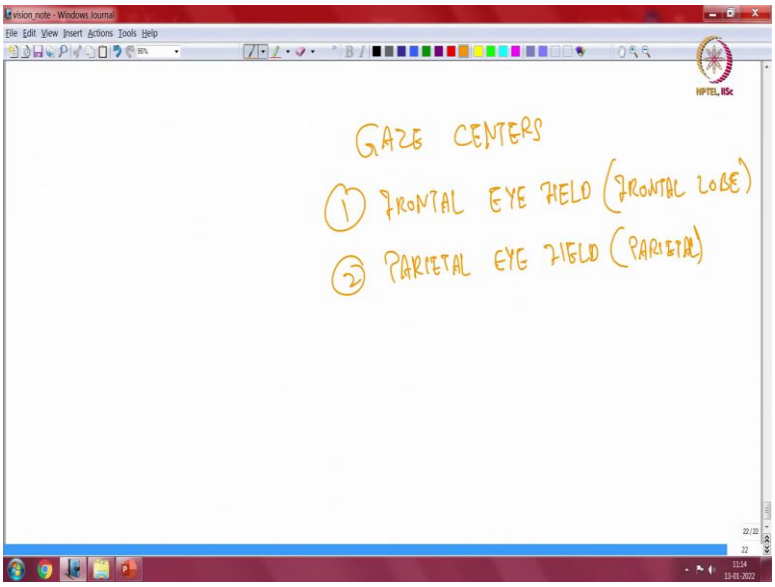
**Neural Science for Engineers**
**Prof. Vikas V**
**Department of Electronics and Communication Engineering**
**National Institute of Mental Health and Neurosciences (NIMHANS)**
**Indian Institute of Science, Bengaluru**

**Lecture - 39**
**Human vision system - III**

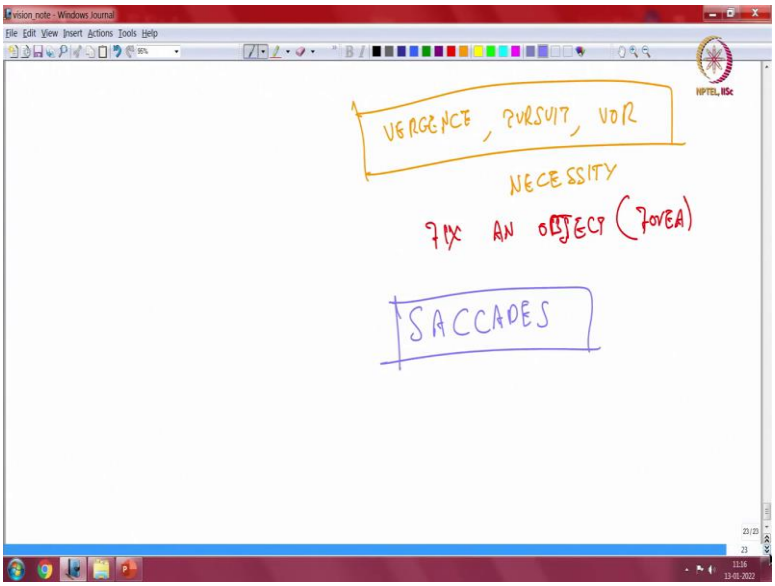
(Refer Slide Time: 00:22)




So, gaze centers you have two; one is frontal eye field, basically in the frontal lobe that is all that is required and parietal eye field parietal lobe. So, these eye fields send signals to single nucleus, that nucleus is hard wire to the opposite side nucleus, and they send signals to their respective muscles where which are innovated.

And that acts synchronously which results in these synchronous kinds of movement. So, that is about the wiring part of it, the nomenclatures and little bit of what constitutes the mechanism for eye movement.

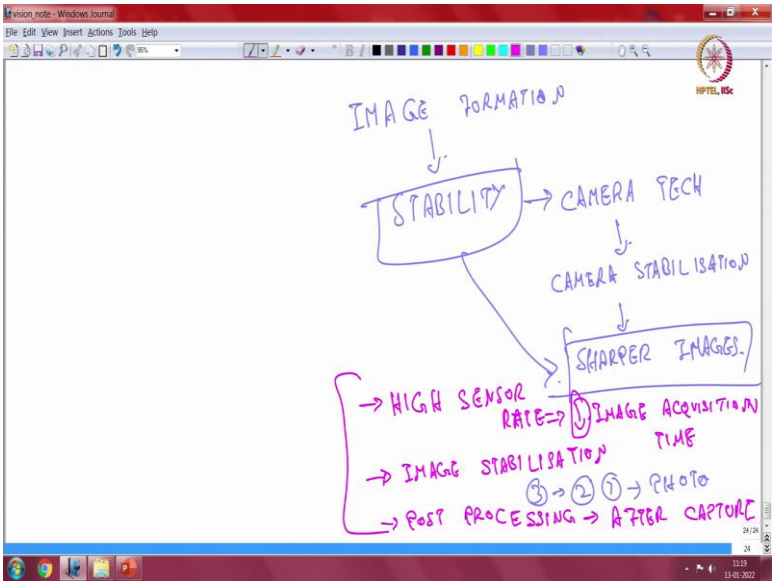
(Refer Slide Time: 01:33)




But we jump in a little. So, vergence, pursuit, VOR are logical, you have a necessity and I think I have explained to you what the necessity is. You need to fix an object to the fovea, that is the function which is being implemented. You ensure that the light from that particular object is always falling onto the fovea and that is how you get attention.

So, that is the idea of it. Now having said that, the odd man out or the odd woman out here is saccades and saccades is a mystery. So, I told you that at the end of this story I should tell you how it is different from camera.

(Refer Slide Time: 02:41)



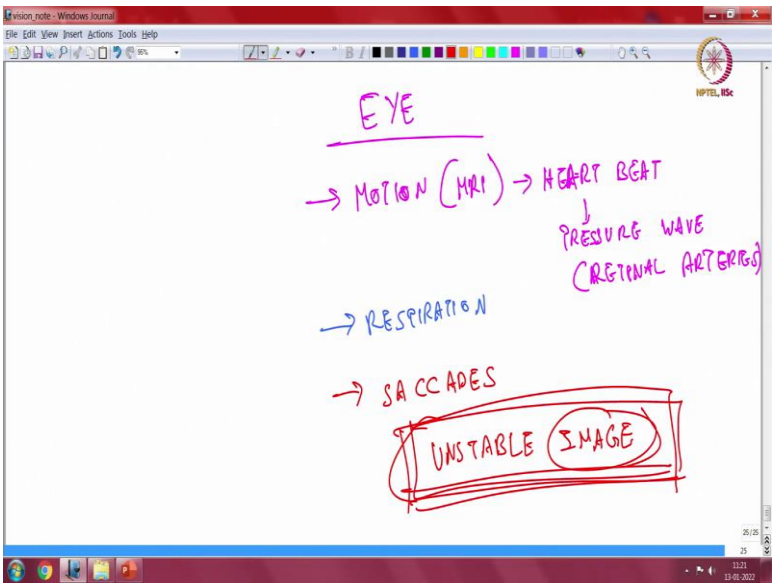
Now one of the key concepts in image formation is stability and if you look at camera technology a lot of effort is there in camera stabilization, so sharper images right. So, you are the engineers you should tell me that you agree with this logic that stability is directly connected to sharper images. That is the more stable the camera you have sharper images. So, stability can be ensured with a high sensor, what do you call sensor rate which is implying that you know very low image acquisition time right.

So, you have a high sensor rate you know you have very small durations of exposure by which you capture that and so, that causes reduced image acquisition time, then you have image stabilisation. So, you have this you know 3, 2, 1 and photo, that is you have time for the camera to be stabilised when you capture the photograph.

So, and then you obviously have got post processing after capture of the image. So, there is a lot of tech which has been devoted to this idea that you need to have a sharp crystal clear images and there is a lot of tech devoted to ensuring that the light gets spread uniformly across the image. And this is the image which we use. The raw material for image processing and all subsequent things.

So, better the quality of the image, better is the output in segmentation object recognition etcetera. So, this is a fundamental principle which is there in camera tech.

(Refer Slide Time: 05:41)

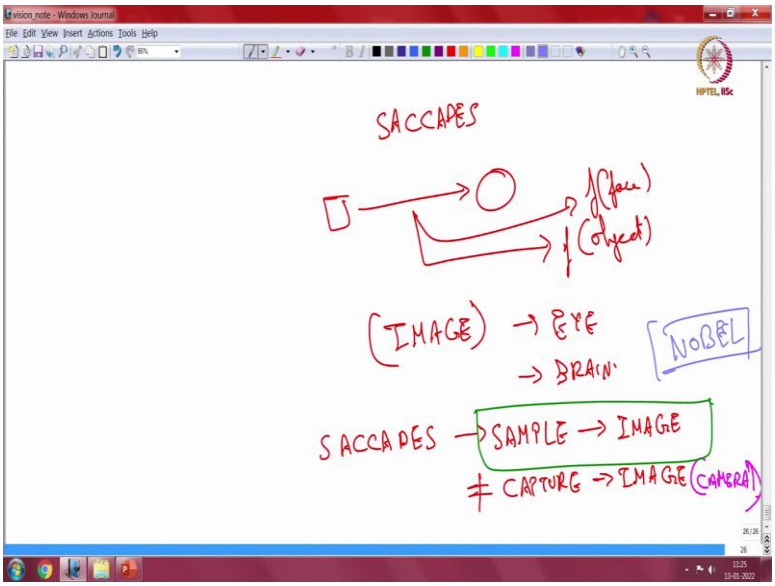


Now if we look at the eye, its odd because you have motion as a fundamental problem. Now motion is a fundamental problem if you remember my discussion on MRI, you have heartbeat. I told you there is a pressure wave which is generated from the heart and then it goes. And if you remember where all the pressure wave there are these arteries in the eye.

So, retinal arteries you can sort of see the pulsation it's more than seeing part of it I want you to imagine that these things exist. So, you have motion due to that and on top of that as if that is not sufficient, you have a respiration. In fact, your entire body moves with respiration and on top of that you have saccades.

So, it is as if the body is looking forward for unstable image. So, somehow the body conspires that you have an unstable image. Having said that the term image itself is a question because of things which I have discussed in my earlier classes. So, there is this notion that human vision is completely different from camera-based vision, image-based vision and video vision.

(Refer Slide Time: 07:56)




So, when we saw our earlier diagram that saccades help in fixing from one object to another object which maybe face there can be an object. So, this is what the saccades do. So, what it means to say is that we almost never have an image neither in the eye nor in the brain.

So, there are these fleeting glimpses of the entire environment a part of which is captured through saccades. The saccades sort of sample and image as opposed to capture and image which is what happens in a camera. So, this is an audience to which I can confidently discuss this kind of stuff, you have to acknowledge that it is there, and it has been there evolutionarily.

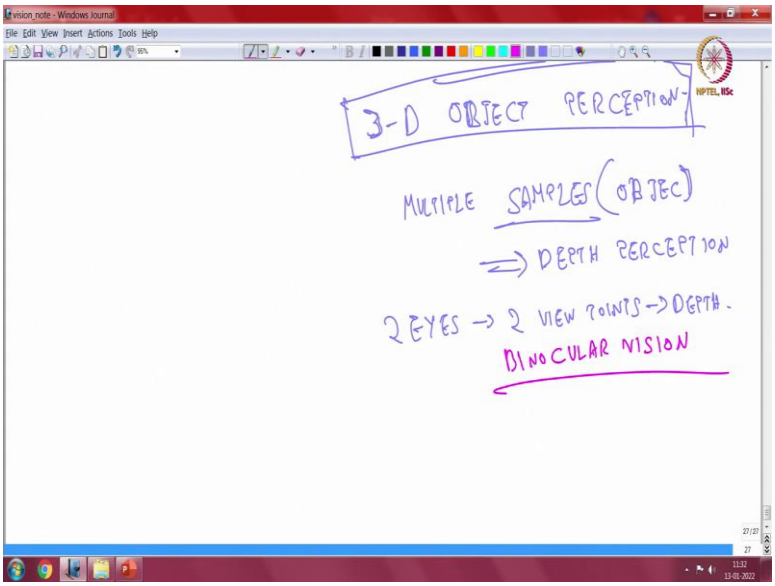
So, you should understand that it has some significance for which it is retained. For systems which are dynamic you know for the body, the biological system understands that it is never at rest. You have to be dead to be at rest. So, there is no way in which at the highest levels of your concentration, at the deepest levels of sleep are you stable, static, immobile.

And the visual mechanism incorporates systems, I am calling it a system, by which it does something different to capture the visual information photon-based information from outside. And this information is what we use for majority of our work and that is something which I wanted to highlight. So, the term sampling of an image is something which I need you to take forward, people who are interested can work on it and if you remember somewhere before in my prior class, I had used this key word Nobel. So, why it is a key word is now I think you can understand.

So, for people who are familiar with image processing people are familiar with camera tech who have an idea of how camera tech works the gyroscopes to stabilize cameras and you know the fancy cameras which are there. They would understand that the eye human eye or the biological eye works on very different mechanisms, very different principles and it's a very effective image processing system.

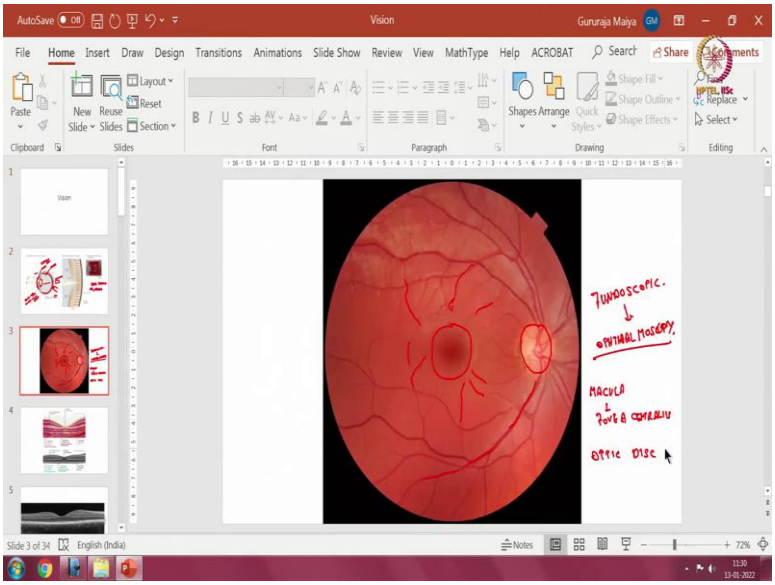
So, image processing in the biological concept it is not just about capturing images and getting shapes, segmenting, feature recognition and comprehension of the objects, it is a different ball game altogether. So, it is at various levels. I think I will module it a little more. Now we look at a very related topic of 3D object, perception. Now why did I choose that, I think you would arrive at the answer at the end.

(Refer Slide Time: 11:36)




So, 3D object perception. So, we will go back a little bit on my earlier slides on vision and we will start out with that.

(Refer Slide Time: 12:07)

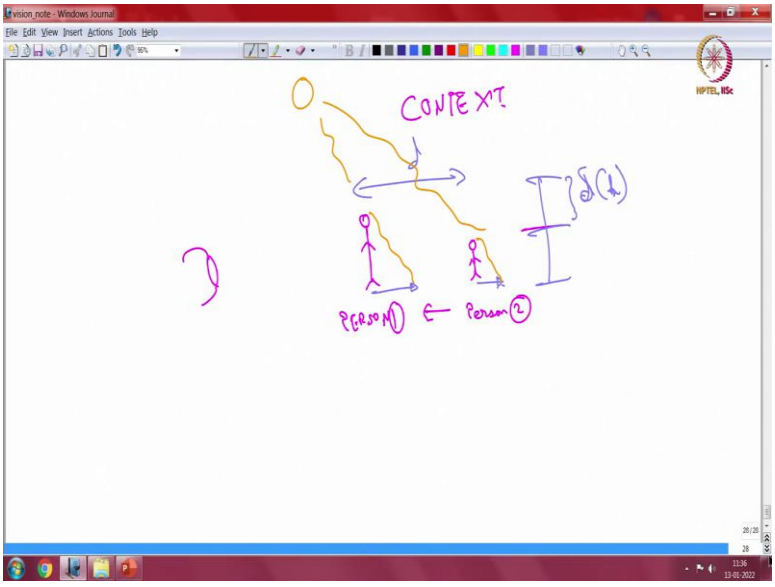



So, 3D object perception is; how do you perceive 3D, you need multiple samples of object and that would infer depth perception right. So, why I use the term multiple samples. So, you have two eyes which give two viewpoints and that gives you an information on depth then. So, that is the conventional idea, it is called as binocular

vision. So, binocular vision is you are looking at from two different eyes and then you are able to perceive depth in a given visual scene.

So, that is how you perceive depth in it, but you know you close one of your eyes and then see objects you still can find out a lot of depth information which is there. So, which indicates that you know two eyes are not absolutely essential for depth perception.

(Refer Slide Time: 13:54)




So, a lot of information is got from context, if you are able to see two human beings standing person 1 is closer to person 2 because of change in height. So, this distance can be computed based upon based on this difference in height.

So, this is the way in which you can compute distance between two objects based upon known factors. So, known factors are you have a perception of how objects look within your field that is an learnt experience and even more than learnt many of it is ingrained within your networks.

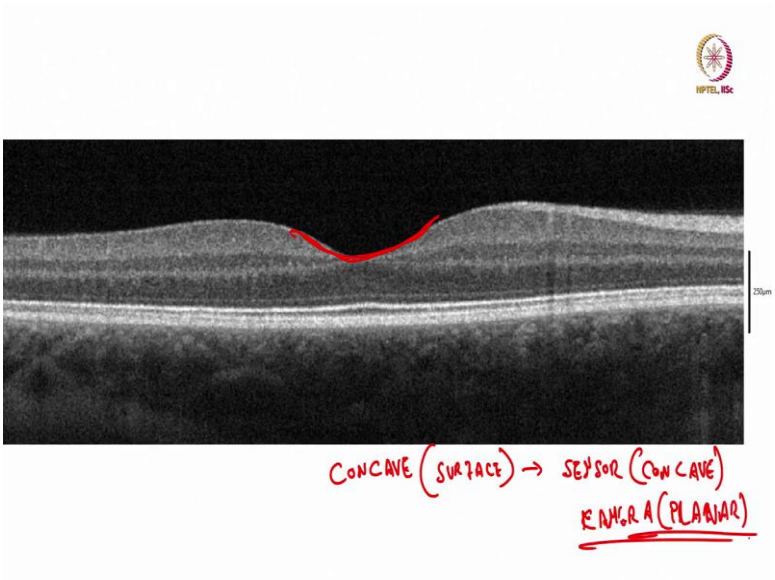
So, object recognition is already built in and then you can decide which object is in front of what other object and you have a sense of distance based upon incidentally based upon your experience. So, for me as a surgeon I can perceive objects which are within about 2-3 milli metres in depth, that is my job.

So, for people who are outdoor and who work in large distances can actually relate to objects to an extent of a couple of kilometers; I am very bad at that. So, I know that when

I look at an object at a distance then I would not be able to exactly relate how many miles or kilometers its far from me.

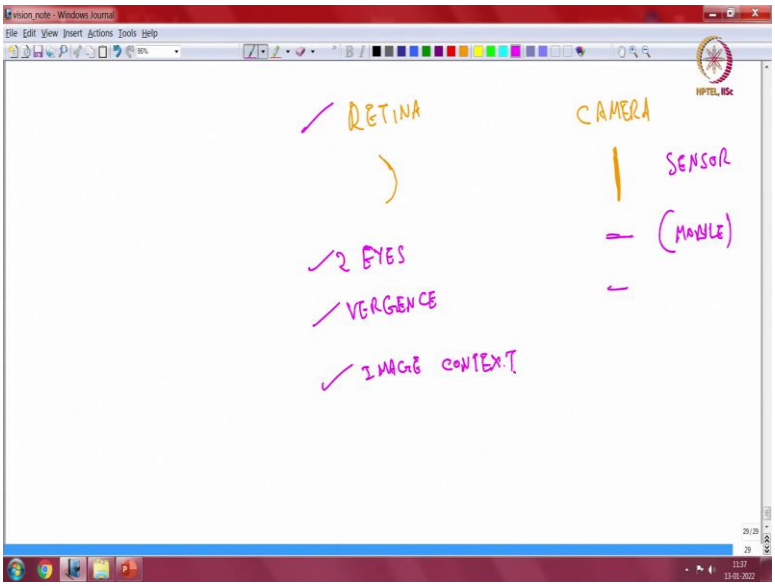
So, there is a lot of learned stuff there and the perception of depth is related to all of that. Now also you can also if you add in lighting, you have more interesting things in which you can get a shadow out of the person. So, these are mechanisms by which you can relate to distances and depth and you compute depth. So, once you get the depth information you have 2D switching on to 3D. Now why did I spend time discussing something like this in a context of a saccades.

(Refer Slide Time: 16:44)




Now that is where I would like to go back to this particular diagram. So, I did specify earlier that this is the fovea and please do note it is concave. So, you know the place where the image is formed is a concave surface. So, the sensor is concave. As opposed to I think most cameras at least which I know, camera is all planar you know you have a plane planar and then planar.

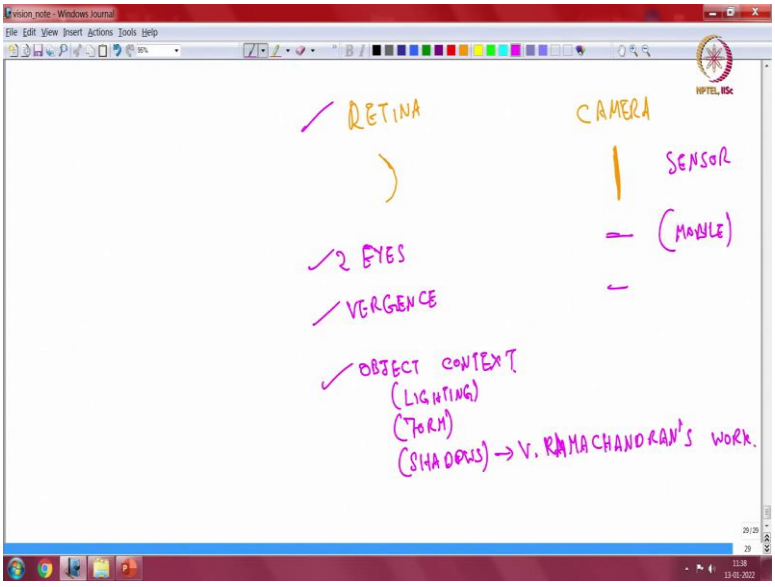
(Refer Slide Time: 17:43)




So, retina camera. So, concave retina planar camera. So, that is the sensor system, so this is sensor. Next is you have two eyes and then there is vergence, none of these things are there in camera. You do have two camera and three camera systems. But say for example, mobile in which it is sort of better to extract the 3D information.

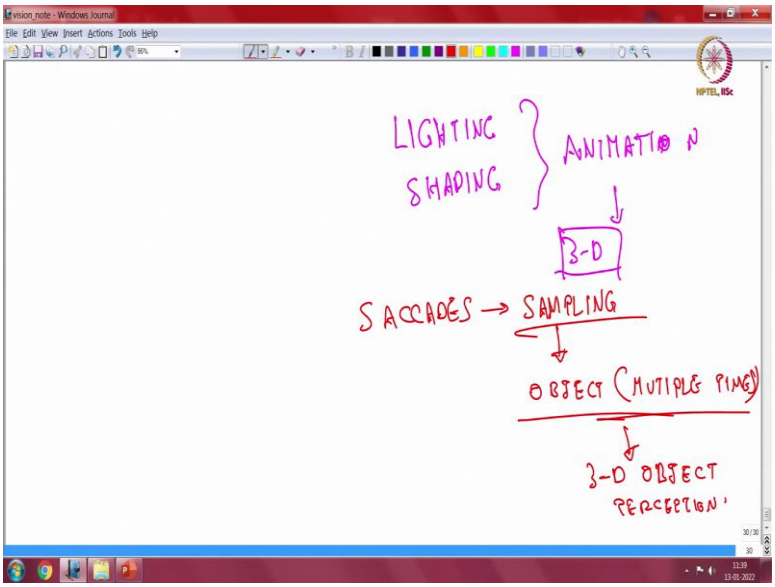
But for us we have retina, you have two eyes, and you have vergence which is a dynamic system by which you compute. And then you have contextual image, I think that is the wrong way of putting it image context.

(Refer Slide Time: 19:13)



Or more than image, it is object context. That also is lighting form shadows. I think those from India please do look up Professor V. Ramachandran's work. And you know how shading gives you the sense of depth.

(Refer Slide Time: 19:56)




People who are interested in animation would understand the importance of lighting, shading as important concepts in animation in 3D depth perception. So, that is how things are. Now I still have not explained or why I have been looking at it. So, if we look at saccades. So, we come back to our original discussion saccades, and I did use this term of sampling. So, you know you are sampling an object multiple times. So, you are sampling an object multiple times and maybe saccades do have a role in 3D object perception.

Now, how it is I have not found any literature, please do check up if you do find literature get back to me on that topic. But what I perceive and understand of saccades, one of the roles of saccades is this, there is another role which I told you which I think you can connect to my earlier slide where I showed a Nobel link its connected to that.

So, saccades are very interesting phenomena of the eye which are very mysterious, you do not have an exact role, it works in all works, against all principles of camera tech which we have had so far. In which you always feel that as an engineering problem to stabilize camera, reduce camera sensor exposure times and to get better images, the eye works exactly the opposite. In which it deliciously makes an already chaotic system

more chaotic with saccades, by which images are formed captured processed, processed not only in three-dimensional space, but also in time.

So, with that I leave you with a lot of food for thought and food for thought to understand what is happening. For those people who are research oriented, the very good PhD problems listed all along the way in both the vision parts of the story, the movement part of the story, the depth perception part of the story.

Why PhD problem? Because basically I am asking you to re look at the visual apparatus in a completely different light, after having listened to my some three hour lecture on the visual apparatus in general. So, with that I think I will conclude vision for the time being, maybe some time later I will have to use some context, but some aspects of vision.

But this is sort of the closing statements for this huge and important chapter on understanding human vision, as we understand it now and as I told you that is an important closing statement. Because I have left it as we understand it, now lots of stuff to be discovered. There is a lot of tech influence which need to come to biological to understanding biological vision and that is where I stop, please do contribute.

Thank you.