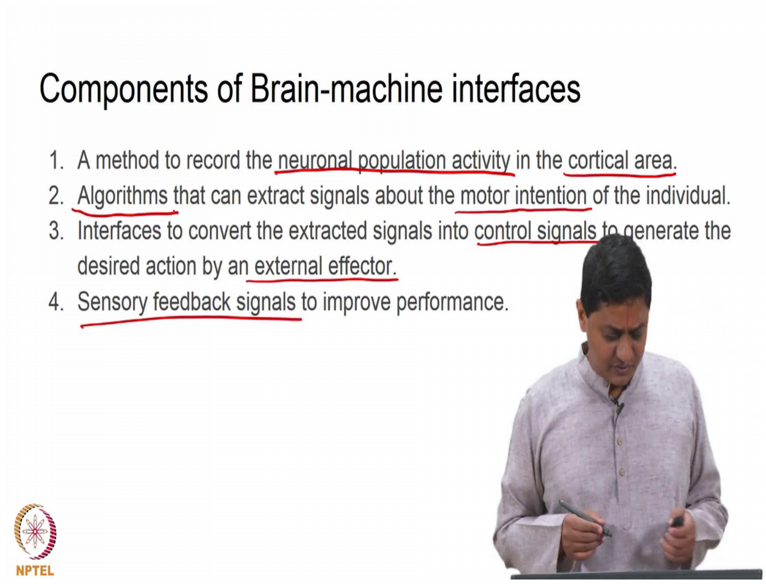

There has been substantial improvement in the micro electrode technology. So, we could implant you know electrodes in the cortex and record population activity from multiple neurons. And then use relatively advanced algorithms that can extract signals about the exact motor intention. What do you want to do? It is not clear what the person wants to do. I mean in a healthy person that is clear what the person wants to do the person will do after the person does what they want to do you know you know that is what they wanted to do.

In the individual with compromised system they want to do something, but nobody knows what they want to do. So, the intention decoding of that intention he is the challenge, right So, can we extract the motor intention from the signals that are recorded that is one, then this intention must somehow be converted into control signals that control mechanical interfaces, is it not control signals to generate you know particular movements by an external mechanical effector and more.

In the real system in the intact system we have feedback from the sensory system what are these we have said what these are, these are proprioceptors, cutaneous, receptors etcetera that are sensed by the whose activity use information about the external world to the primary somatosensory cortex. So, in these individuals it is possible that the sensory area is also compromised. So, sensory feedback signals are very useful to improve performance. So, then there must be two loops, one is sensing the other is actuation both of this must happen; relatively advanced algorithms are required. So, that is that.

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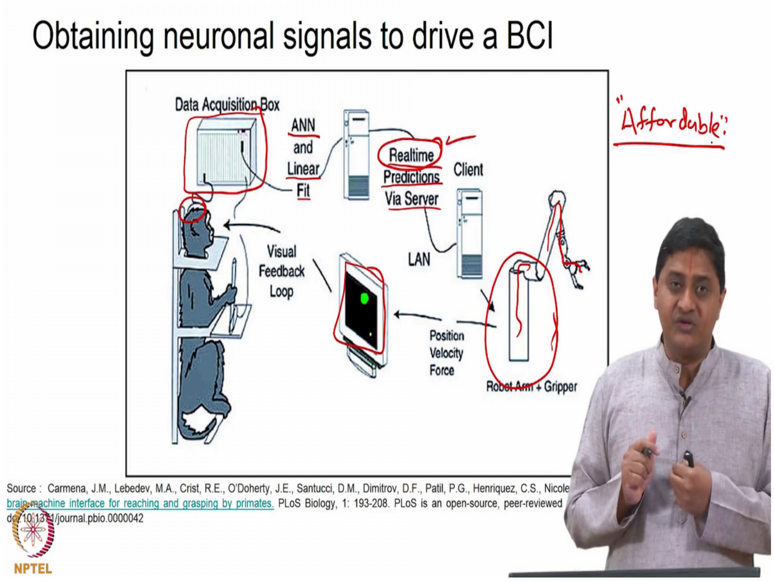

Here is an example system or a block diagram model or a rough block definition. So, this is a relatively early system about 15 years ago. So, the monkeys intentions are recorded from the; so this is from implanted electrodes and from a relatively advanced data acquisition box. So, these are the challenges that we will have to overcome.

The system that we make must be portable must still be very very effective and have high computational power, is it not. So, must be able to execute algorithms such as artificial neural networks and perform fits may be linear or non-linear as the case may be. And then predict make you know real time predictions that are then converted into actions by this robotic arm this is multi degree of freedom robotic arm the displacement. And this position and velocity is fed back to the monkey, so the monkey is seeing what is being done and it wants to learn to move the actual robot up. All this we want to happen, most important word real time.

Now, we have been somewhat successful in achieving this, but not super successful, there are still challenges. Challenges exist in you know reducing size, challenges exist in improving computational efficiency, challenges exist in instrumentation, challenges exist in signal processing. Most importantly challenges exist in making these systems affordable.

Unless the system is going to be useful to a relatively large number of people these systems will continue to remain in scientific in the scientific papers, but not necessarily in the hands of individuals. How do we make these systems affordable and help people? Are we doing this to why are we doing this? I would I would presume that we are doing this to help people, if we are doing this to help people the goal is to make them affordable and practical and practically useful.

So, it should not be so difficult that nobody wants to use it not, it should be too simple that it has no practical application. So, that trade of, that (Refer Time: 16:05) is difficult to achieve that is the reason why there is less commercial success of these systems when compared with for example, cochlear implants. Cochlear implants are relatively successful commercially when compared with say you know movement prosthesis. Why? From time to time you see this exciting YouTube videos that show, oh here it is you know a robot that is moving by mere thinking. Yeah, those things are cool.

But is are these things being used by individual who need it, are these things commercially viable and sustainable as an option. That continues to be the question and that is one area where people like us can contribute.

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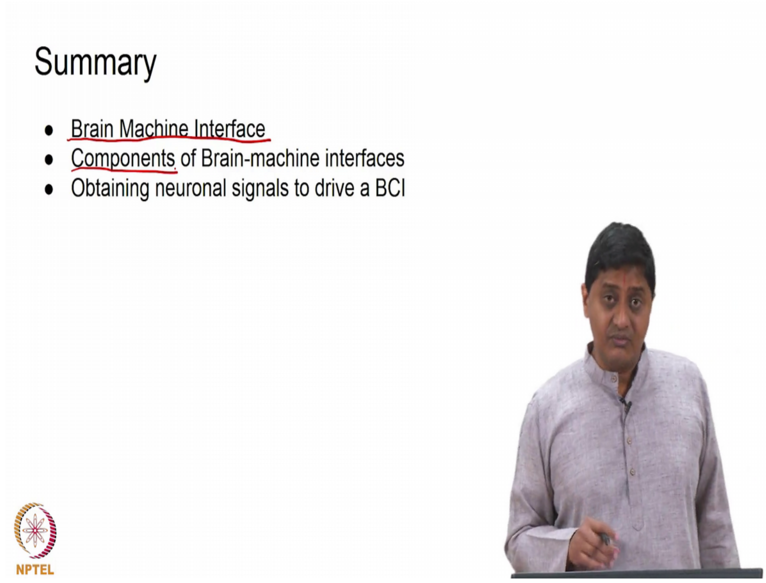

So, in this class we have seen what is a brain machine interface and discuss some aspects of brain machine interface, what are the components and how to obtain neuronal signals, how is this obtained nowadays from implanted electrodes. By the way with implanted electrodes there are challenges, ok. So, with this we come to the end of this class.

So, thank you very much.