Computer Vision and Image Processing

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Lecture 1

Introduction to Computer Vision

Welcome to NPTEL MOOC's course on Computer Vision and Image Processing, Fundamentals and Applications. This is my first class, so in this course, I will discuss some fundamental concepts of computer vision and image processing. And finally, I will discuss some important applications of computer vision.

So what is computer vision? Computer vision is a field of Computer Science; the objective is to build a machine so that it can process and interpret images and the video just like a human visual system does. So I can say it may be a compliment of biological vision. So let us see the formal definition of computer vision.

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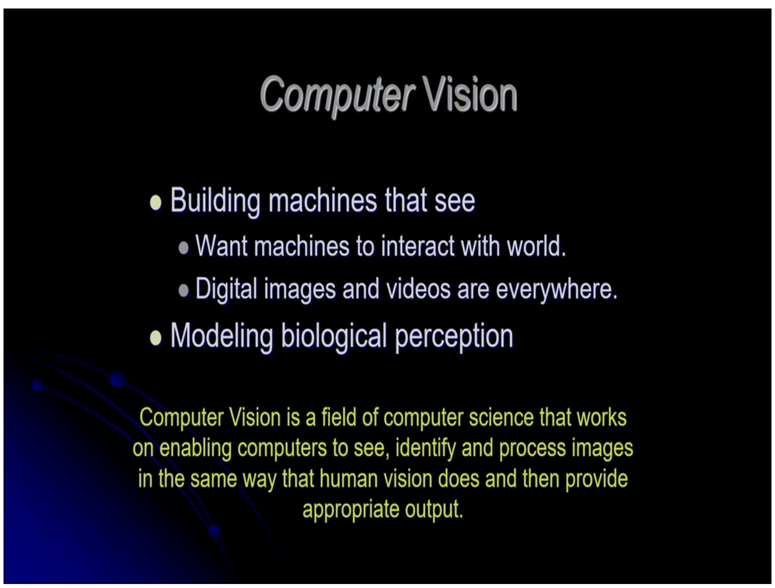

So building machines that see. It is mainly the modeling of biological perception and input to a computer vision system is mainly the digital images and the videos and the definition of computer vision is computer vision is a field of Computer Science that works on enabling computers to see, identify, and process images in the same way that human vision does and then provide appropriate output. So this is the formal definition of computer vision.

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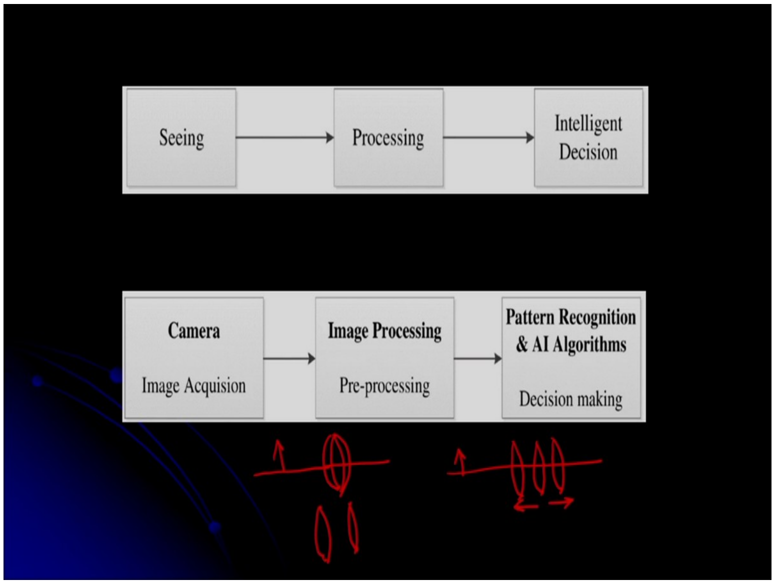

So in this block diagram, I have shown the similarity, I want to show the similarity between human visual system and computer vision system. So in the first block diagram, I have shown the human visual system.

So for human visual system, we have eyes to see images or we can see videos or maybe we can see objects. And after this, we do the processing in our brain and after this, we take intelligent decisions. In case of the computer vision, we have cameras, and they are maybe single camera or maybe multiple cameras for image or the video acquisition.

And after this, we have to do pre-processing, that is, image pre-processing we have to do. And finally, we have to apply the pattern recognition and artificial intelligence algorithms for decision making. So you can see the similarity between the human visual system and the computer vision system.

One basic difference I can highlight in case of the human eye and a computer vision in the cameras, that image acquisition device, the light is converted into electrical signal but there is a basic difference I can show you. Suppose if I consider a camera, so this is suppose lens of the camera; this is a convex lens. I want to focus this object.

So to focus this object, I can move the lens maybe in the forward direction or maybe in the backward direction. Like this I can do this, and by this process, I can focus a particular object in the camera. In case of the human eye, in case of the human; this is for the camera; in case of the human eye, that is not possible.

Suppose if I want to focus this particular object and I have the lens, lens of my eye. I cannot move the lens in the forward, in the backward direction. What I can do, I can sense the shape of the lens. I can sense like this or I can sense like this. By this process, I can sense the focal length. So that is the only difference between the human eye and the camera.

In both the cases, the light is converted into electrical signal. In human eye, we have retina and in case of the camera, we have photo sensors, which converts the light into electrical signal.

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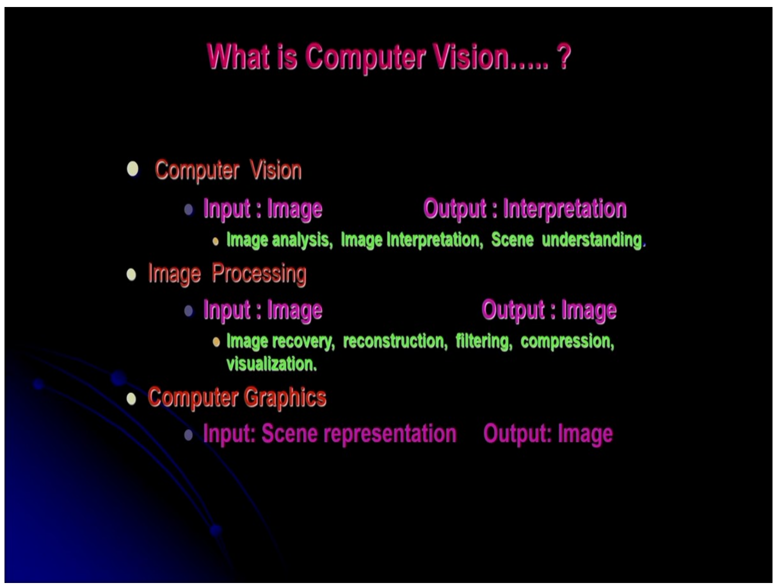

In this case, I have shown the distinction between computer vision, image processing and the computer graphics. In computer vision, my input is image and output is interpretation. The interpretation of the image, the interpretation of the video; that is computer vision.

In case of the image processing, my input is image and output is image. So I can give one example. Suppose if I want to improve the visual quality of an image, then in this case, I have to do the image processing. And then in that case, my input is image and output is also image. Suppose if I want to remove noises in an image, then in this case, I have to do image processing.

And in case of the computer graphics, my input is model. So from the model I have to generate the image. So you can see the distinction between image processing, computer vision, and computer graphics.

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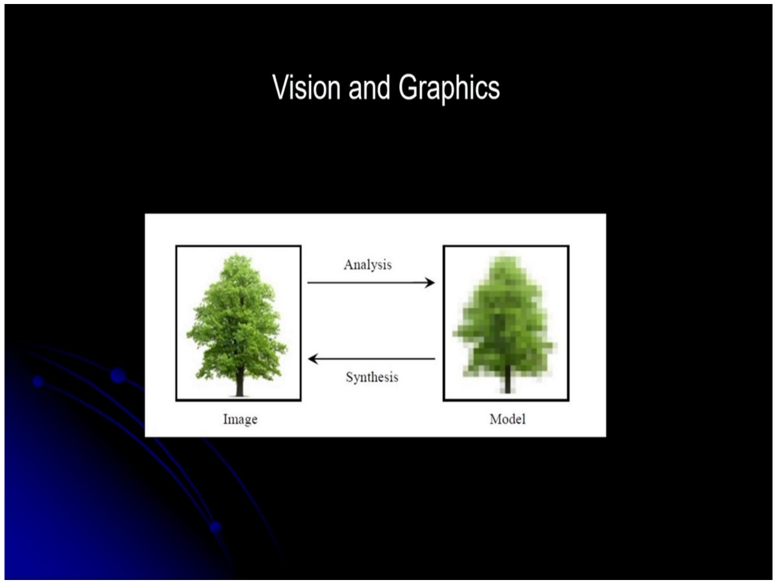

In this figure if you see, one is analysis, image analysis; another one is synthesis. So what is analysis? From the image, if I do some interpretation, if I get some model, then it is computer vision. And in synthesis, if the model is available, if I can generate the image from the model that is called synthesis.

So in this case, the analysis means computer vision, and synthesis means computer graphics. So you can see the distinction between computer vision and computer graphics.

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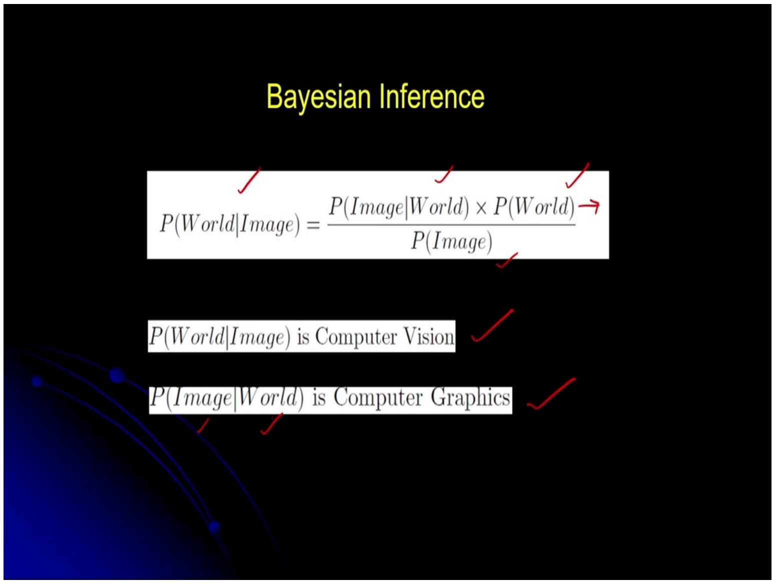

And this interpretation, I can show like this by Bayesian Inference. So what is the Bayesian Inference? The probability of world given the image. So it is the probability of world given the image that is equal to probability of the image given the world into probability of the world divided by probability of the image. So this is by using the Bayes law.

So in this case, probability of the world, that means, the model, world means the model, given the image is computer vision. That means, from the image, I have to do some interpretation; I have to get the model. That is computer vision.

And if you see that this one, computer graphics from the model I have to generate the image. That is computer graphics. What is the probability of world? The probability of world means, the modeling of the objects in the world. So by using this Bayesian Inference, you can see and that the definition of computer vision and the computer graphics

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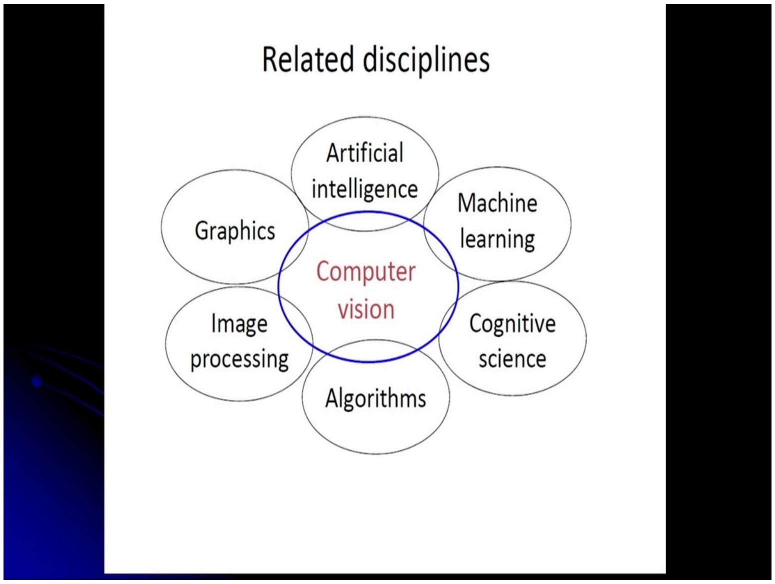

And some of the related disciplines of computer vision, computer graphics, artificial intelligence, machine learning, cognitive science, algorithms, image processing.

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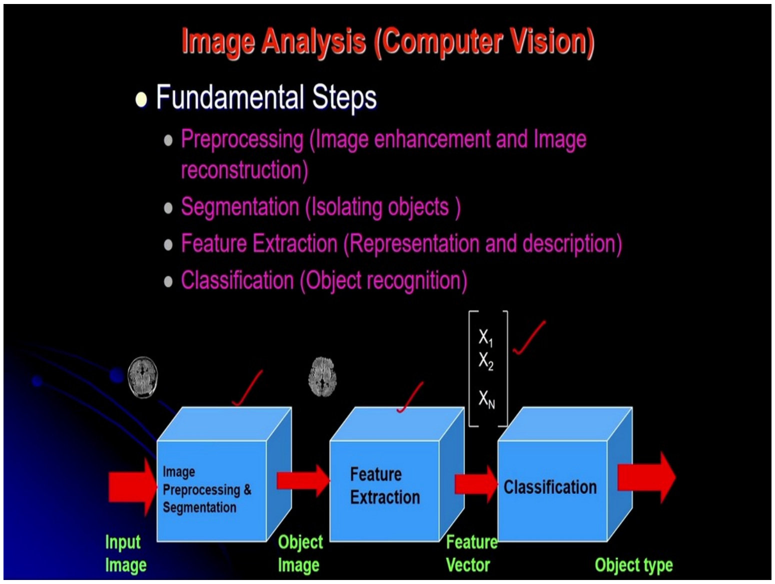

Now, let us see the fundamental steps of computer vision. In this block diagram, I have shown some of the steps. The first one is the input image. I have the input image. So for this, I have cameras.

After getting the input image, I can do some pre-processing like if I want to improve the visual quality of an image, I have to do the image pre-processing, like if I want to remove the noises in the image, I have to do image pre-processing. After this, I can do image segmentation. Segmentation means the partitioning of an image into connected homogeneous region. So I can do the image segmentation.

After this what I can do, the feature extractions. So from the image, I have to extract some features. So in this block diagram, if you see, this is the feature vector. So this feature extraction is this, image pre-processing is this, so after this, we have to extract some features. Based on these features, I can do classification.

So this is a typical block diagram of a computer vision or maybe the image analysis system. So first, I have to do the image pre-processing, after this we have to extract some features, and based on these features, I have to do the classification.

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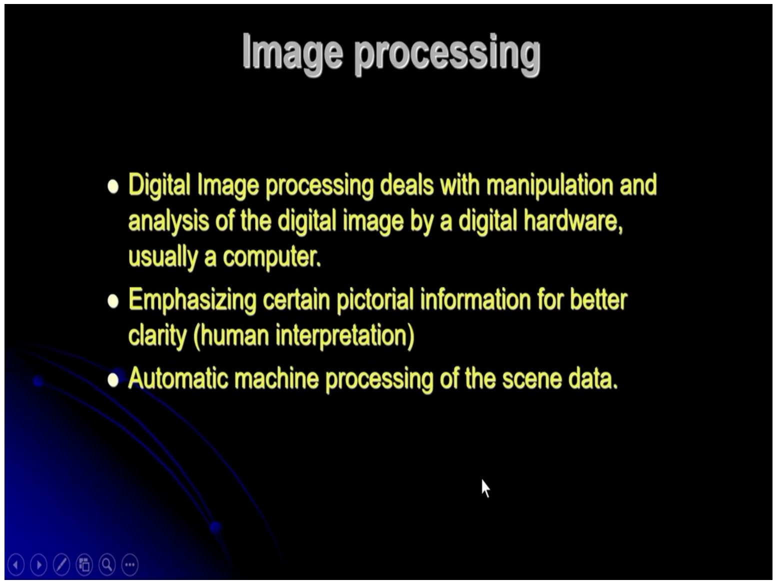

Now, what is image processing? So image, if I consider a digital image, digital image is nothing but a 2D array of numbers. So I have x-coordinate and the y-coordinates, and it is a 2D array of numbers.

So image processing means, I have to manipulate these numbers. Suppose, if I want to remove the noise of an image, then in this case, I have to manipulate these numbers. Suppose, if I want to improve the brightness of an image, if I want to improve the contrast of an image, I have to manipulate these numbers. So that means the manipulation of these numbers is nothing but the image processing.

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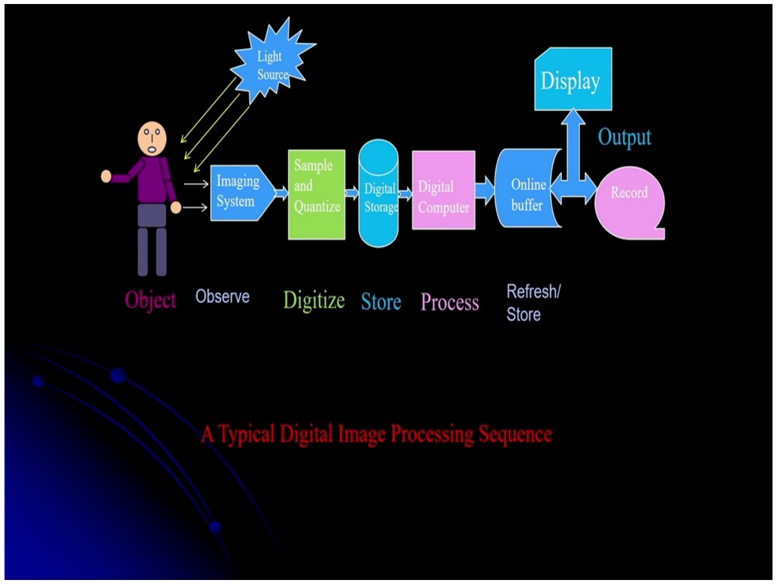

Now, in this block diagram, I have shown the typical image processing sequence. So you have seen that one is, the light source is available. The light is coming from the source and it is reflected by the object. And after this, we have the imaging system. That is nothing but the camera. This camera actually converts the photon, the light proton into electrical signal.

So here, if you see here, that is, the light is coming from the source and it is reflected by the object. And after this, we have the imaging system that is the camera. So this is the analog signal I am getting. Analog means it is a continuous function of time. This analog image, I can convert into digital image. So for this, I have to do the sampling. That sampling is called the spatial sampling; sampling along the x-direction, sampling along the y-direction. And after this, I have to do the quantization; the quantization of the intensity values.

So like this, I can get the digital image from the analog image. This, the intensity value or the pixel below actually depends on the amount of light reflected by the object. So that means there is a property; that property is called a reflectance property. So later on, I will discuss about what is the reflectance property. Sometimes it is called the albedo of a surface.

After doing, after getting the digital image, what I have to do? I can store this image in the digital computers in a memory. I can process this image in the digital computers, I can display the image, or I can store the image. So this is a typical image processing sequence.

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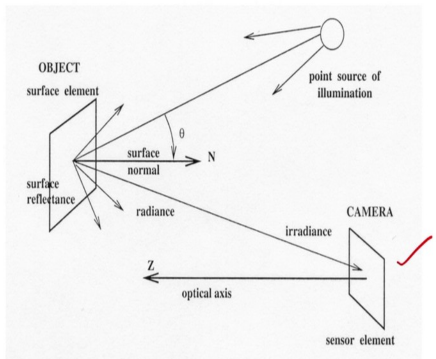
Image Formation



S. Jayaraman *etal*. "Digital Image Processing", Tata McGraw-Hill

This image formation principle here I have shown again. From the light source, the light is coming. Light is reflected by the surface. So here, I am considering the surface reflectance. And after this, the radiance is coming and in this case, I have the camera, this is the camera. So I am getting the analog signal. This analog image, I can convert into digital image. So this is this is the simple image formation principle.

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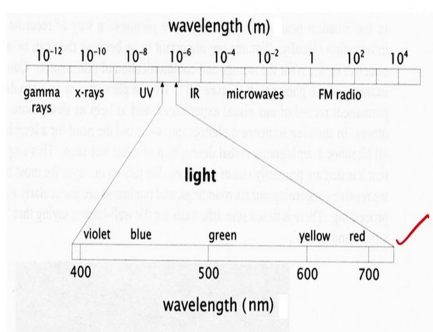
Source of Illumination



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And here I have shown the sources of illumination. So here, I have shown the electromagnetic spectrum. In this case, I have shown the gamma rays, x-rays, ultraviolet, infrared, microwaves, FM radio. So if you see this portion, this portion is the visible spectrum that is from 400 to 700 nanometers.

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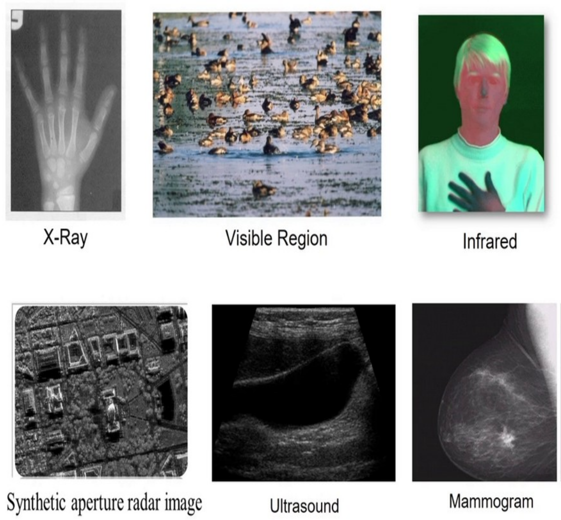

So based on this electromagnetic spectrum, I have this type of images that may be, I may have X-ray images, and images from the visible region of the spectrum, infrared image, synthetic aperture radar images, ultrasound images, or something like mammograms also. So we have number of images like this.

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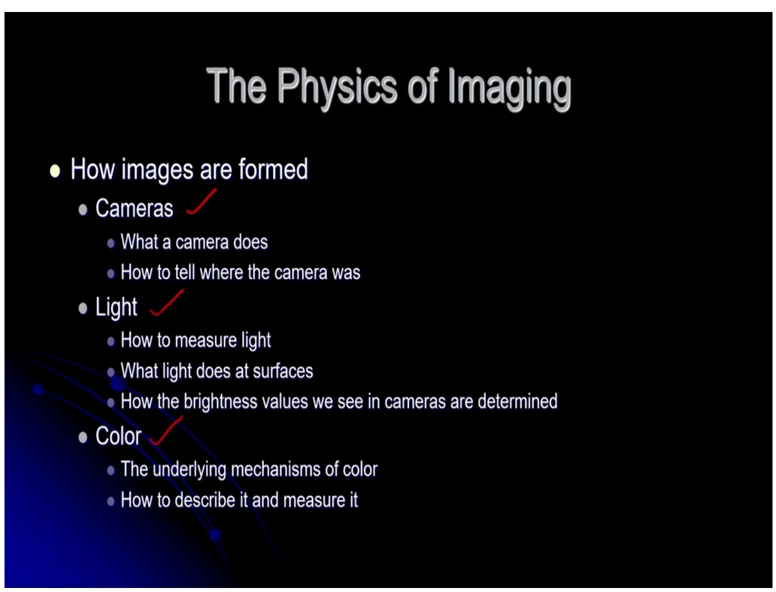

Now, this computer vision actually depends on the physics of imaging. That means, the principal of cameras; first point is the cameras. Next is the measurement of light, that is, the how much light is coming from the source and how much light is reflected by the surface; so that is the light. And that is called the radiometry; the measurement of light is called the radiometry. And also the concept of the colors, different types of colors. So the physics of imaging is quite important.

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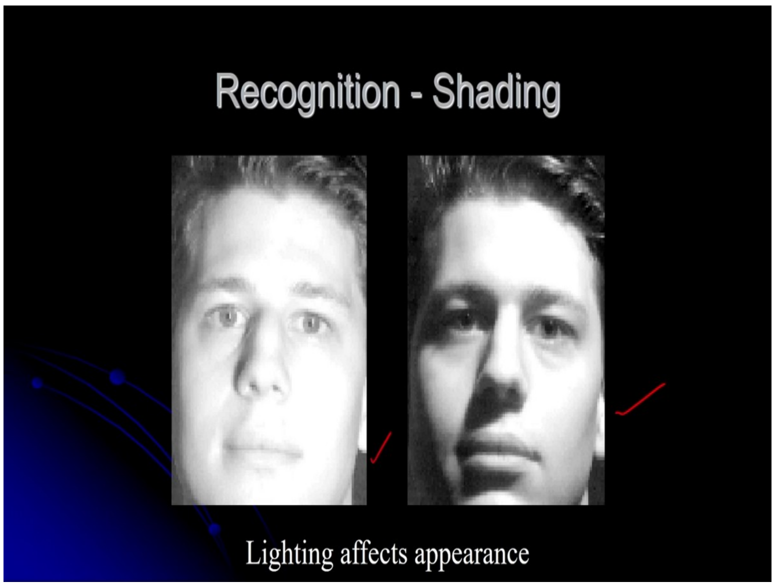

Now, let us consider here. If you see the same person under different lighting conditions, shading effect is there. So you can see the person the same person, but different appearance. So in this case, I have to develop some computer vision system, so that the computer can identify these two faces; this face and this face but different lighting conditions different shading conditions.

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I can give another example. So in this case, two faces but dependent shading condition, the lighting conditions.

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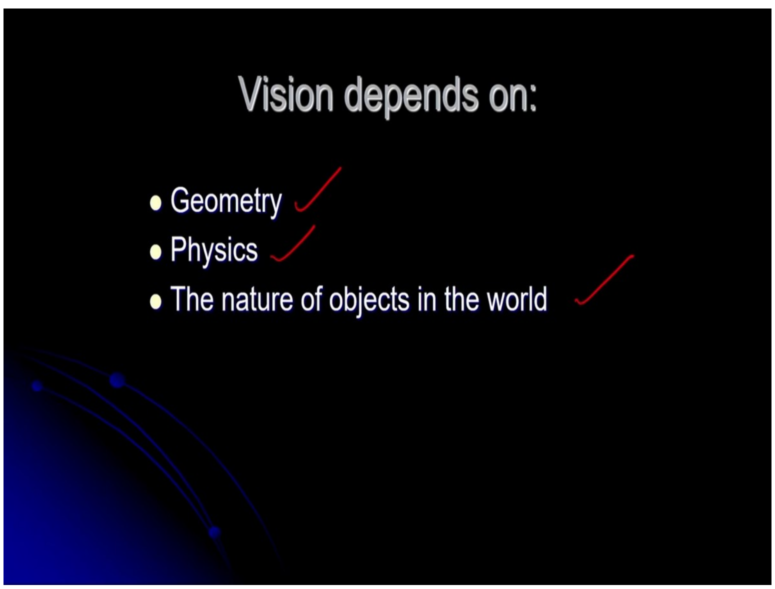

So that is why the computer vision depends on geometry, physics, and a nature of objects in the world. So these are the main things one is geometry, I can consider the geometry of the camera. Physics, that is the measurement of light and also the basic geometrical configuration of the camera. And also the nature of objects in the world.

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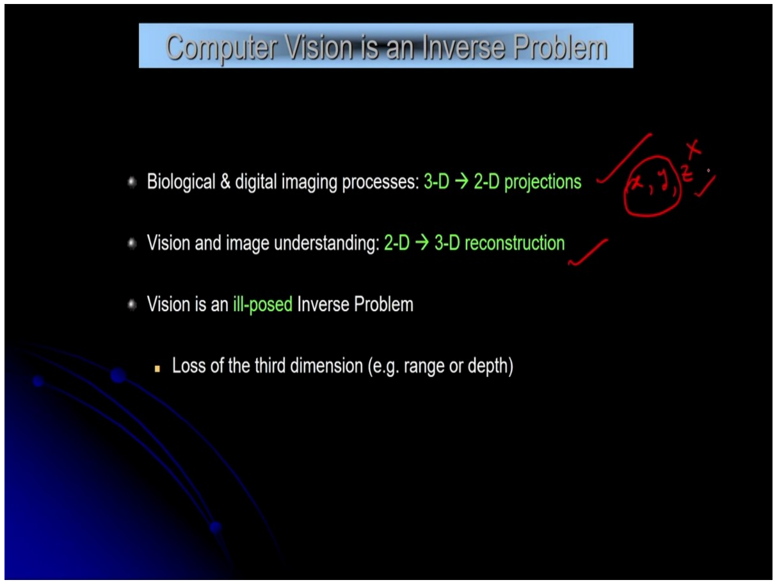

Now, you see here, computer vision is an inverse problem. Why it is inverse problem? Because if you see, if I want to take one image that is nothing but the 3D to 2D projections. So objects in the world, it is the 3D objects, but if I take the image, then in this case, I am getting the 2D image. That is the 3D to 2D projections.

So one dimension is lost that is the z-dimension. So because x, y, and the z-coordinate. So after the projection, I will only have the x and y coordinate but this information will be missing; that is the depth information.

But in case of the vision, computer vision and image understanding, that is 2D to 3D reconstruction because from the image, I have to get the model, I have to do the interpretation. So that is why I can say vision is an ill-posed inverse problem. Loss of the third dimension that is the depth information is, if I consider z is the depth information, depth information will be missing. So I have to determine the depth information.

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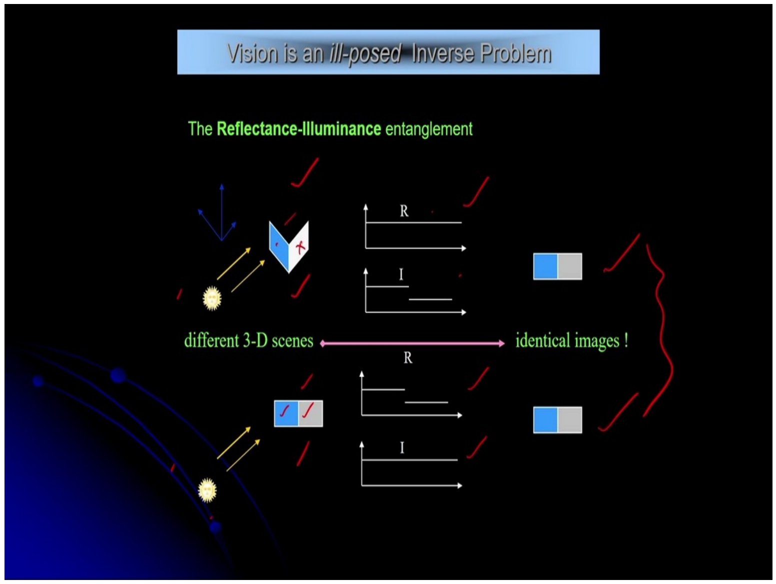

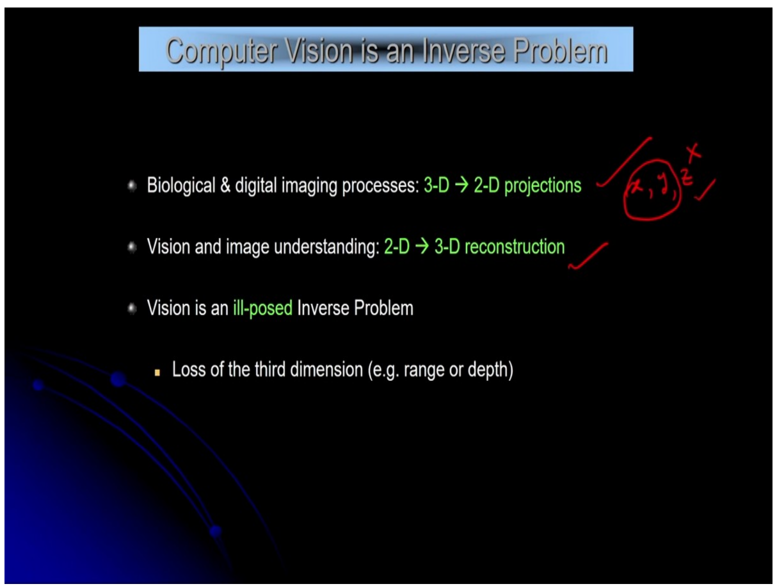

Another is a vision is an ill posed inverse problem, so here I am showing two cases. In this first case, I am considering actually the two different surfaces that is illuminated by the light source. This is illuminated by the light source. In the first case, what I am getting here. I am getting the reflectance something like this. Reflectance is a new from, but illumination will be like this. So this surface is not illuminated, only the surface is illuminated. So corresponding to this I am getting the image here, this is the image. So this is the reflectance and this is the image.

In the second case, I am considering this surface suppose, the scene, and it is illuminated by this light source. Corresponding to this case, this is the reflectance and illumination will be something like this. This is also illuminated and this is also illuminated. So in this case also I am getting the, this image.

These two images, I am getting the identical images. So that is why it is very difficult to identify whether the scene is this or this. So then in this case, that is why I can say the vision is an ill-posed inverse problem. Here I have given two examples. One is this example, because of the 2D to 3D reconstruction problem, another one is this, that is reflectance illumination problem.

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Now, let us consider approaches to vision.

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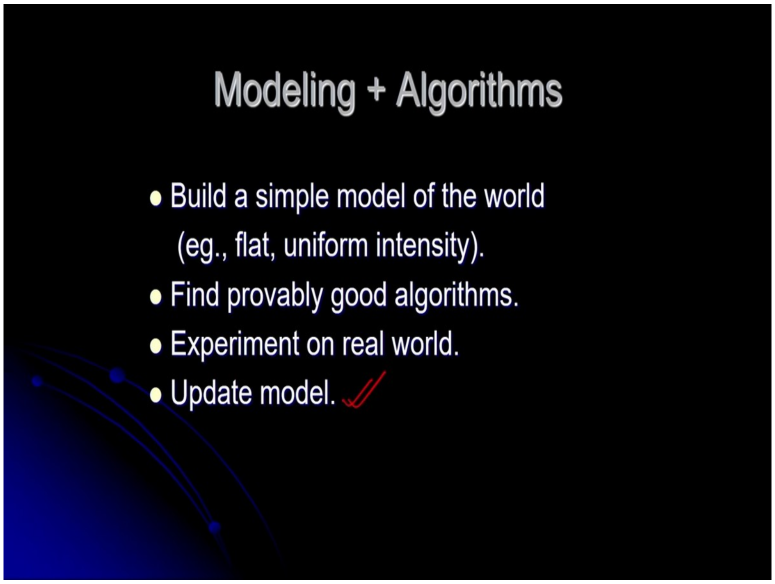

So far computer vision, first, we have to do some modeling, build a simple model of the world. After these find the algorithms, the appropriate algorithms. After this, we have to experiment on the real world. And after this, we have to update the model. That means, after getting the model and after selecting the algorithms, we have to do some experimentation.

That means, we are doing some training. And after training I am doing the updation of the model. So first I have to do the training and after this, we have to go for testing. So that is the modeling plus algorithms.

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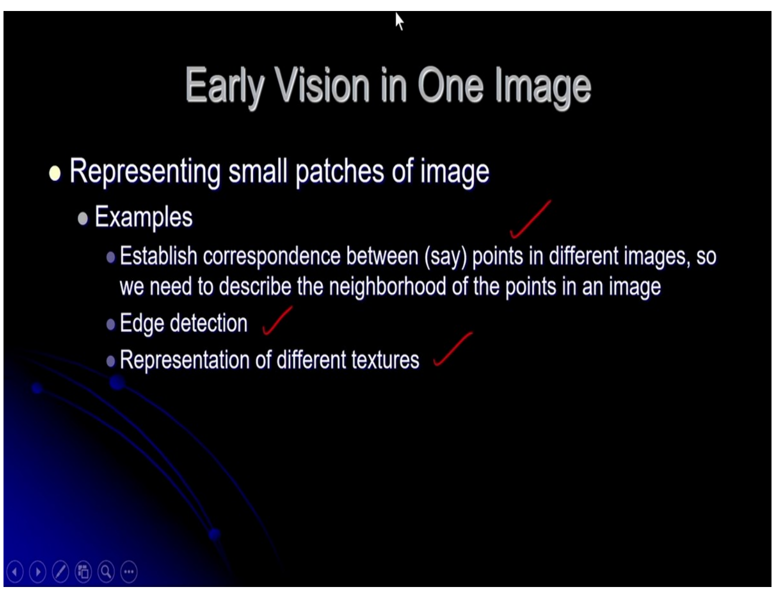

So now, let us consider the approaches of the vision. The first one is the early vision in one image. So in this case, representing small patches of image. So maybe something like finding the correspondence between the points in different images or maybe something like the age detection or maybe the representation of different textures. So these are the examples in early vision.

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So I can give some of the examples like this. The edge detection and the boundary detection, this is one example.

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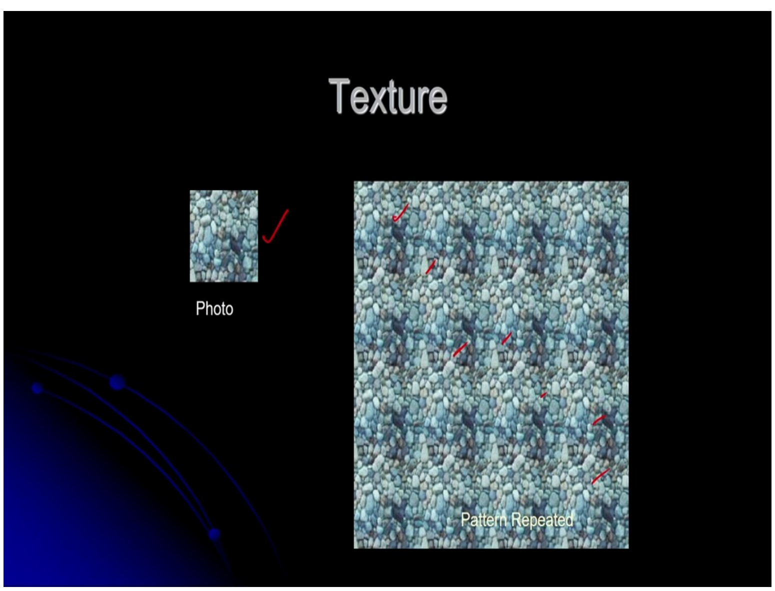

The second example I can show the representation of the texture. So here do you see this pattern is repeated here. I am getting the texture pattern. So how to describe a texture?

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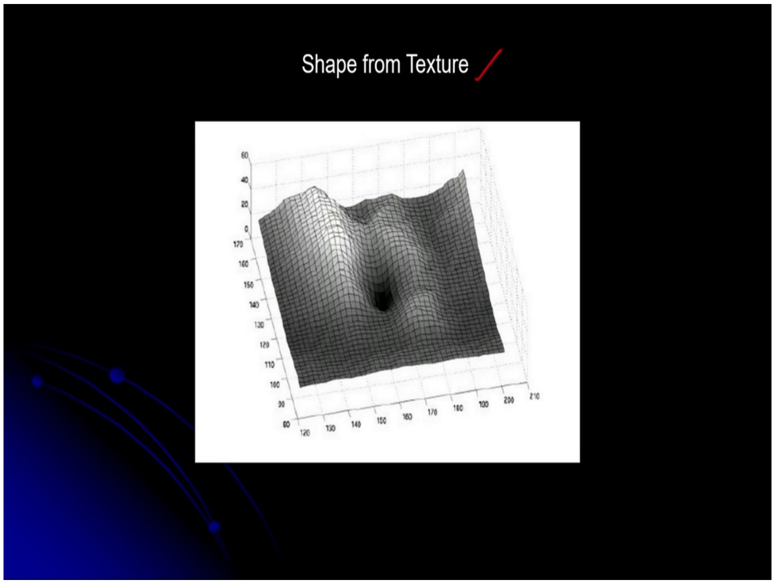

Now, shape from texture. Now, this is one important research problem in computer vision that is how to determine shape from texture information. Here, I have given one example. So you see from the deformation of the texture, whether it is possible to find the shape information. That is one important problem of computer vision. I can give another two examples; two or three examples I can see here.

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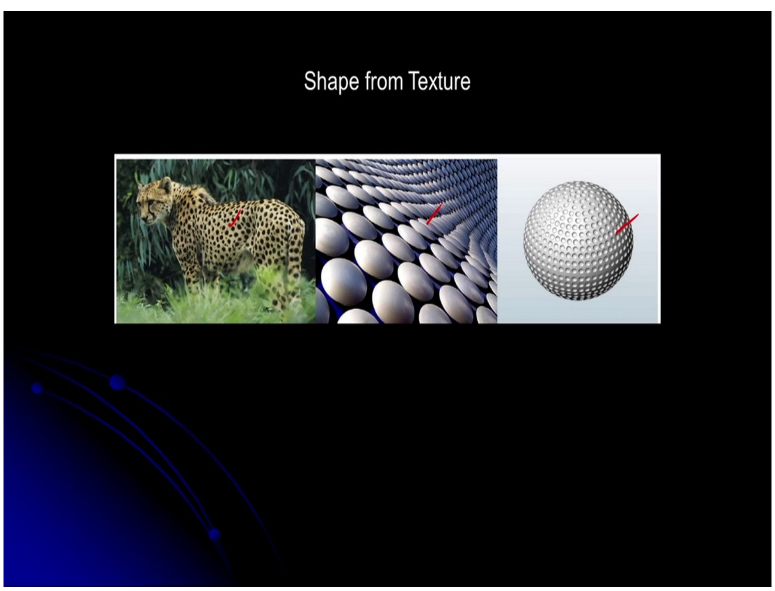

Shape from textures, I have different types of textures, if you see. So this texture actually indirectly gives some shape information. The texture variation, if you see the texture deformation, it indirectly gives some shape information.

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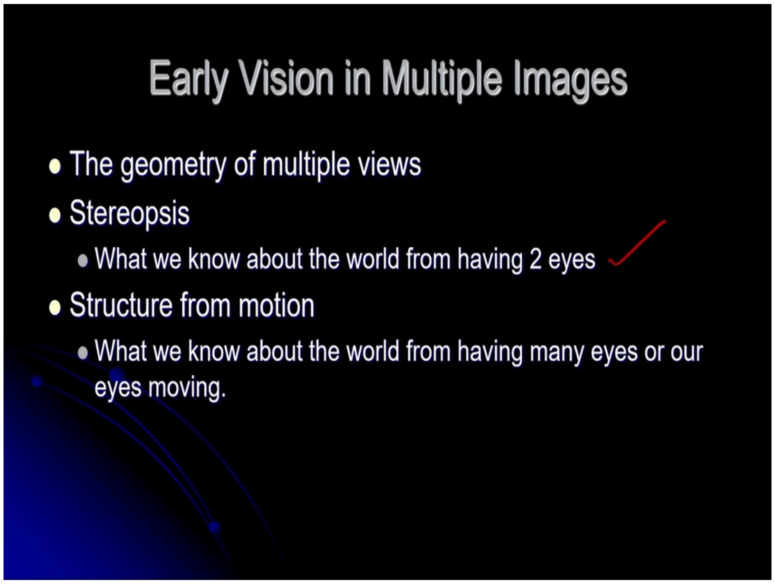

Next one is early vision in multiple images. So in this case, I can consider multiple views. So instead of considering single camera, I can consider two cameras. If I consider two cameras, then it is something like the stereo vision. I can consider multiple cameras. And in this case, that is called a stereo visions. And another research problem in computer vision is structure from motion.

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Now, this is one example of the stereo image. In stereo image, I can get the depth information. I have the x and y coordinates and also I can determine the depth information. And this is one example of a stereo image.

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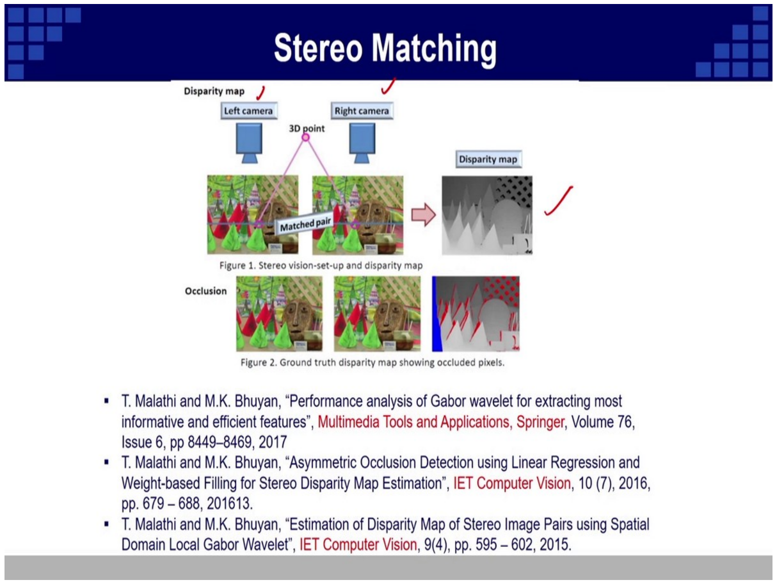

This is another example of a stereo image and here I have shown one stereo matching system. So I have two cameras; one is the left camera another one is the right camera. So corresponding to this, I am getting two images; the left image and the right image. And from the left and then right image, I can determine the disparity map. This actually, disparity map, gives the depth information.

So I have two cameras the left and the right camera and from this I am getting two images, one in the left image another one is the right image. From this I can determine the disparity map and this disparity map will give the information of the depth of a scene.

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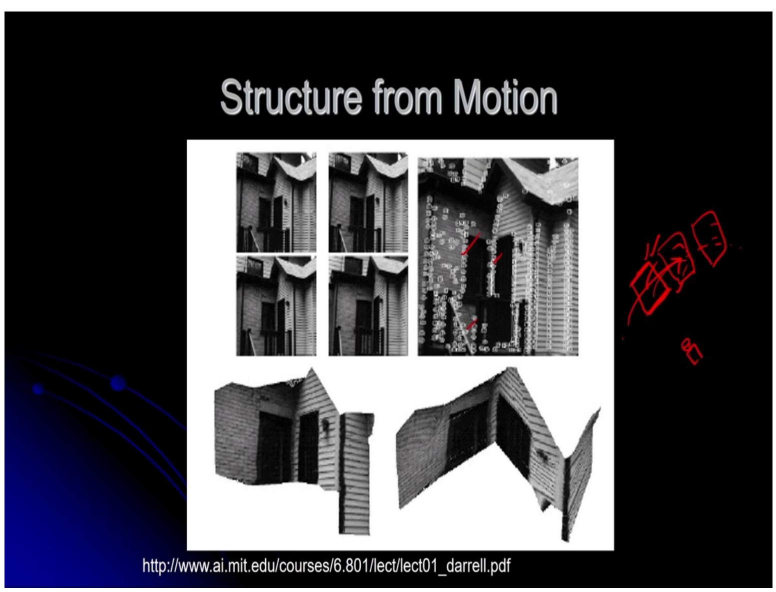

Another research problem I have already mentioned the structure from motion. So from the motion information, whether it is possible to determine the structure information. Like in human visual system, we use the motion parallax.

So suppose if I consider, suppose this is the object. The object is moving suppose. This object is moving like this and I have the camera. This object is moving, so in this case, this surface is close to the camera as compared to this surface, this is the closer to the camera.

So from the camera, it looks like this it moves faster as compared to this surface, this plane; this is one plane, another plane is this. The object is moving like this, so if I take number of images, what I am getting. This surface or this plane moves faster as compared to this. So this is similar to the motion parallax.

So from this, actually the problem is how to determine the shape information; the structure from the motion. So I have number of images like this. So in this case, I have to find the correspondence between the points because I can get number of images and from these images, I can find a correspondence like this between the points. And from this, I will try to determine the structure. So that is one research problem, the structure from motion.

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So this is another example I have given, the motion application. So I have given two important research direction. One is shape from texture, another one is the structure from motion. This is, these two research problems of computer vision; very important research problems in computer vision.

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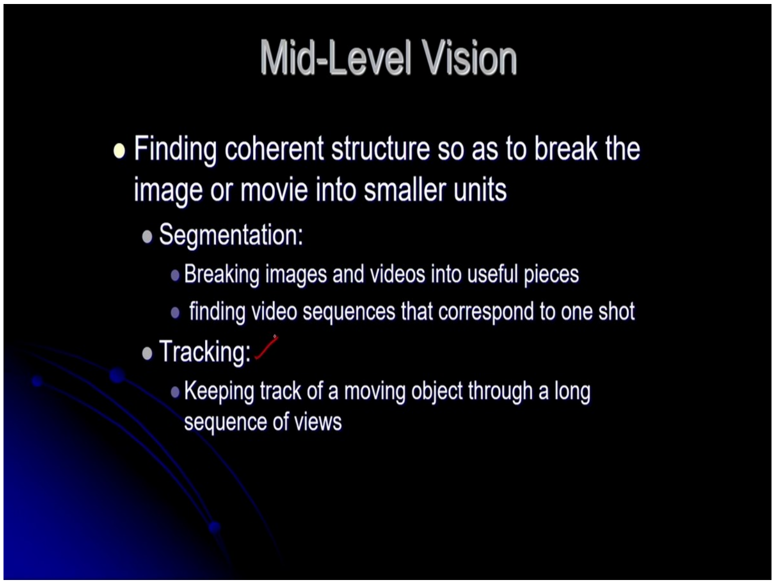

The next one is the mid-level vision. So in the mid-level vision, we can consider the problems like the segmentation of an image or a video and also we can consider the problems like tracking in the video.

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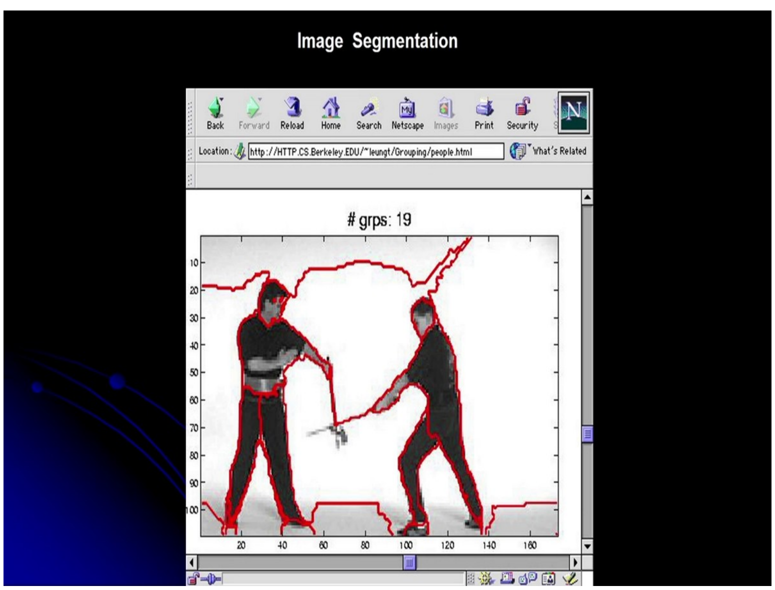

So I can give some examples like the segmentation. In an image, a segmentation means the partitioning of an image into connected homogeneous region. I am doing the segmentation, so this is a segmentation.

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And here, I have given one example of a skin color segmentation. So skin color is detected, if you see here the results, the skin color is detected.

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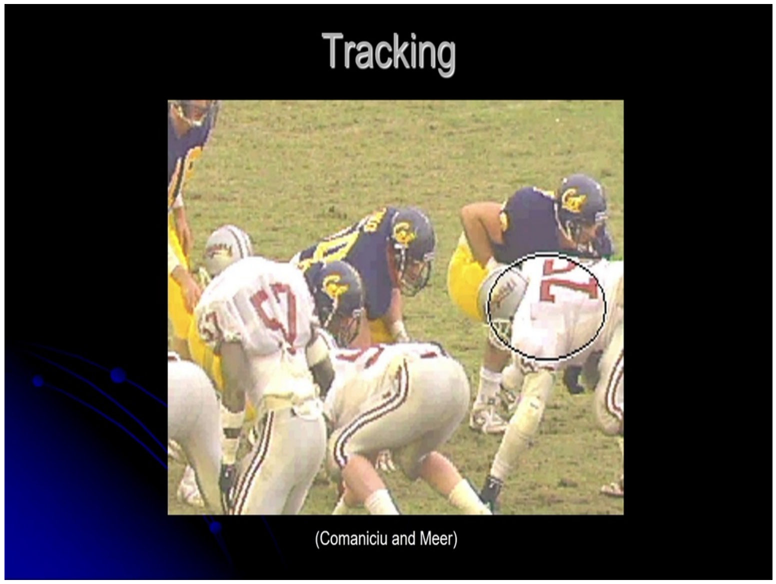

Next, another problem is the tracking in the video. So in a video, I have number of frames. So tracking means finding the correspondence between the frames. So this is one example of the tracking. I can give another examples like the tracking.

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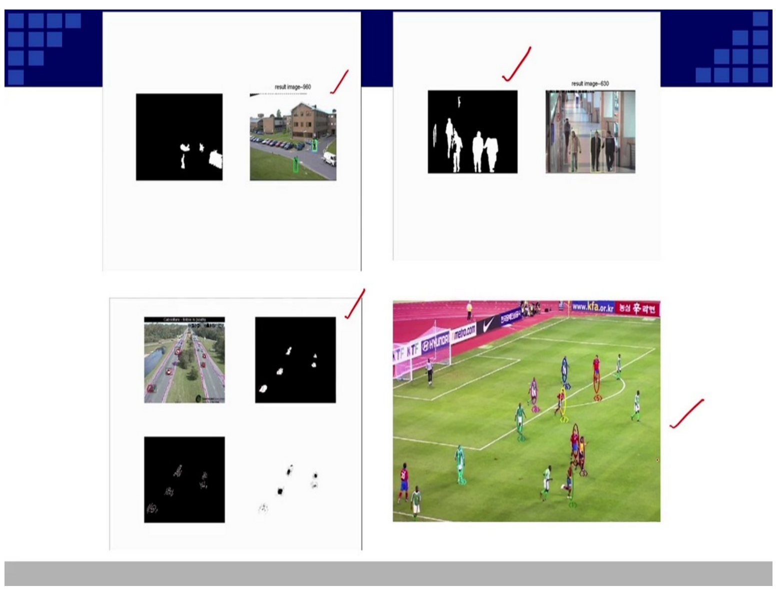

You can see here the videos, I am playing the videos. And these are some examples of the tracking. If you see the videos, in this case, I am doing the labeling also. This is called a background subtraction. The foreground is removed and the background is considered, and I am doing the tracking. A tracking of cars, tracking up persons, and you see the tracking of players like this.

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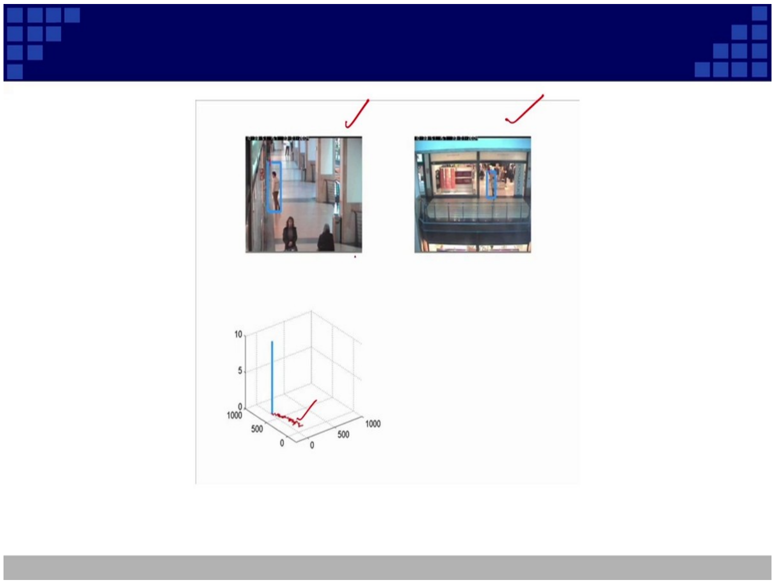

So now, I can give another example. This is the tracking by considering two cameras; this is one view and this is another view. So in this case, I have to find a correspondence between these two views, two images. And you see, the tracking I am doing and you can see this is the trajectory I am determining. So this is mainly the tracking in a stereo vision setup. So this is one camera and this is another camera.

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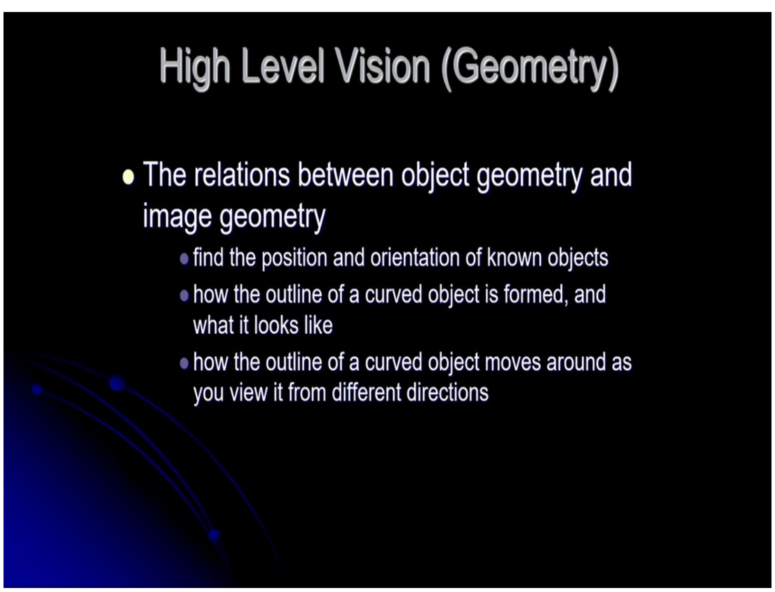

And finally, we will go for the high level vision that is one is geometry. So what is the geometry? The relationship between object geometry and the image geometry, that I can determine. That is one example of a high level vision.

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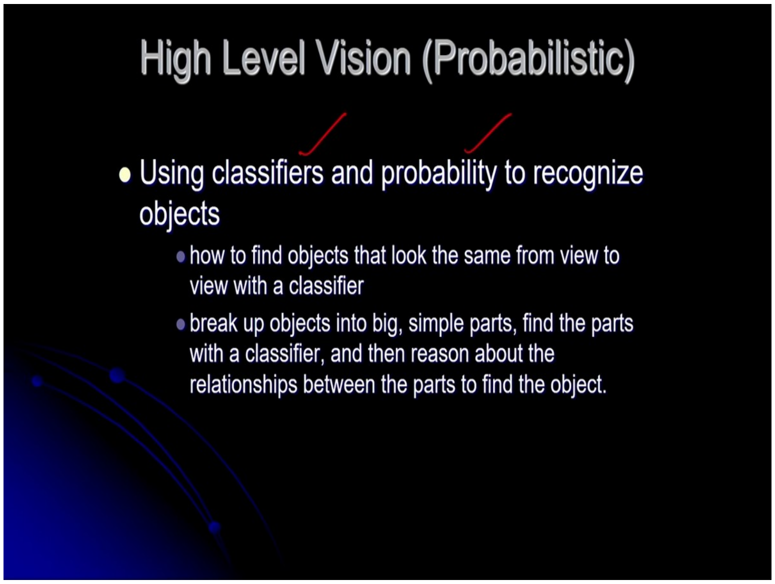

High level vision, the probabilistic. So the concept of the classifiers like in pattern classification, we have to use the pattern classifiers and in this case, this is the one example of the high level vision. That means we have to consider the classifiers and for this, we can use the concept of the probabilities.

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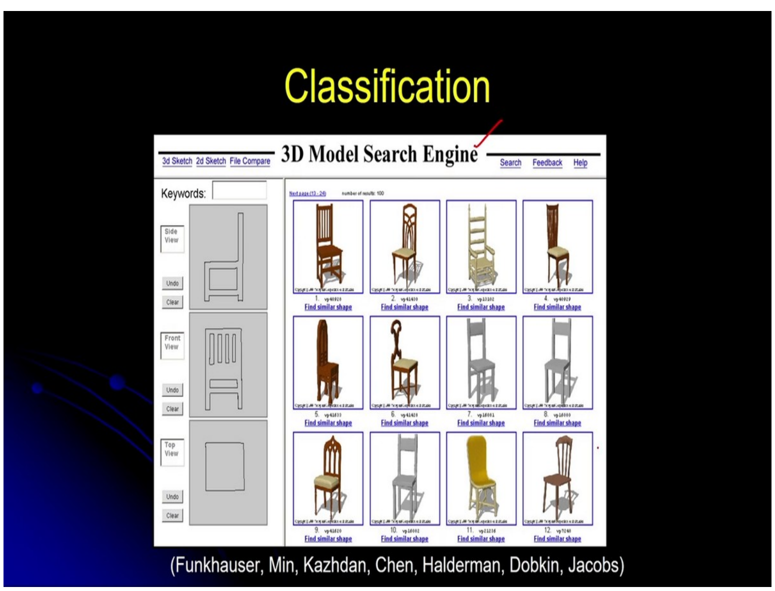

So in case of the like this, this is one example of the classification. Here you see 3D model search engine. So for this, I have to extract some features and after the features I can do the classification. And this is one example of 3D model search engine.

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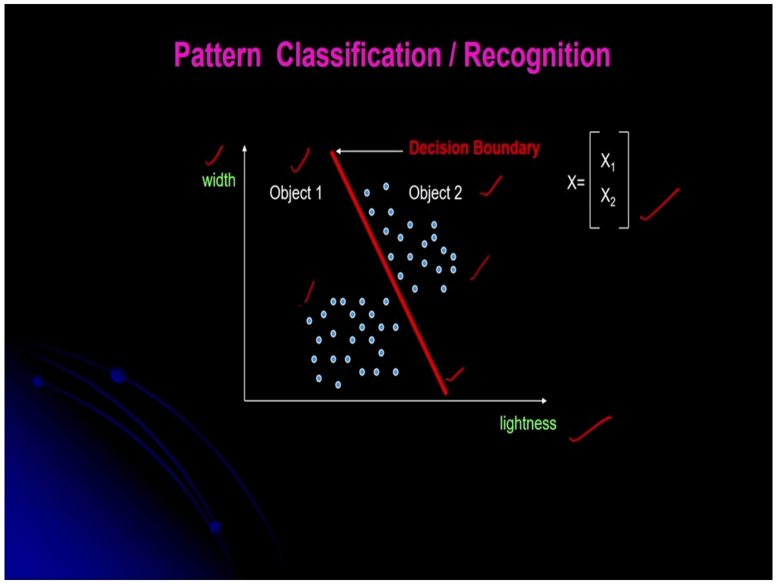

And for pattern classification, we have to extract some features and this is the feature vector. And after extracting the features, you can see in this example, I have two objects; one is object one, another one is object two. And I have considered two features; one is the width, another one is the lightness.

This is the decision boundary between two objects. These are the sample points of the object one and these are the sample points corresponding to object two. So we have to find a decision boundary and after this, we have to go for pattern classification.

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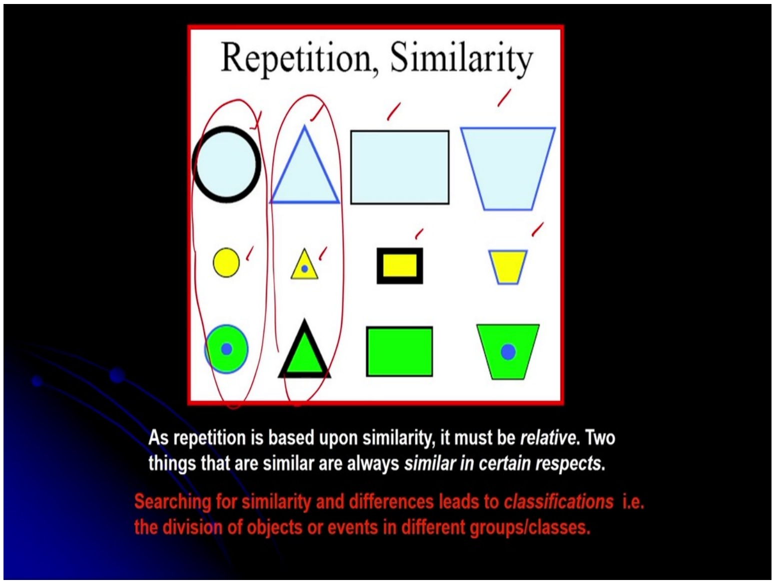

Also we can do the grouping of similar objects. That is called a clustering. So in this example, if I consider color as a feature, then in this case, this, this, this, this will be in the same class. This, this, this, and this will be in the same class. Like this, I can do the grouping.

But, if I consider, the shape as a feature, then in this case, this will be in one class; this will be in one class, like this; I can do the grouping like this. So in pattern classification, portion of this course, I will discuss about the clustering. So how to do the clustering? So this is the basic concept of finding the similarity between the patterns between the objects.

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Now the question is, is computer vision is as good as human vision? We know that human vision is more powerful as compared to computer vision. So I will explain why human vision is more powerful than the computer vision. I will give one or two examples, but there are many examples in this case.

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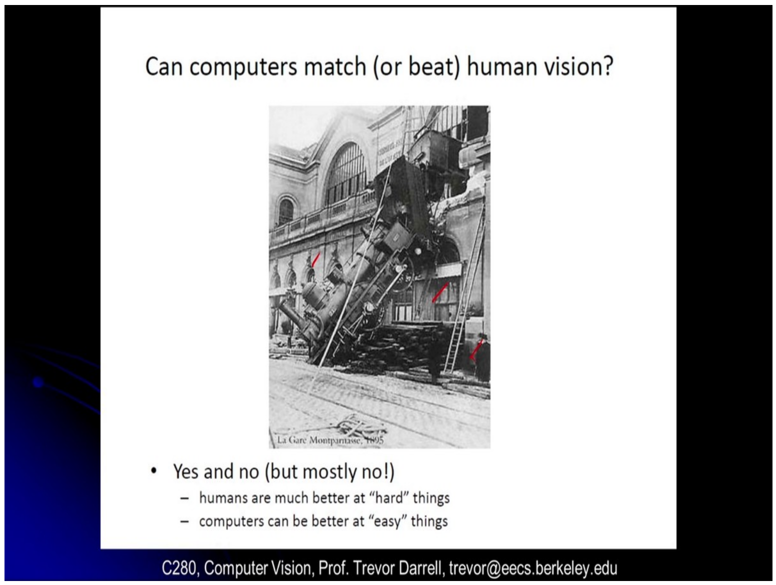

So this is one example, in this image, if you see, I have number of objects here. Where it is possible to identify all the objects in the image, the human can identify most of the objects present in this image. But in case of the computer vision, we have to develop some algorithms so that computer can identify the objects present in this image. That is very difficult. Even in case of the human also it is very difficult to identify all the objects present in this image.

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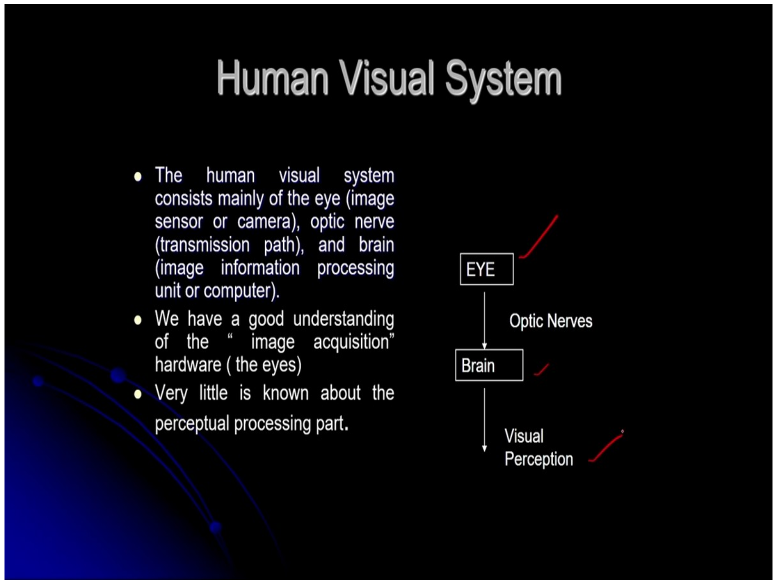

And in human visual systems, this is the block diagram of the human visual system. We have eyes and we have the optic nerves. What is the function of the optic nerves? The signal, the eye actually converts the light photon into electrical signal, the electrical signal is transmitted via optic nerves, and the brain processes this signal for visual perceptions. So this is the structure of the human visual systems.

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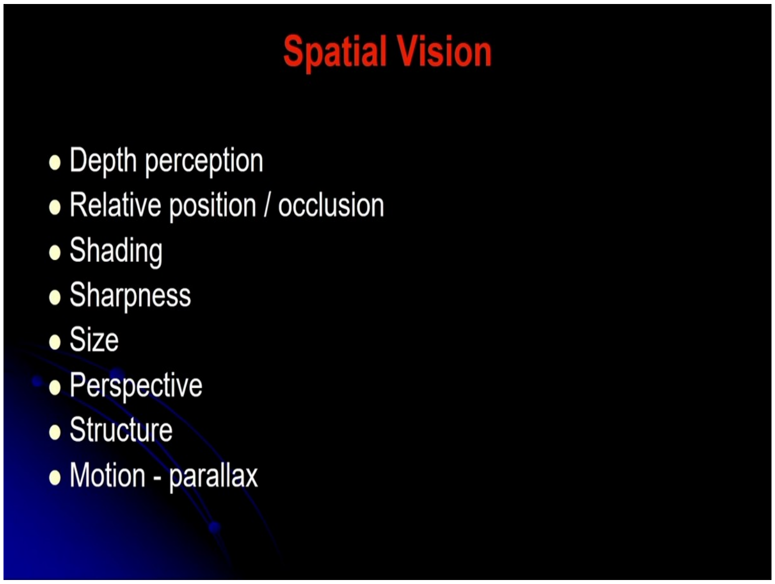

Some very important features of human vision I can say, this like depth perceptions, relative position occlusions, shading, sharpness, size, perspectives, structures, motion parallax. I can give some examples related to, relating to these concepts.

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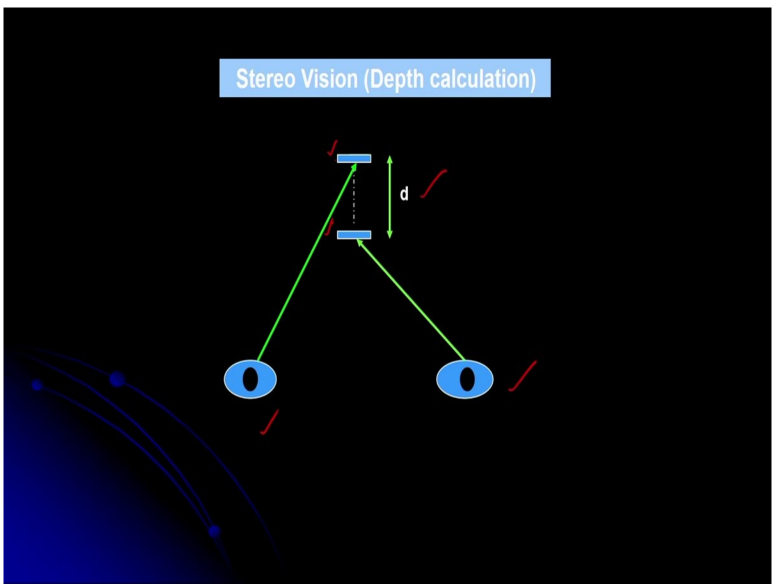

One is there are many theories regarding human stereo vision, the binocular vision I can say. So we have two eyes and if I want to find a distance between these two, this is one surface, another surfaces is this. This is one plane, another plane is this. So that is the distance between these two is the depth information.

So one theory I am explaining that is not the general theory, but I can give one simple theory. This eye measure this distance, the another eye measure the distance and from these two information, the brain determines that distance; d is depth information and that is one theory. There are many theories regarding the stereo vision, the binocular vision.

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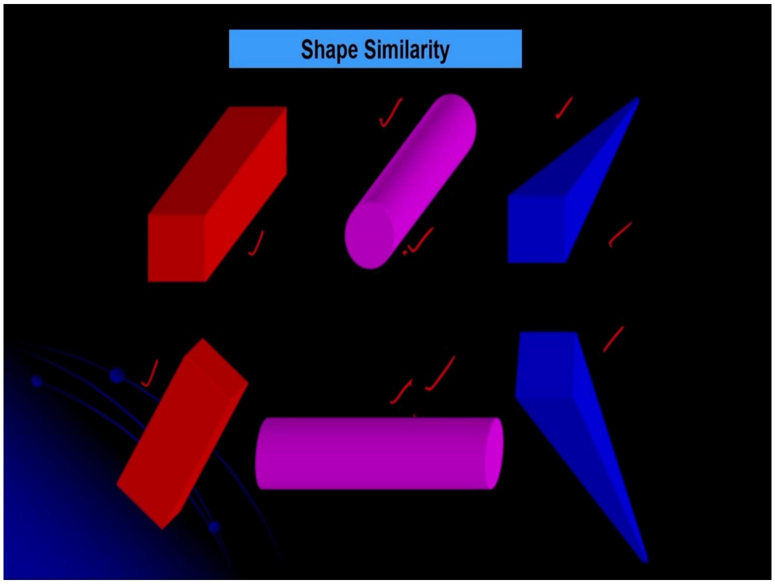

Also, if you see this example, shape similarity. So in the shape similarity, human can easily do. This object, this is similar to this; this is similar to this; this is similar to this. We can identify this, the human can do this. You can see the position is different, orientation is different, here, the orientation is different if you see these two objects.

Still we can identify that this shape is similar to this, this shape is similar to this; the human vision can do this.

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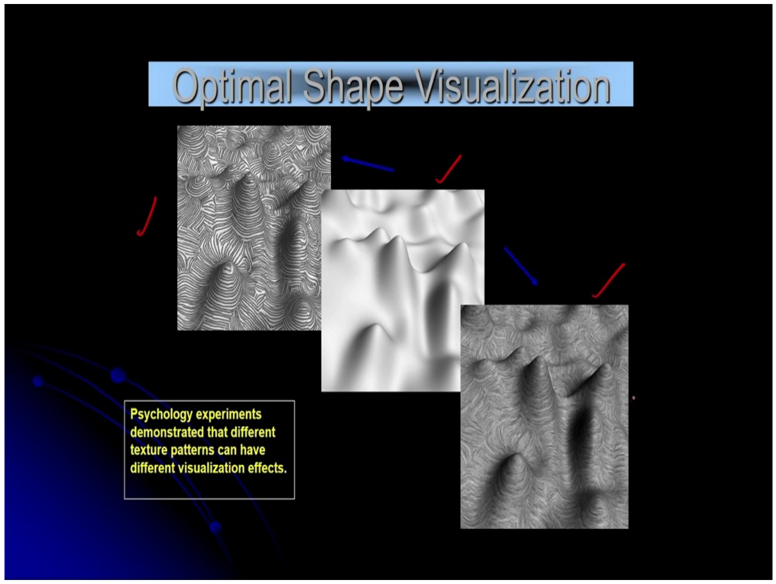

And also, another thing is that texture recognition. So here you see, I am considering three types of texture; this is one texture, another texture, another textures. So human can identify different types of textures.

So when we recognize different types of textures, so what is going within our brain, that is very difficult to explain. In this case, this is different, this is different and this is different.

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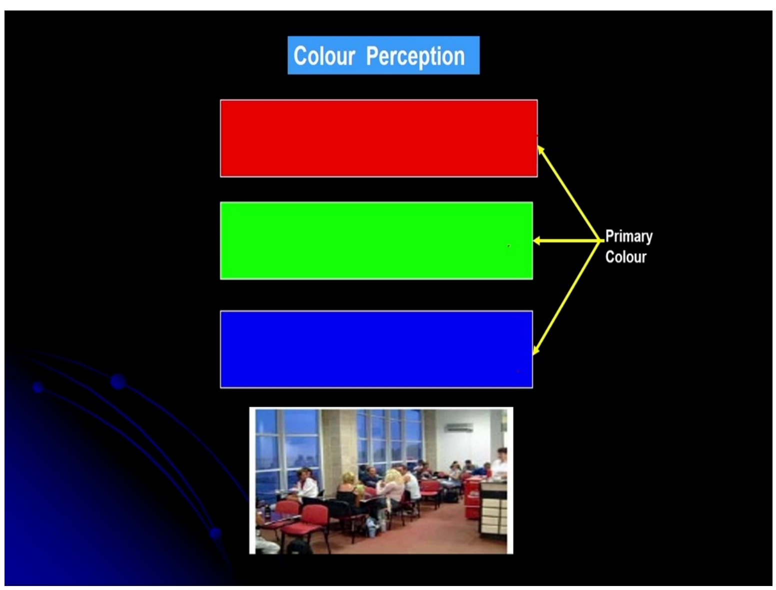

Similarly, another one is the color perceptions. So in this case, we can recognize different types of colors, like these, the primary colors; the red color, green color, and the blue colors. And based on these colors, I can identify different objects present in an image. So that is called a color perception. So we can recognize different types of colors and by using this color information also, we can recognize objects present in an image.

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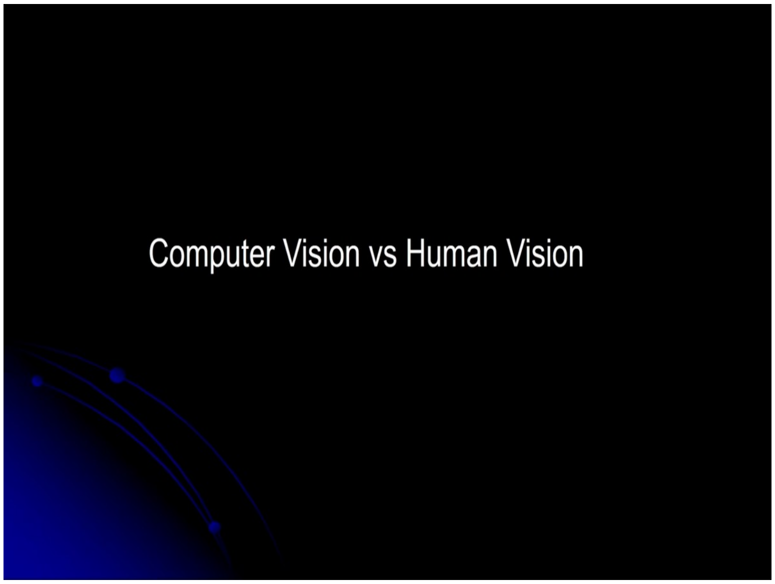

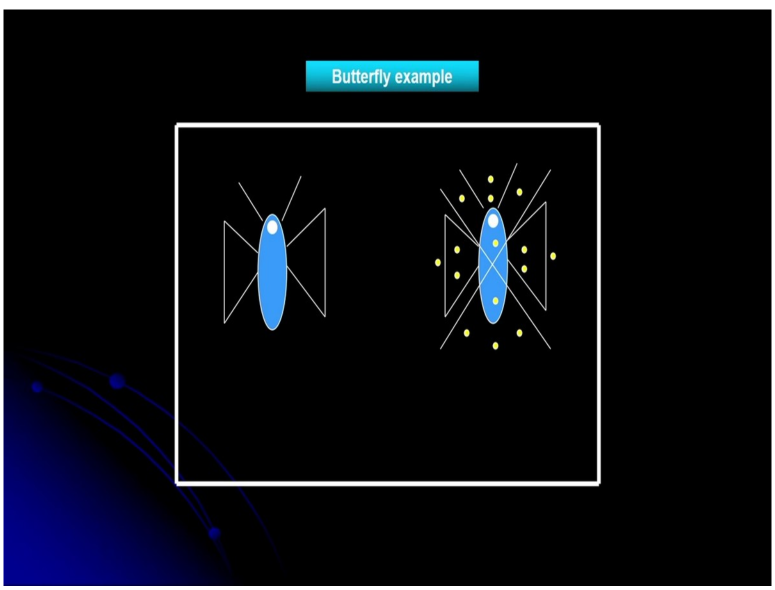

Now, you see the difference between computer vision versus the human vision. I can give two examples; I can give many examples, but here I am showing only two examples. The butterfly example. So this is a butterfly, this is a butterfly. So human can identify that this is a butterfly. Even I can develop some computer vision algorithms so that the computer can identify that this is the butterfly.

After this what I am doing, I am just giving, adding two lines here. Still human can identify this is the butterfly, but in this case, the computer vision fails. So for this, I have to modify the computer vision algorithms, so that the computer can identify that this is the butterfly.

After this, again I am putting some noise. Still human can identify this is the butterfly, but again the computer vision fails. So again I have to modify my algorithms, so that the computer can recognize this is the butterfly. So you can see that human visual system is more powerful than the computer vision in this example.

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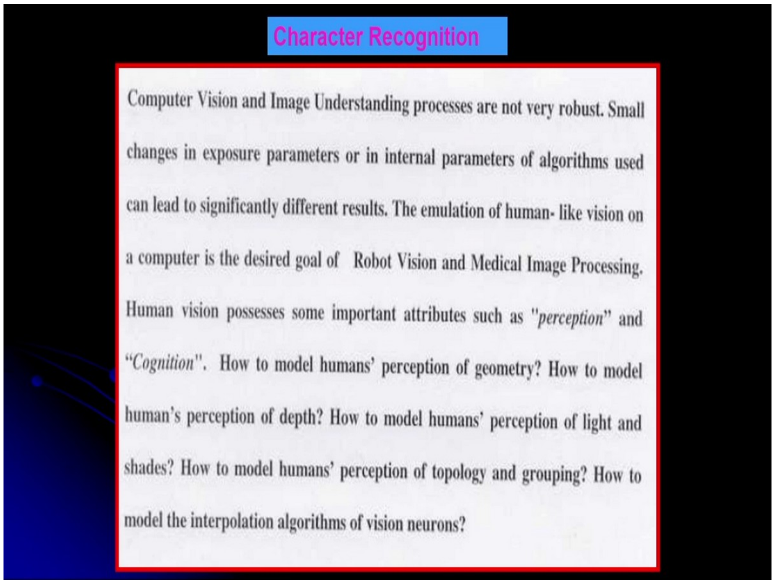

Similarly, I am giving another example, the character recognition. So I can recognize all these characters the human can recognize. Also, the computer can recognize; I can develop some computer programs, so that computer can recognize all these characters.

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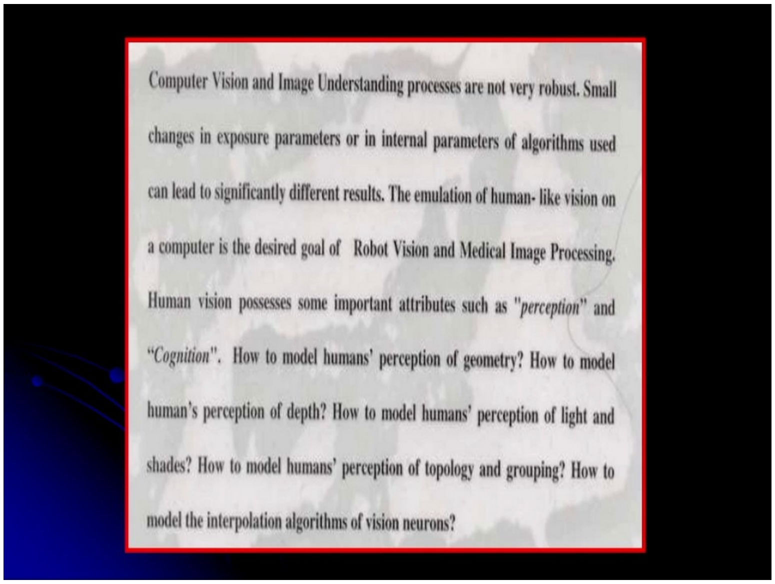

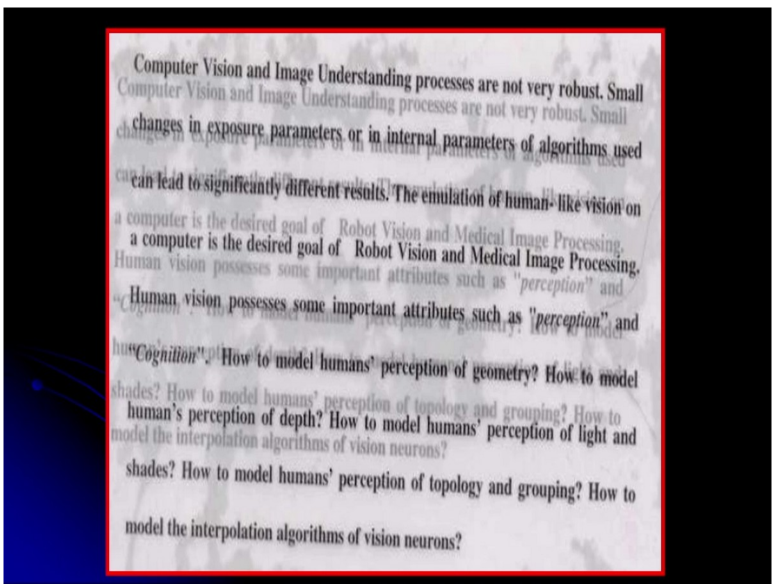

After this, I am putting some noise in the image. Then in this case, I have to modify my image processing algorithms to remove the noise, and if you see the next image, I am giving more noises. Then still human can recognize these characters, but in case of the computer vision, I have to modify my algorithms.

I have to do some pre-processing and after this I can do the recognition, I can go for recognition. So you see the difference between the human visual systems and the computer vision systems.

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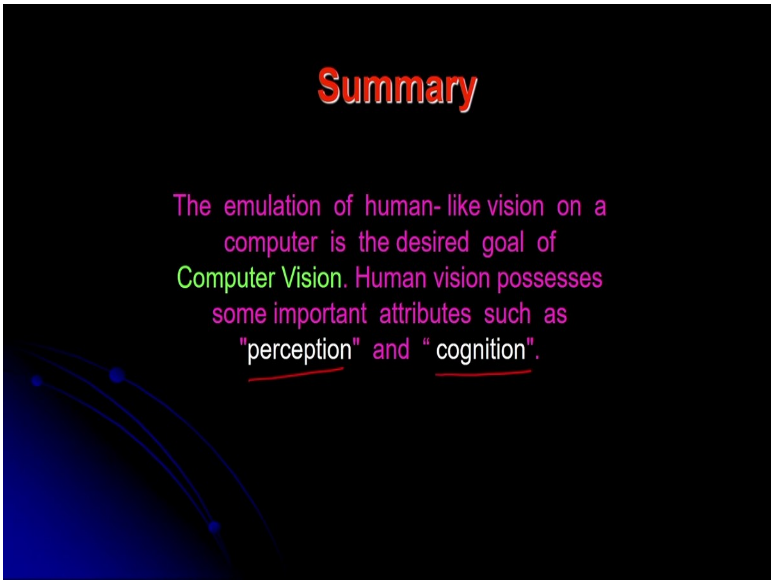

So in summary, I can show that emulation of human-like vision on a computer is the desired goal of computer vision. Human vision possesses some important attributes such as perception is very important, another one is cognition.

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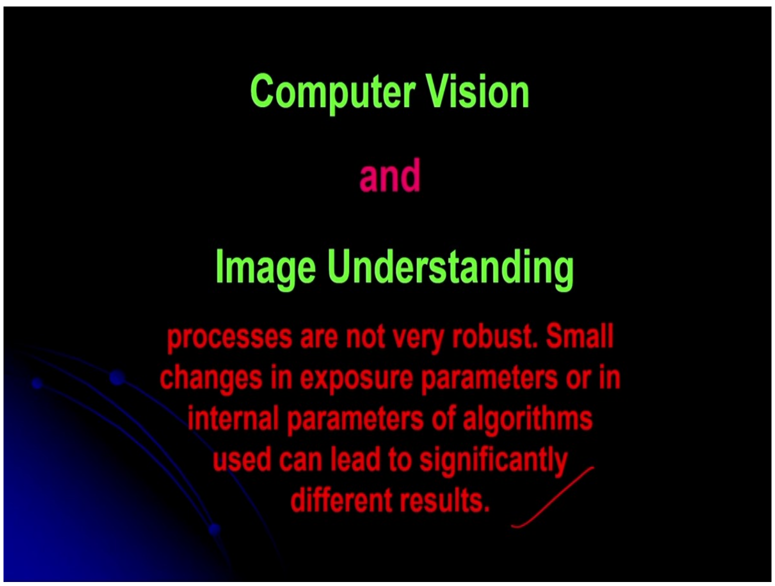

So this is a summary and I can show this case that computer vision and the image understanding processes are not very robust, small changes in exposure parameters or internal parameters of algorithms use can lead to significantly different results. So that is the summary of the, my discussion up till now.

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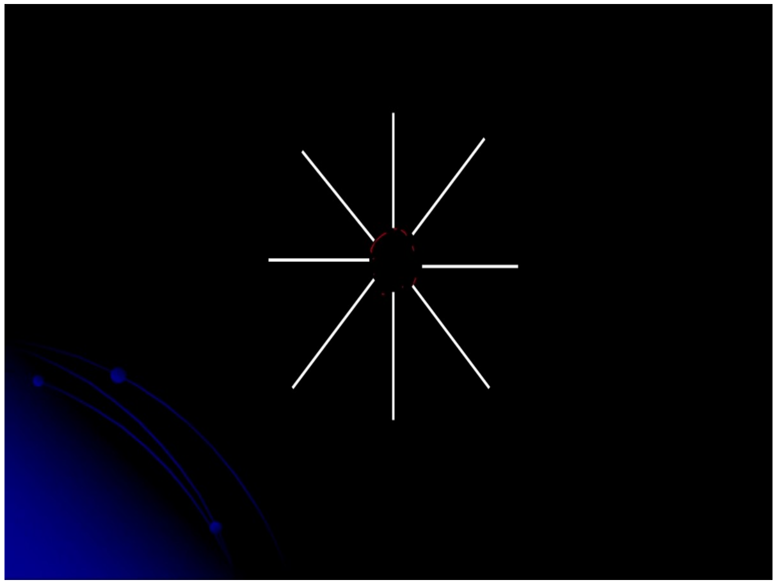

Then, another thing is the interesting facts of human visual systems. So some of the cases like in human visual systems, if you see, we do some interpolation here. If you see this image, that means, we are doing some interpolation. That is something like I am getting the circle here or something like this. We do some interpolation in our brain that we cannot explain what is going on in our brain during the interpolation; why actually we are doing the interpolation that is very difficult to explain.

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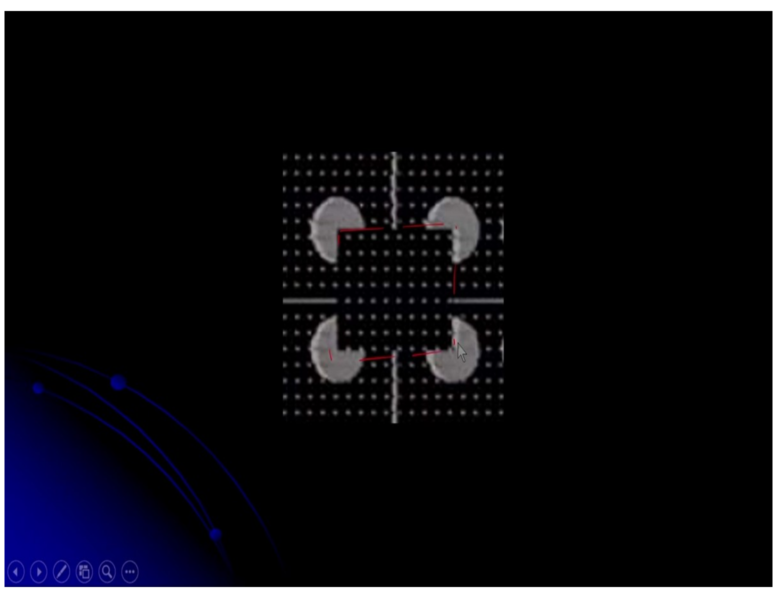

Similarly, I am giving another example that is interpolation. You can see I am getting square something like this. This is the square.

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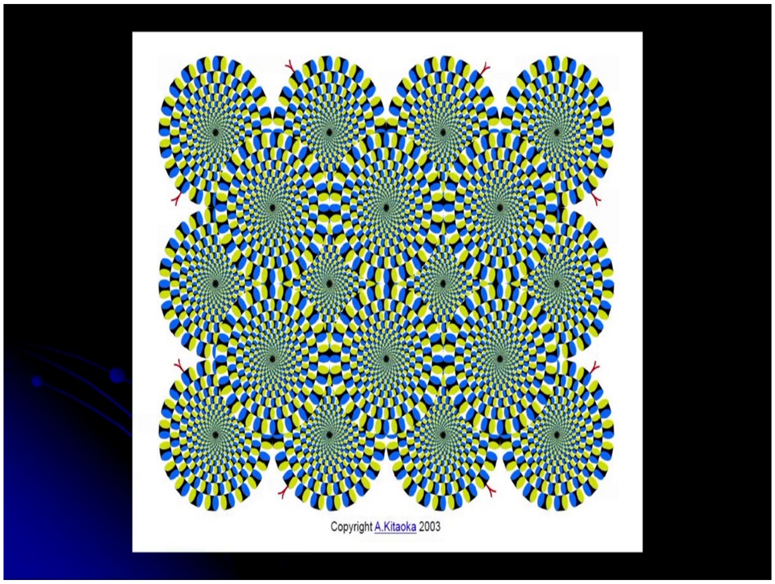

And another you see, the optical illusion example is this optical illusion. So what is going within our brain that is also very difficult to explain in these cases.

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Then why the computer? What is the need of computer vision? So already we have discussed that human vision is more powerful than the computer vision. Then what is the importance of computer vision? So in this case, I will give some applications of computer visions. So I will discuss one by one and I will show the applications of computer visions.

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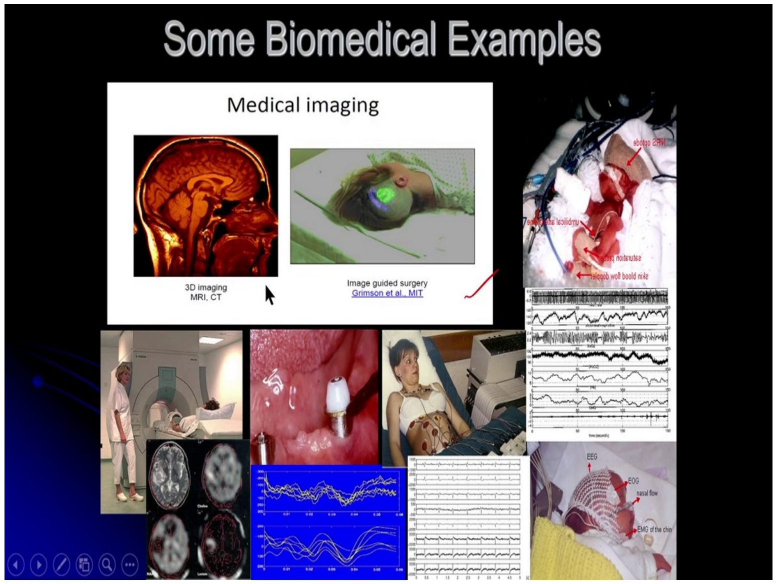

Computer vision applications I have shown here, like in multimedias, the movies, news and the sports, in video surveillance, security, medical imaging, medical image processing like in augmented realities, optical character recognition, 3D object recognitions, even in the games this is the video surveillance, inspection of the industrial components, robotic automation, this is the robotic visions, human computer interactions, and also image segmentations. So there are many applications.

So here, I have given some biomedical examples like medical imaging. So we can use the computer vision for all these cases like the virtual surgery, the laparoscopic surgery, or in case with the medical image like the CT scan, MRI, image analysis, we can use computer vision.

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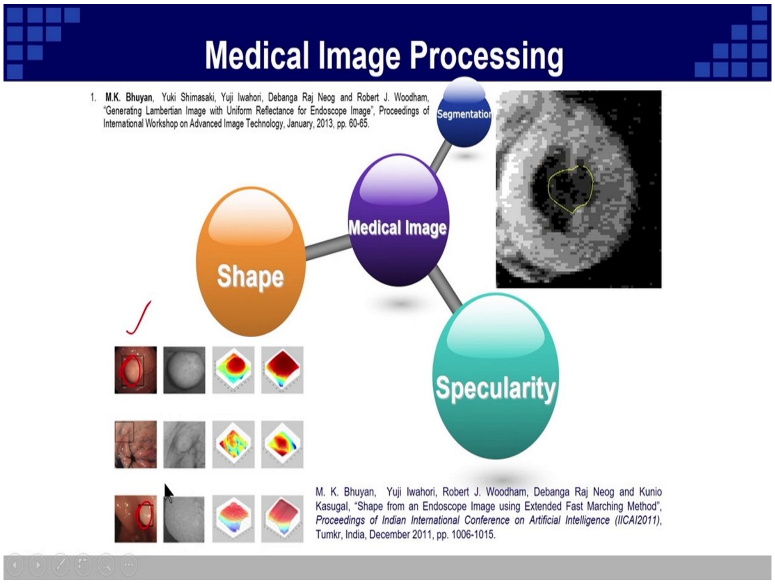

So like this, the medical image processing, we have many, many applications. In this example I have shown and the polyps which are available in the endoscopic video. So we have taken some endoscopic videos and from this, we can determine the polyps; these are the polyps.

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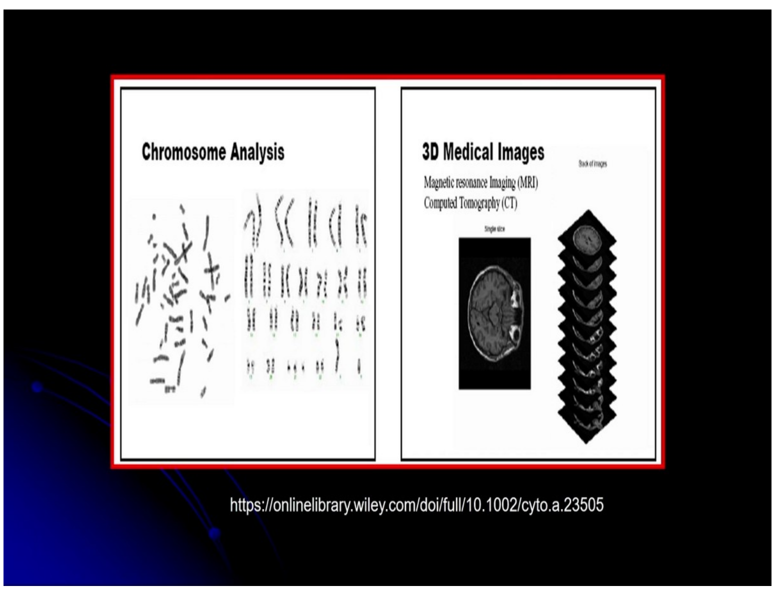

Like some examples like chromosome analysis, 3D medical imaging like MRI images and CT scan images. And something like the virtual surgery and some applications are there.

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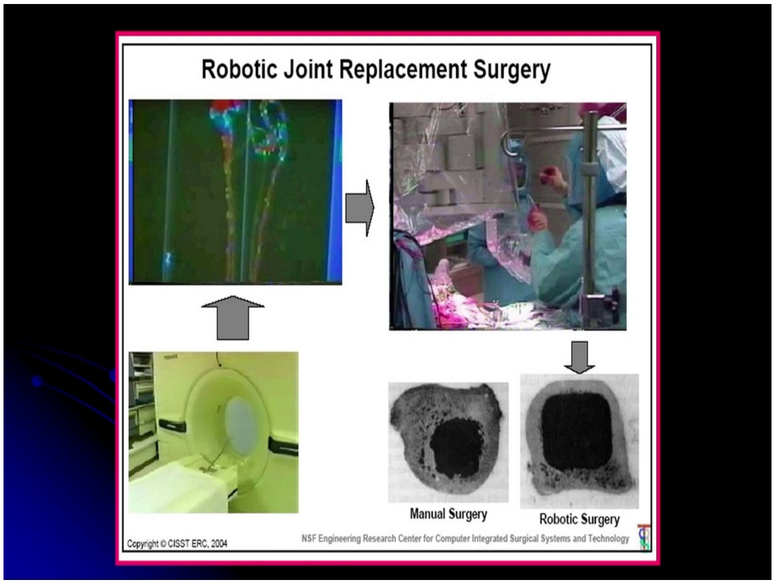

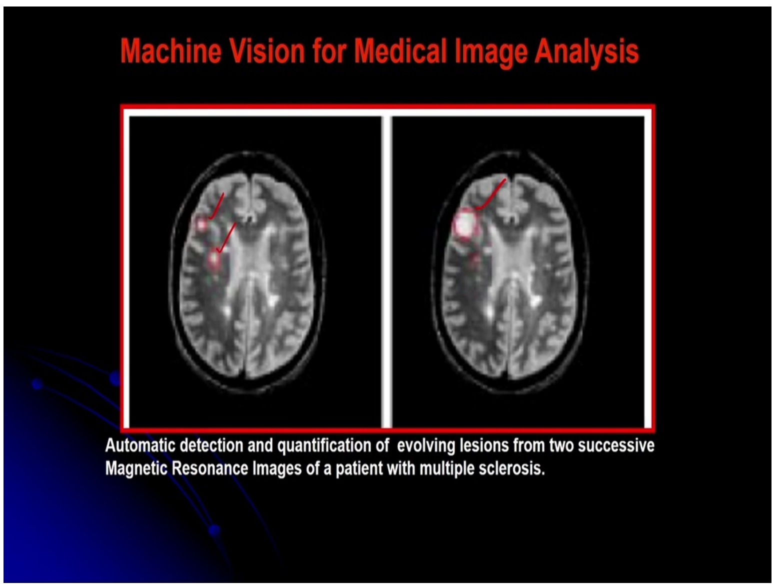

Machine vision for medical image analysis like the detection of the tumor; if you see detection of the tumors. So this is one example of the medical image analysis. Like this detection of the tumors here detection of the tumors, detection of the tumors. So this is one example of the medical image analysis.

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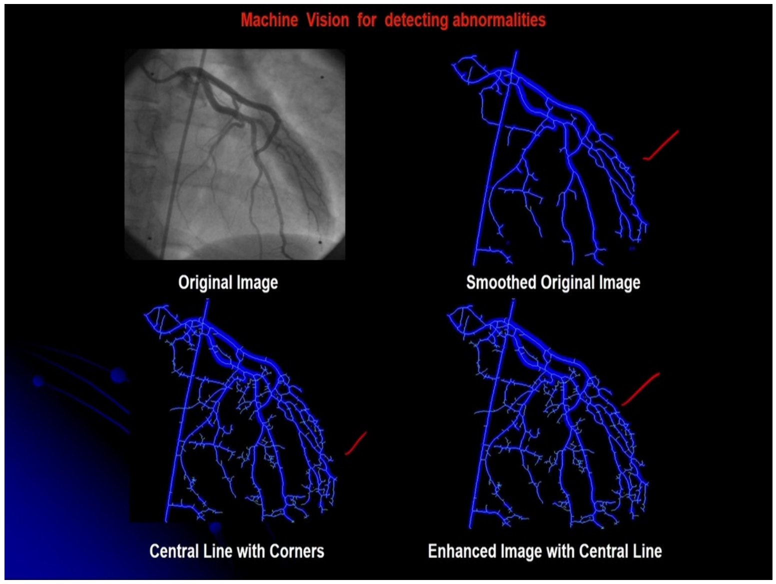

Another one is and this is the one image, the heart image which mainly the arteries and the veins. So we can determine the blockages in the arteries and the veins by using medical image analysis principles.

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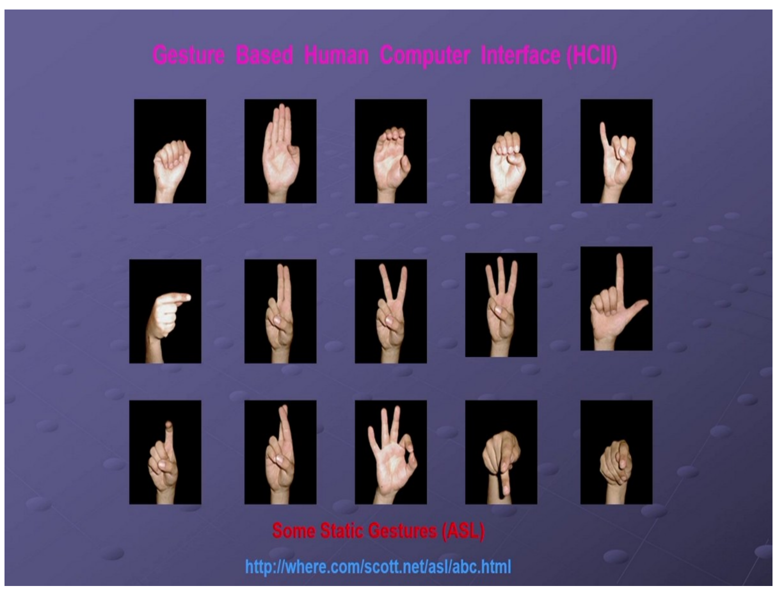

So other applications like human-computer interactions. So this example is, I am showing some American Sign Language. So I can interact with the computers by using gestures. So this is one important application. So instead of using mouse and a keyboard, I can use my gestures to interact with the computers.

So in this example, I have shown some static American Sign Language. So computer can identify this sign languages.

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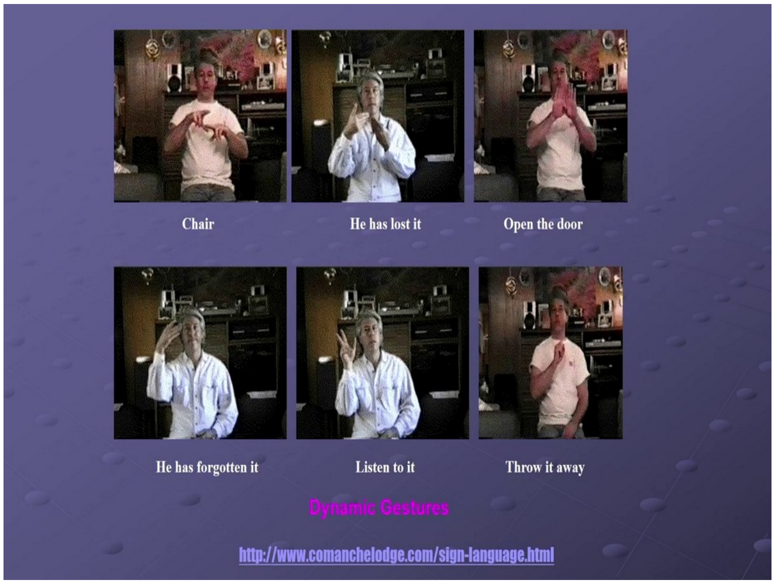

In the second example, I have shown some dynamic signs, so the computer can identify this one. So for human-computer interaction, this is one application of computer vision; the human computer interactions.

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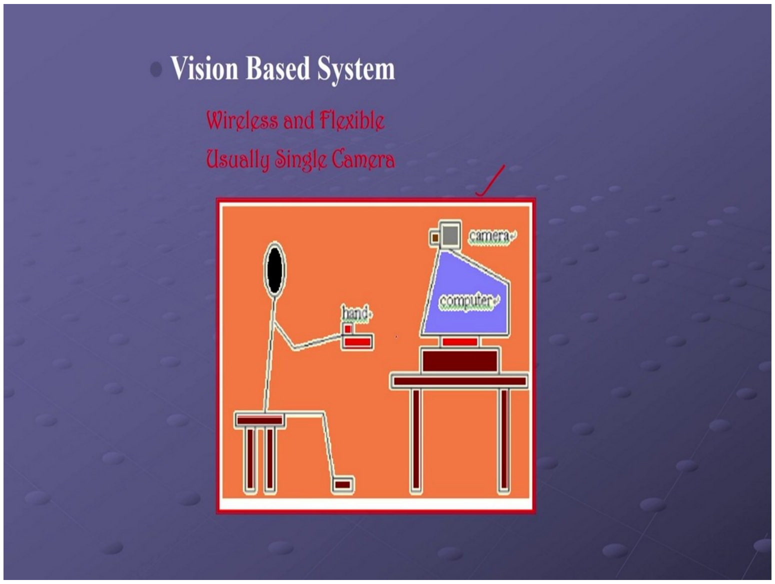

This is the vision-based interface. We have cameras and in this case the camera detects the movement of the hand. And after this, we can recognize the movement of the hands, so we can recognize the gestures.

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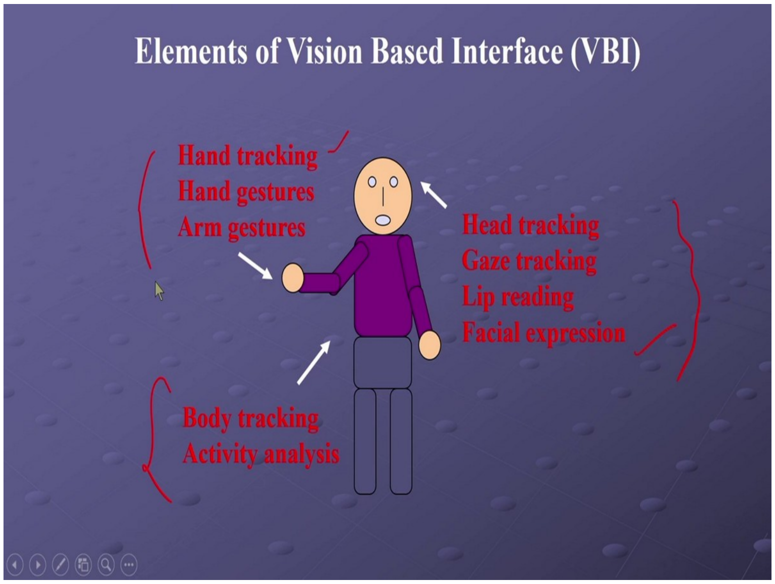

And some of the research areas like these areas, it is very important. The hand tracking, hand gestures, arm gestures, body tracking, activity analysis, head tracking, gaze tracking, lip reading, facial expression recognition. So some of the research areas of computer vision you can see; very important research areas.

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And here, I am showing some human computer interactions examples. This is, the last example is the TV controlled by using gestures. So in our laboratory, we have developed this one. So the human-computer interactions by using gestures, and these are TV controlled by using gestures.

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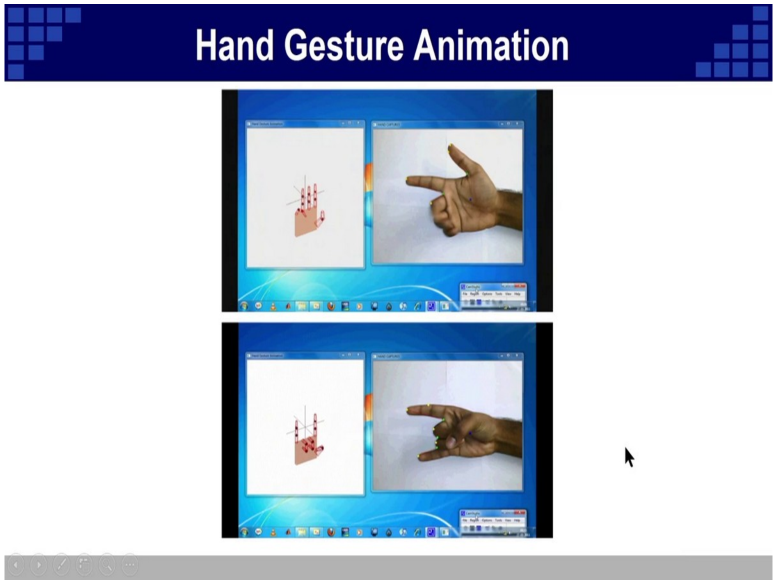

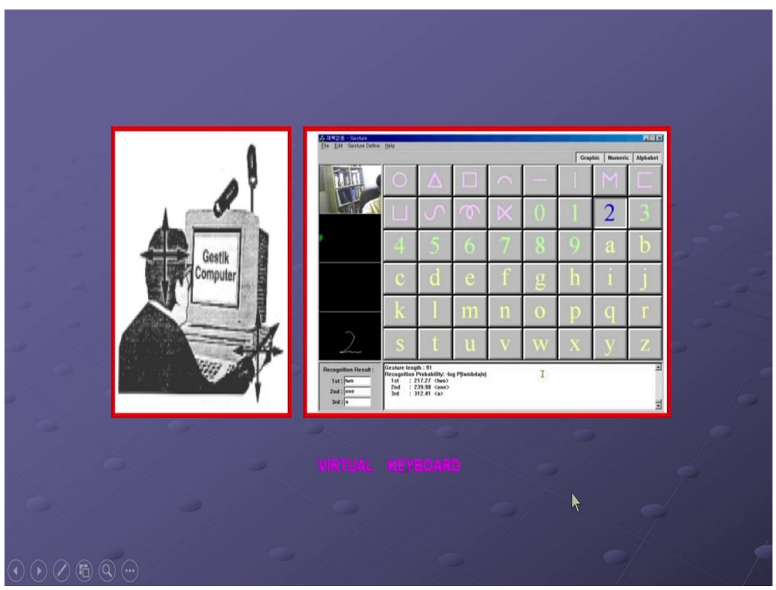

Hand gesture animation, this is one application of computer vision. The virtual keyboard in another example.

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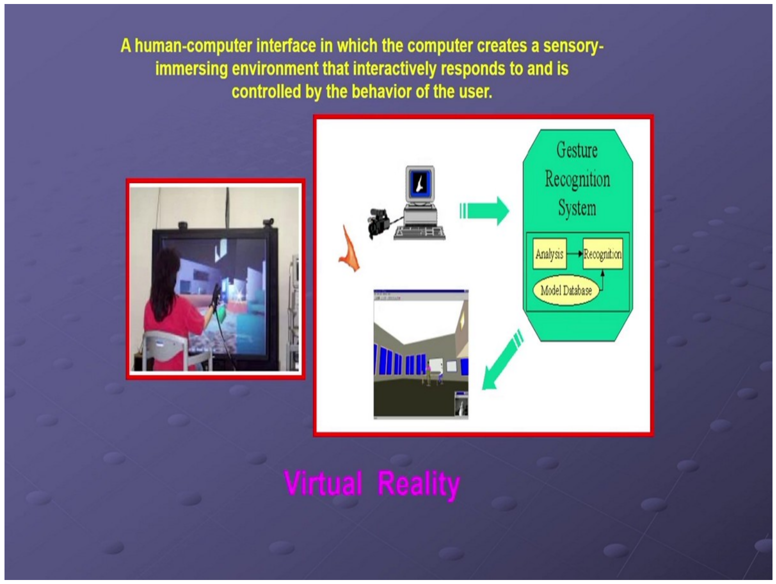

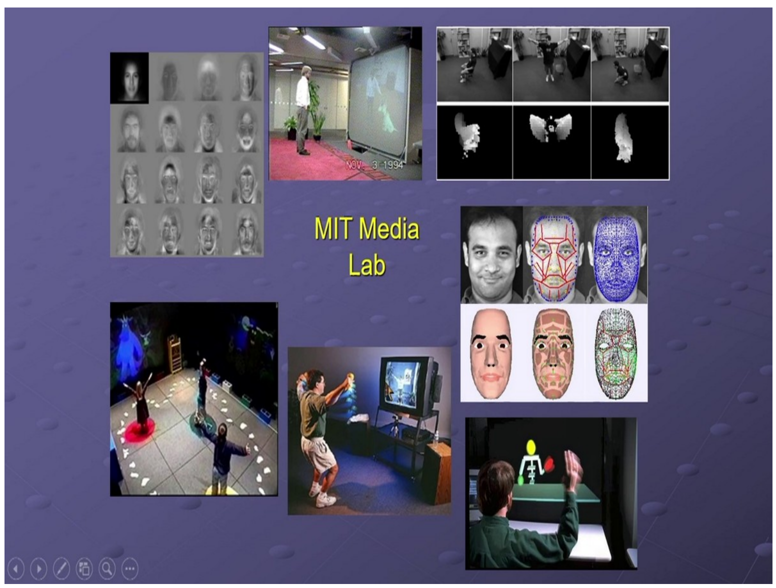

The virtual reality applications like in MIT Media Laboratories, there are many research activities like facial expression recognitions, face recognition, human computer interactions, body activity analysis, these are body activity analysis; so body activity analysis so, there are many activities in MIT Media laboratories. So these are the applications of computer visions.

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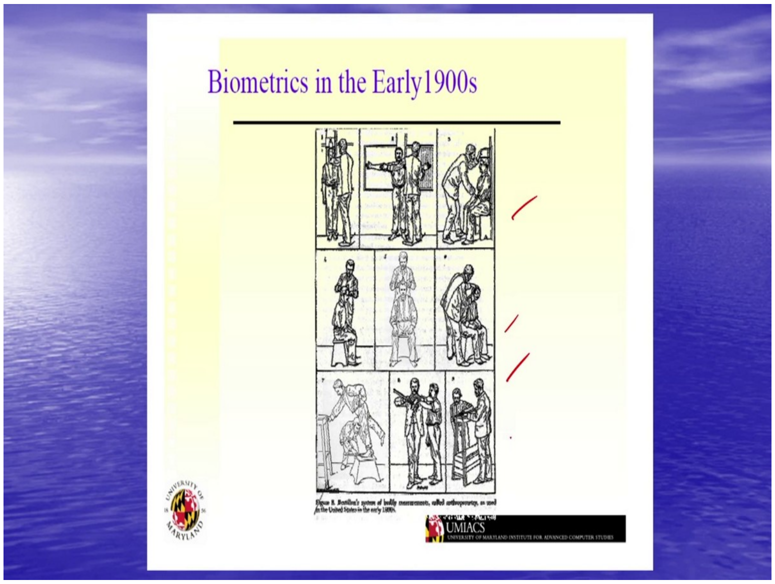

And even in the biometrics also I have many, many applications. If you see this example, this is the biometrics in the early 90s. So for identification of a particular person, we have to do lots of measurement; many, many measurements we have to do. After this, we can identify a particular person.

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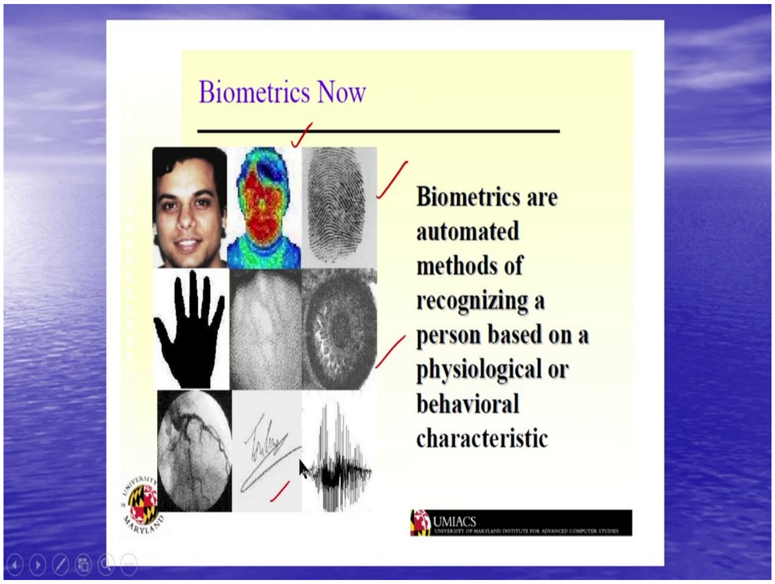

But if you see here, the biometrics now, these are the different biometrics; one is the face recognitions, infrared imaging, fingerprint recognition, that iris recognitions, the signature recognition, there are many, many biometrics modalities. These modalities are now available.

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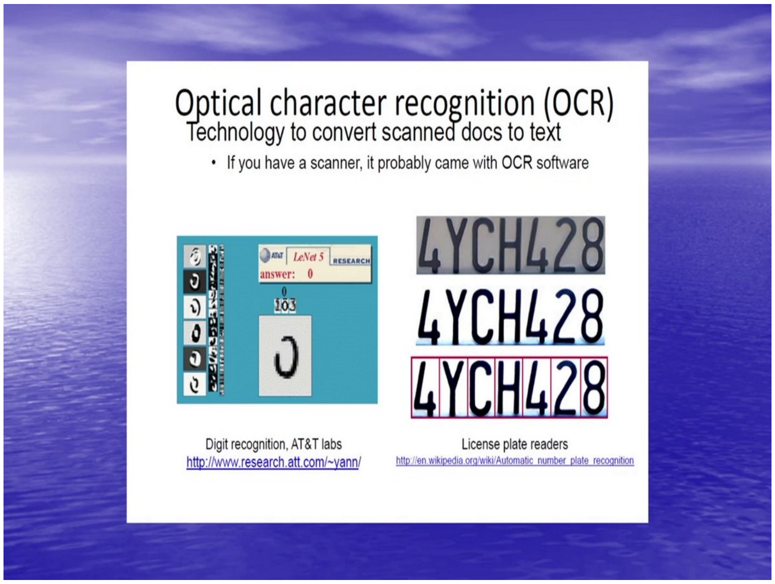

Like another example is optical character recognition. In this case also, the computer vision is useful, optical character recognition.

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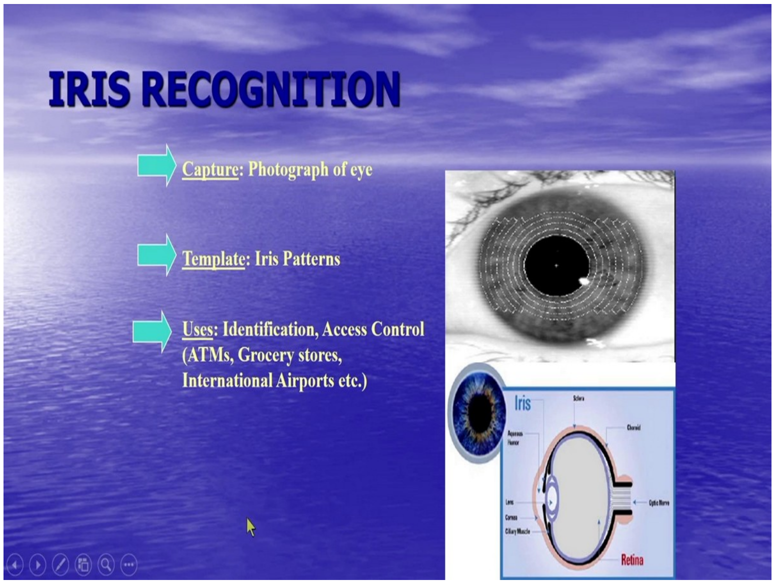

Iris recognition that is one example of biometrics.

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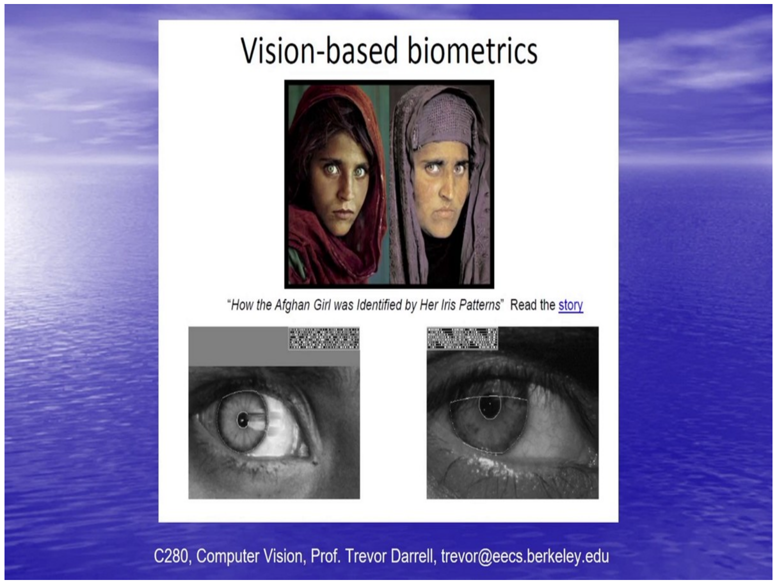

Vision-based biometrics; login without a password that without using the password, you can use fingerprints or maybe the face recognition. So this we can do that login without a password.

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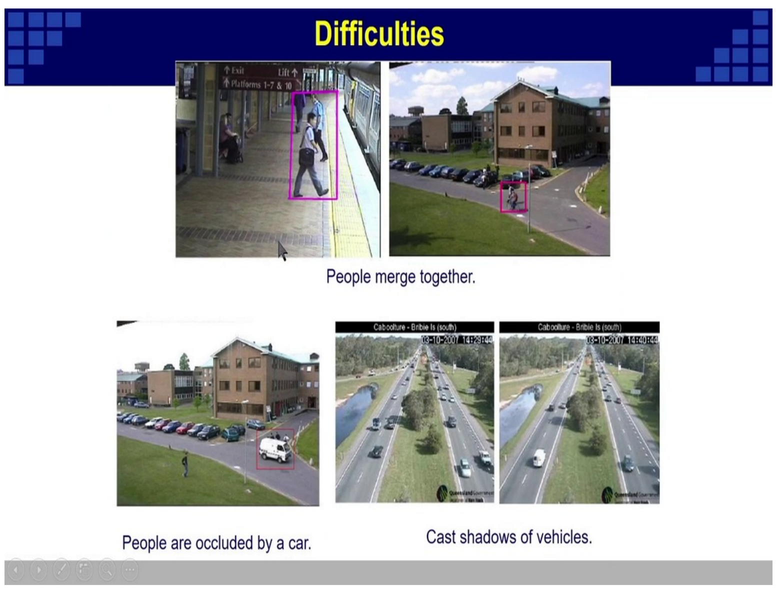

And for automatic video surveillance, computer vision is also you can use because this is one important application of computer vision. So applications like this, access control in special areas, anomaly detection and alarming, crowd flux statistics and congestion analysis, in this case, I have given these examples like the tracking. And you can see this example is the tracking examples. And tracking of vehicles.

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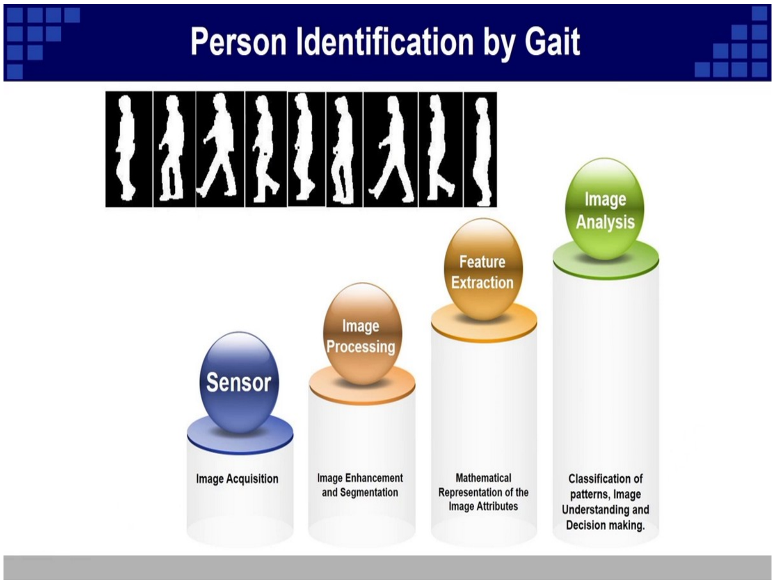

And this is another applications, the person identification by gait. Gait means the walking style. So from the walking style, we can identify a particular person. So this is one application of computer vision.

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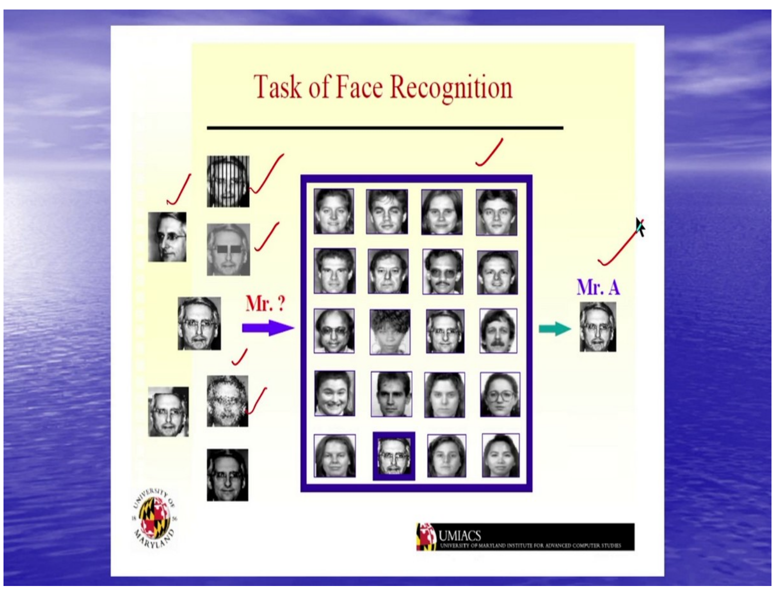

And if you see this, the face recognition. This is the problem definition of face recognition. So we have to identify this face. We have the database, in the database, all the faces are available and whether this particular face available in the database, we have to see. And there may be condition like this, we are not getting good quality image the noisy image or maybe occluded image. This is one example of the occluded image.

This is the pose variation, different poses. One portion is occluded. Even all these cases also, I have to identify whether this person is available in the database or not. If he is available, then we can recognize him. So this is the face recognition and the research problems may be like this. The face recognition with age progression, that is very important research problem. Face recognition for the different pose variations and also for different illumination conditions.

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Also, another problem is the facial expression recognition, so like this, we have done something on facial expression recognitions. Like this, the anger, the fear, happy, like this. So this expression, we can recognize and this is also important application of computer vision.

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Smiled detection in the camera, that is also one application of computer vision.

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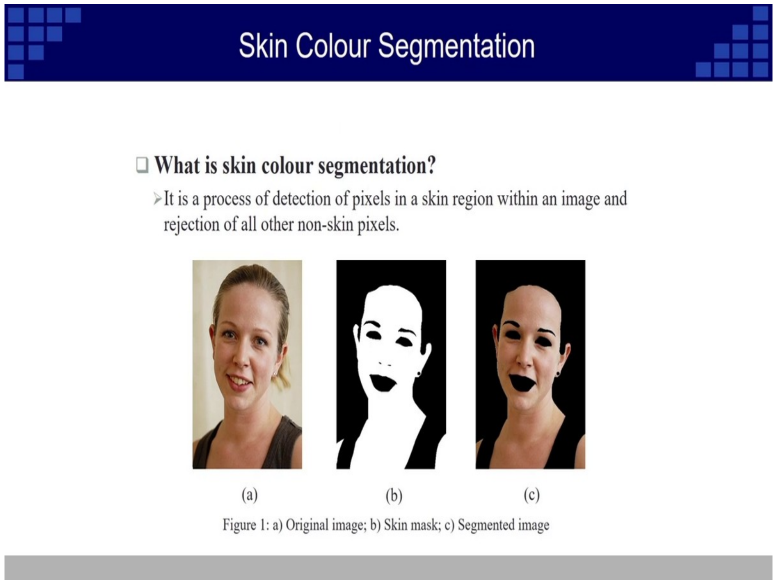

Face detection in camera and skin color segmentation, that is also one important research area of computer vision. So I have to identify the skin color. Here, I have shown one example. So we have detected the skin colors like this in the video and that is one example of skin color segmentation.

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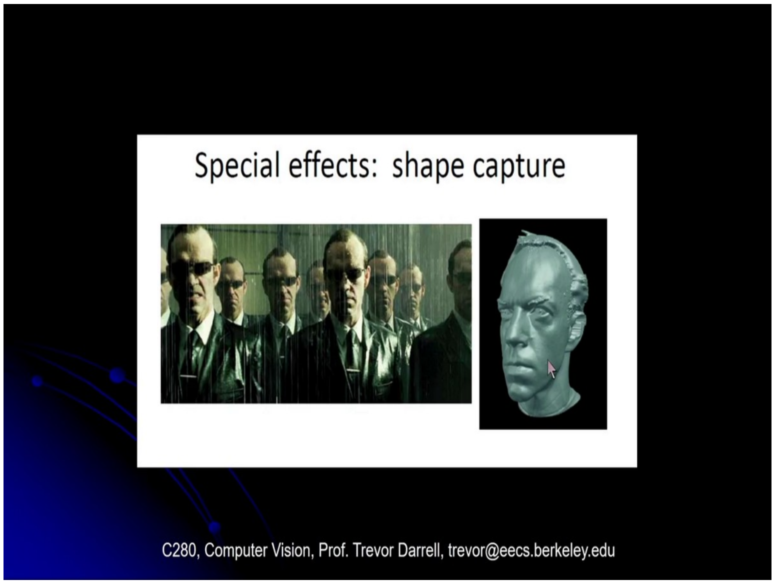

And special effects. So in special effects in movies, computer vision has many applications.

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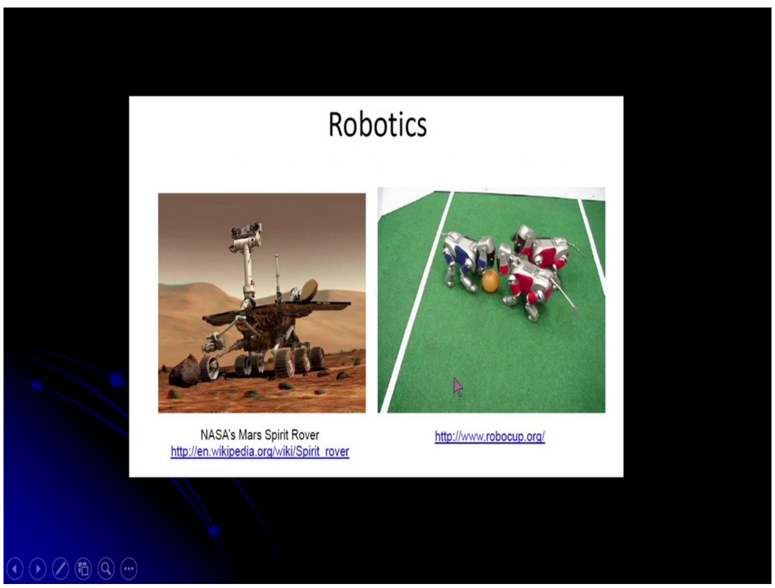

Even in the robotics also, computer vision has applications. That is the robotic vision.

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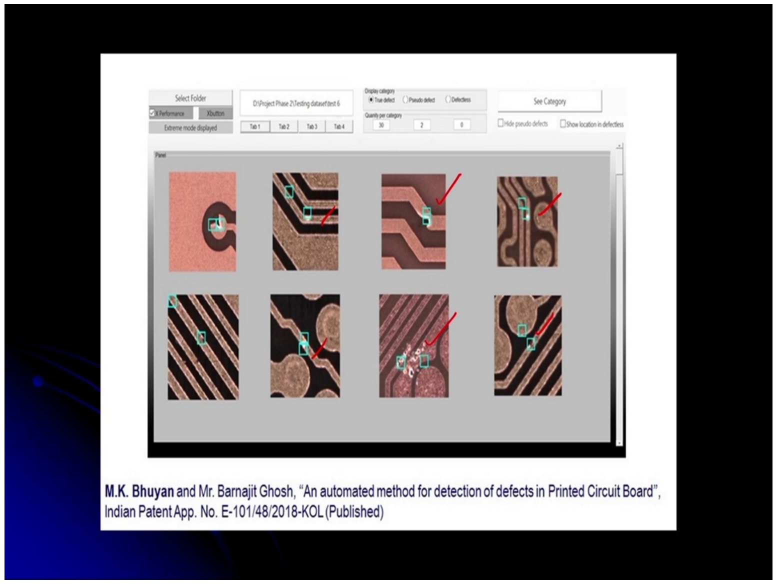

So these are the applications of computer vision and one application I can show here. It has very interesting applications, that is finding defects in the VLSI components. So in this example, I have shown defects in the PCB, the printed circuit board. So we have used the computer vision for identifying the defects in the PCB, the printed circuit board. Some of the defects we can identify like this. So this is one example.

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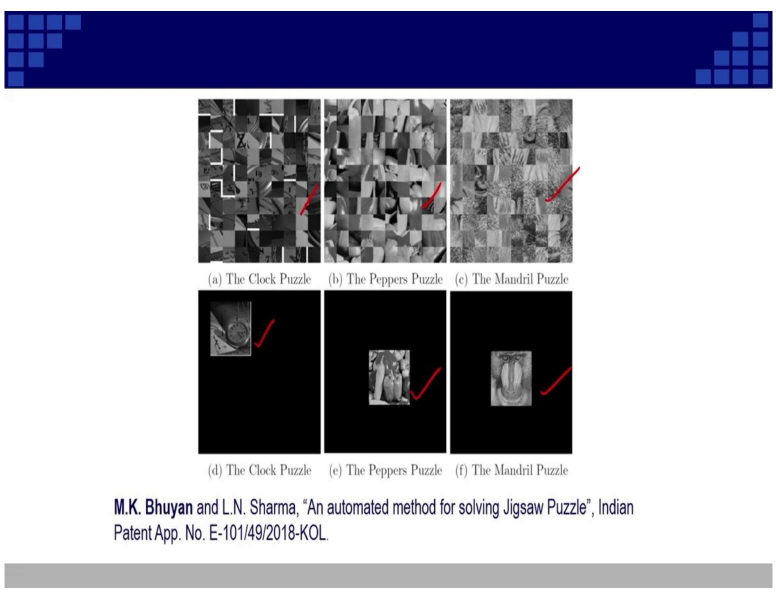

Another example I am showing here that is an automated method for solving jigsaw puzzle. So here, you see that this is the jigsaw puzzle. If you see, this is the jigsaw puzzle; this is jigsaw puzzle. And after the simulation, after this, what I am getting? I am getting one meaningful image. So in this case also, some algorithms we are using to solve the jigsaw puzzle.

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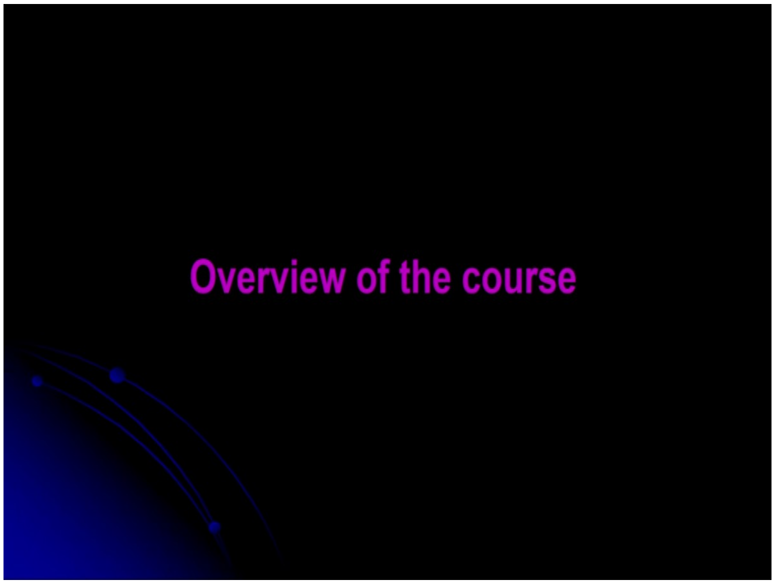

So overview of this course, the course on computer vision and image processing, fundamentals and applications, so let us see what is in this course.

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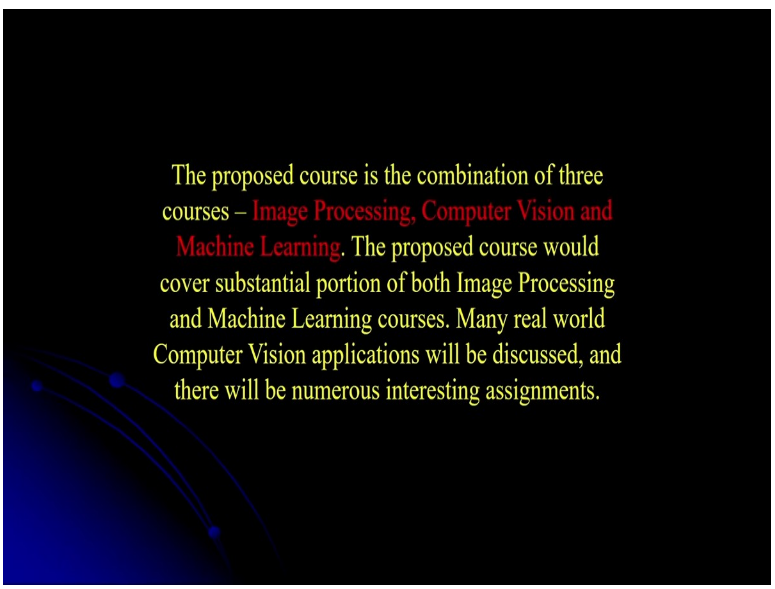

The proposed course is the combination of three course. The first one is the image processing, another one is the computer vision, and I will discuss some of the machine learning algorithms which are mainly used in computer vision applications. So in this case, we will discuss some of the statistical machine learning algorithms and also the artificial neural network, and the deep networks used for the computer vision applications.

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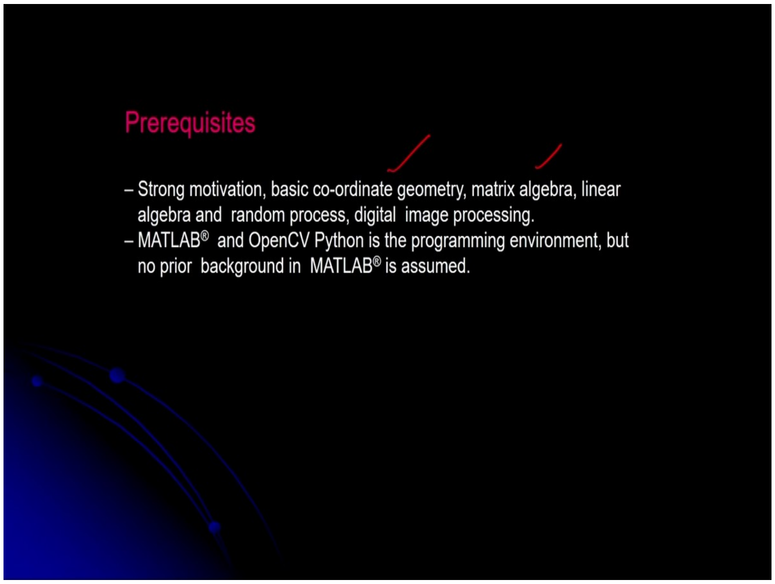

The course is something like this. The pre-requisite is basic co-ordinate geometry, matrix algebra, linear algebra, random process, and also the fundamental concept of digital image processing. And regarding the programming, we can use MATLAB or maybe the OpenCV Python is the programming environment.

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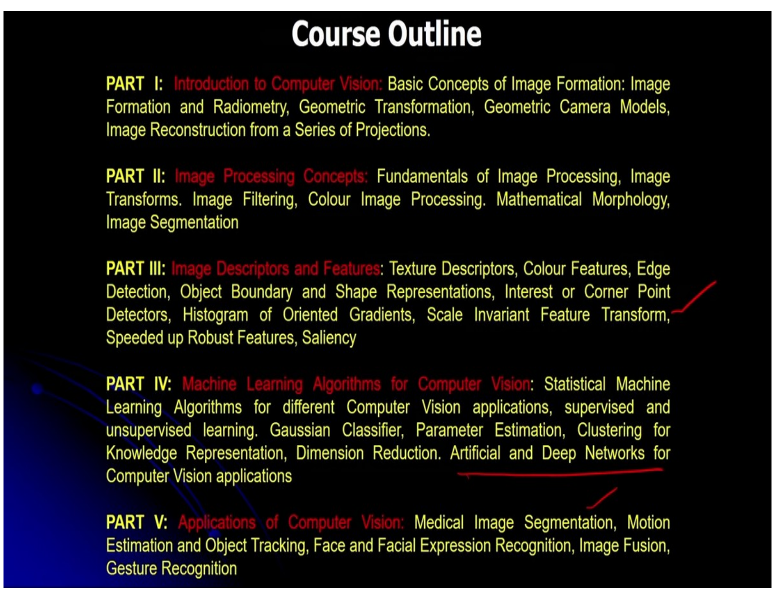

And the course outline is this. The part one is introduction to computer vision. So in this case, we will discuss the concept of image formation and also the concept of radiometry, radiometry means the measurement of light. And also we will discuss about the cameras, the camera models.

The part two is the basic image processing concepts. So we will discuss about the image processing concepts like image transforms, image filtering, color image processing, image segmentation, so briefly we will discuss about this.

Part three is about the image features. So in this case, we will discuss the texture features, the color features, edge detection and some other features like HOG features, the SIFT features, so we will discuss about this features.

Part four is machine learning algorithms for computer visions. So in this case, we will discuss some statistical machine learning algorithms for different computer vision algorithms. And also, we will discuss about artificial and the deep networks for computer vision applications.

And finally, I will discuss in part five, application of computer vision. Some of the applications like medical image segmentations, motion estimations, face and facial expression recognitions, gesture recognition, image fusion. So these applications I am going to discuss.

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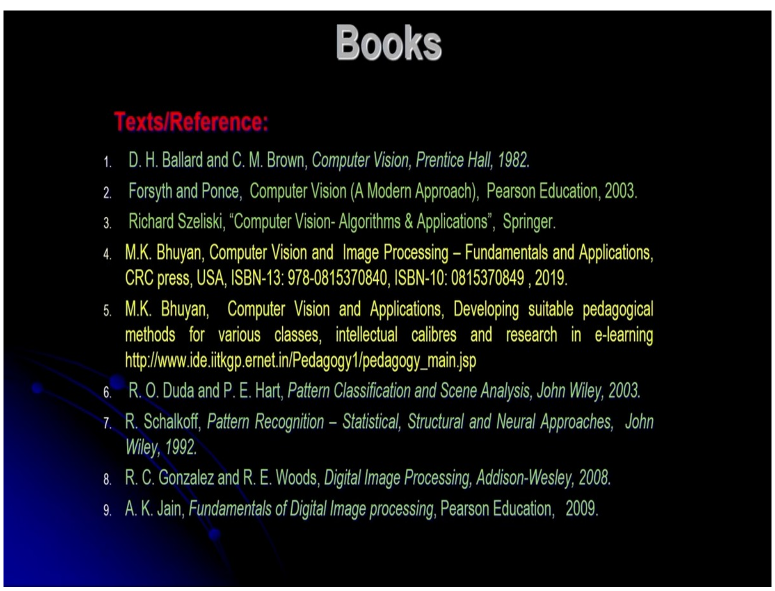

Regarding the books, the text books, you can see the first book is the Ballard and the Brown. That book is the very old book and that is available in the internet, you can download the book.

The another book is the Forsyth and Ponce that you can see this book. And I have my book, that my book is Computer Vision and Image Processing by M K Bhuyan and this was published by CRC press.

For machine learning, I will be considering this book, the Duda and the Hart. And for image processing, you may see the book by Gonzalez and by A K Jain. These are the books. So I hope you will enjoy the course.

So in this lecture, mainly I have defined the computer vision and also I have seen the difference between the human visual system and the computer vision systems. After this, I have discussed some important applications of computer visions. So in the next class, I will discuss the fundamental concept of image processing. So let me finish here today. Thank you.