Image Signal Processing
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Applications of Image Processing – Part 2
Lecture 03

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And then here is rolling shutter. Now what we find is what? Okay if you see these images, right if you see this building, what do you notice? You notice that this edge looks a little curved. But you know for a fact that it should be in a straight line. So if we do the rolling shutter corrections much correctly, see this kind of pillar or whatever, this pillar here that has come out bend. This will happen only if you have a rolling shutter camera.

And this is happening because something, because the camera has moved. The building cannot move, right. So the camera has moved and therefore it has introduced you know sort of what you call a distortion. This is called a rolling shutter effect. And therefore, people have to work on.

This is a very-very important problem. This always, almost always happens especially very significant motion. Otherwise you can ignore it.

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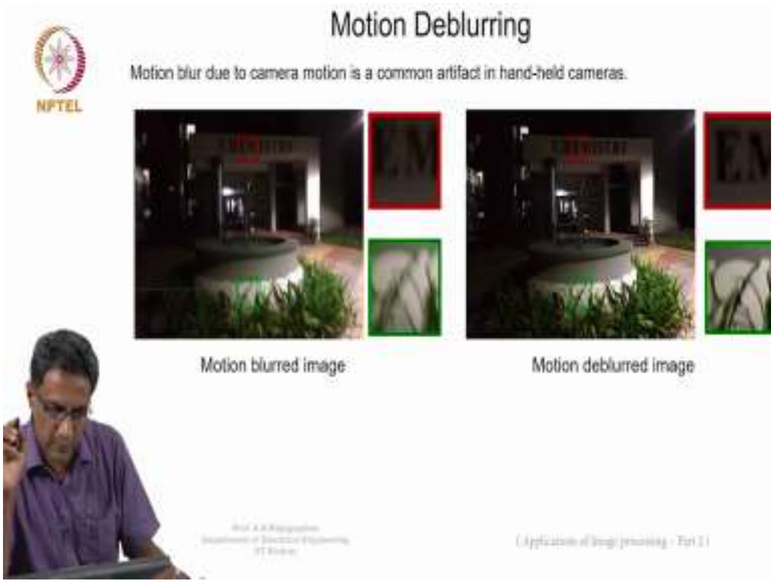

Then motion deblurring I already talked to you about it.

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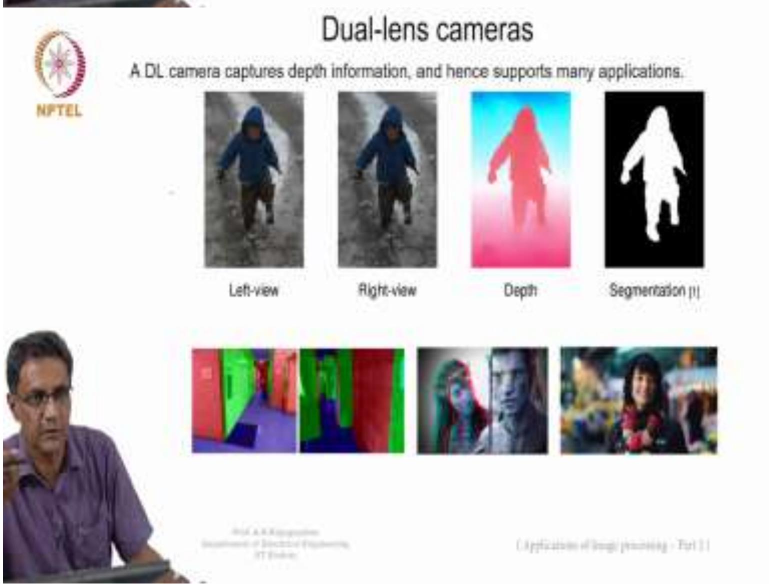

Then the dual-lens, all these cameras have multiple lenses. What can you do with them? You can get a sense for depth. You can do segmentation. You can do some kind of, you know see an understanding in the sense that you can even tell how many planes there are. For example, this indoor sea you might want to, you want to segment it into various different planes.

And then there is also called you know a bouquet rendering. What does, what that means is that only some of the interest can be brought into focus and then everything else around it is kind of say blurred out. So that the person that is looking at the image knows that your focus is on this percept and not on whatever is there around it. This is something you even observe in a DSLR camera.

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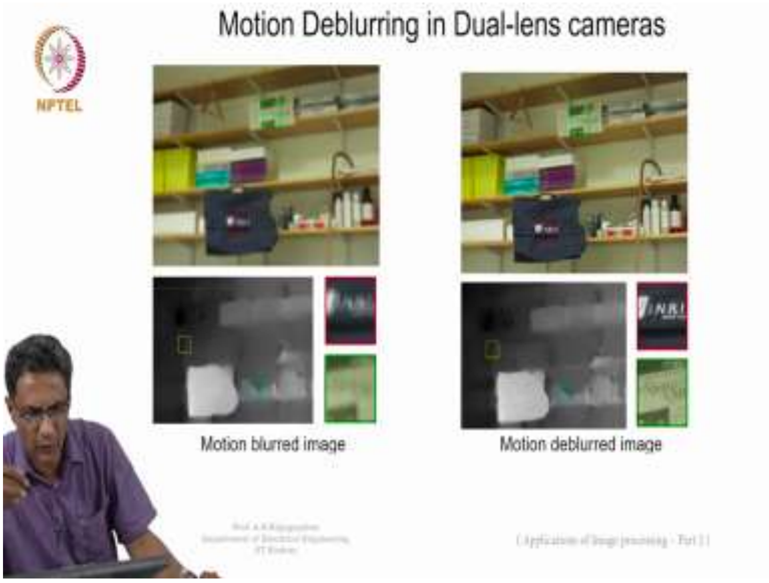

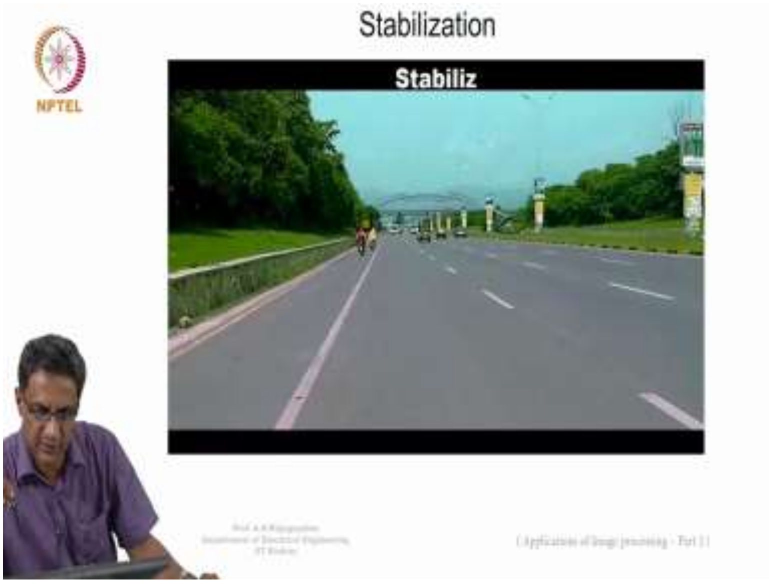

Then motion deblurring in dual-lens camera. So all these things are all emerging things. A fair amount of understanding has gone into how these things work and so on. Stabilization is another.

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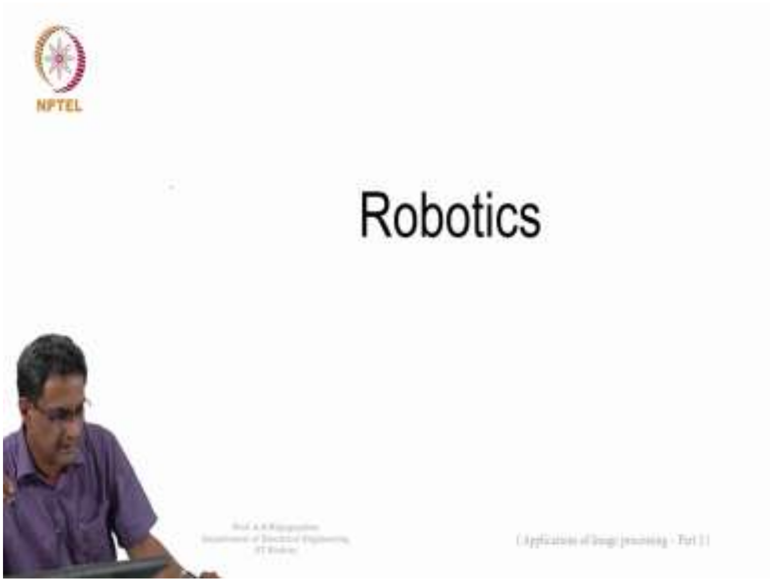

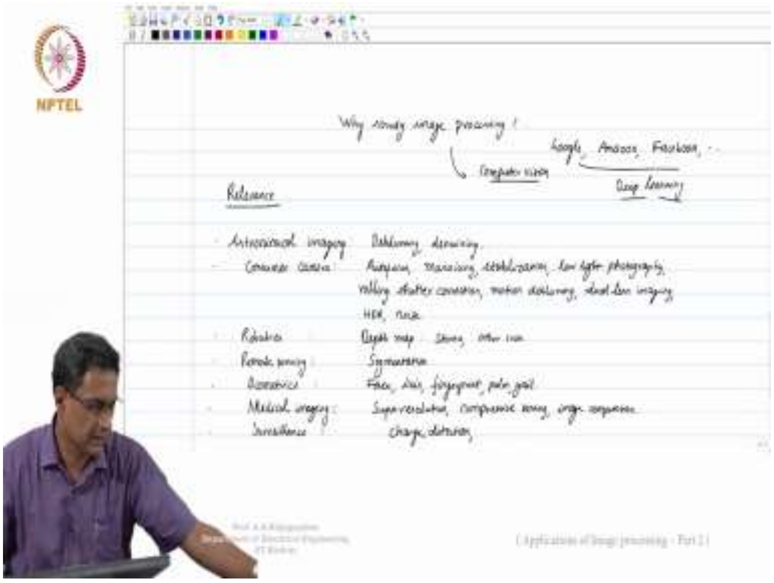

And then the third one that I wanted to talk about is robotics where okay in terms of robotics, so it is like saying that if I had to, if I had a robo that had a camera on it, and then it needs to have a sense what is around it. So here what is really, what really matters is what is called a depth map. And this depth map again you could acquire through various means. But our interest will be in terms of how do you acquire through pure images.

You know that we can also do other kinds of time of light sensors and so on but our idea will be how do you do stereo or whatever radar there, you know other cues that one can use is simply stereo. You will be amazed to know that the way our, so for example, if I just close my eye, one of the eyes not both, if I close one of the eyes, I can still make out who is where, right. That means that the brain is not just depending on stereo, choosing something else also in order to tell who is where.

So all these things are, so that is what I mean by other cues. Cue means some kind of a clue. So robotics, then let me write down a few more. Then another area where it is very-very useful is what is called remote sensing. And one of the mini projects will be on this, will ask you to do some kind of image segmentation. So one of the main things is what is called image segmentation.

See although we may not look at a consumer camera per say or we may not look at an astronomical image per say, but there are many of these things which have, which I am mentioning here you would hopefully end up not all of them but you will end up doing many of these with, okay during whatever, during the assignment or say otherwise.

Remote sensing segmentation then another area is ofcourse, a biometrics. So you would have heard about face of course, then iris, this is something that you all heard about. Fingerprint and then anything else that you heard about? Fingerprint, heard about palm. People use palm, people use ears, what else? People use gait, you know gait? Gait means simply the way you walk. And it is a very-very important sort of a cue.

Apparently, why apparently? You can actually make out that it is your friend. You have to see your (face) see your friends face to know it is your friend, most of time know. It is walking around, right our chap is going there. How do you say that? That is because you have a sense for, the guy has a unique way of walking.

Each fellow is unique, you should watch this, you knows. When you walk down the corner, just watch how each person walks. It is very interesting. So gait is another thing and especially gait is very useful if you have to identify somebody from far.

When they face another cues are will be a failure. Because you have to zoom in and then if you zoom in right, you have to re-zoom in or maybe it does not even show your face to you. Then there is a medical imaging. So as you would understand, it is again a very-very important problem. Medical imaging especially what is called super resolution, as I say there is not anything super about super resolution.

It simply means that you have to be able to build a high resolution picture given a low resolution picture. And then imaging, the medical imaging people do what is called compressive sensing. It is not the same as compression. Compression means you have actually take in lot of data. Then you start to trim. Compressive sensing means you only sense as much as you want, right do not sense too much and then start to chop. Okay so image compression and so on.

Then surveillance, this is again interesting. We all find these cameras all around. On the roads as you travel there are these cameras. I wonder, I have always seen that they are all dumb cameras in the sense that when, they are not seem to be doing anything intelligent. But at least there are at least giving you data and then somebody at the backend should be actually doing something.

But then I have seen in airport Madras itself as about I think 2000 odd obvious cameras. Madras airport. You would not probably, you would not have noticed it. But then you know in all this, there is some kind of a control room where somebody is sitting there and watching all this. It is ad for that chap. I should be looking at and then something will go wrong.

Alright, so in such case, the surveillance, so what is called, but now there are advanced imaging techniques that can tell when something is unattended. The baggage is lying unattended for a long time, so an alarm can be flagged and so on so that somebody can then take appropriate action.

So there are many-many algorithms that come around this. One of the things, one of the other things that is very-very relevant is what is called a change finding. What that means is something which you took let us say a month ago, of some scene and then after a month you come back and then you take another image.

What can happen is it may not be the same camera, the first time you took with some other camera and then second time you do not probably have the same camera. Secondly, you are not probably, you know it seems impossible to be exactly at the same location. I might have taken a classroom image today as of today and then tomorrow I come back, I may take it from here.

In such cases, you want to know what is a real change. You cannot directly subtract the images because the viewpoint is not the same. And you want to know exactly has something changed right, this is all very important for let us say war times and so on.

Even let us say if it is not a war, there always be satellite images that keep imaging, that keep sending images of certain very-very sensitive regions. So it is like saying that you know you could have several army trucks sitting inside some place and suddenly the image shows that there is no activity. But then suddenly you find that those activity trucks are coming out, and that means that something is going on.

So change is such a fundamental thing. The only problem with change is that what is a change is not clear. For example, what I am saying is these are all very-very, if you really sit back and think about it, these are very interesting topics. Because for example, there is a snow and then if you capture a video and suppose through the snow there is a car moving.

For you a change is probably the car, right that is the main thing that you would consider as a change. But then if you have an algorithm, you may simply that the snow itself was heavy at that time, lighter this time therefore all that has changed.

Again, what really do you mean by real change and so on, so that way there is a lot of work into what you really mean by change. But for us we will simply keep it simple. For us change is like something between two images you compare. And then okay you want to be able to see what kind of changes are there. Then going further, so all these are applications where this is being used.

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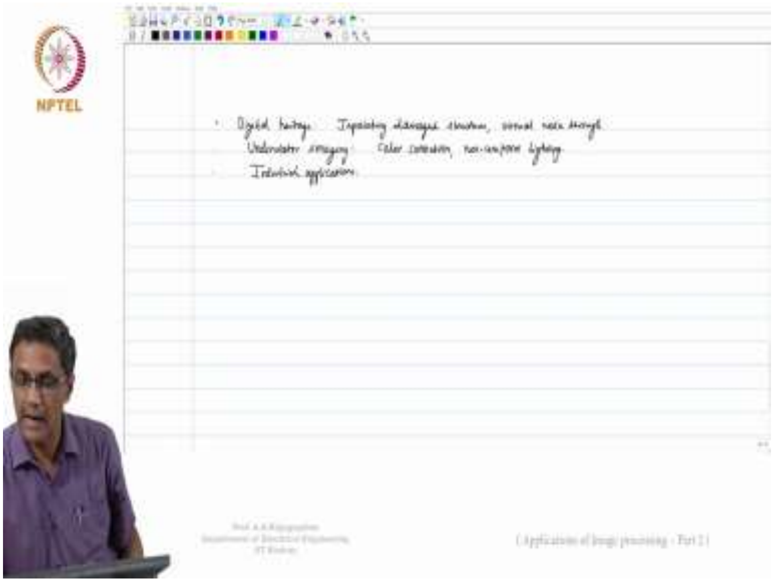

Then there is a digital heritage. This is again something interesting. A digital heritage, what it means is one of the things that is frequently done is you can give a virtual walkthrough. For example, of some of these heritage sites or you can even do what is called inpainting damage to structures and so on, impainting damage structures. You may end up doing a virtual walkthrough and so on.

So what is called an immersive experience? So you should be able to feel as to how, what does it mean to be in a place like that. Now I will show you few examples of this. And then something else that is underwater. All that I said until now is all on the surface. You have camera on the surface, you are capturing everything on the surface but what about the whole thing that is underwater?

Okay there is a whole area on that what is called underwater imaging and then none of these things that you use, none of your algorithms that you have done for the surface things, right you cannot simply take them and then apply them underwater. Because underwater the way attenuation happens is a function of the wavelength. Radius is the one which will get attenuated the most.

So when you see an underwater picture, we will typically you see that it has a bluish and the greenish and so seldom you see a reddish stitch, right simply because it is all function with wavelength and so on. And therefore underwater imaging that people try to use what is called a color correction algorithms, what is called what you call non-uniform illumination handling, so many things.

And again, that is important because you have a light source. Typically, as you go underwater it, after you turn on maybe a few tens of feet, the sunlight you cannot even see it. It will not even come in. So beyond that you have to use your own source. When you use your own source, so it will try to highlight whatever is in the front and then something that is away will all start to look dim.

So this non-uniform lighting is something you know that let us say people have been working on. This is not relevant only for underwater, it is also important for let us say for indoor scenes and so on. But I am saying underwater imaging people are always facing issues with non-uniform lighting.

Then finally, there is something called industrial applications and before I talk about this, I will just show you a few slides on what the earlier ones that I actually mentioned happen to be like.

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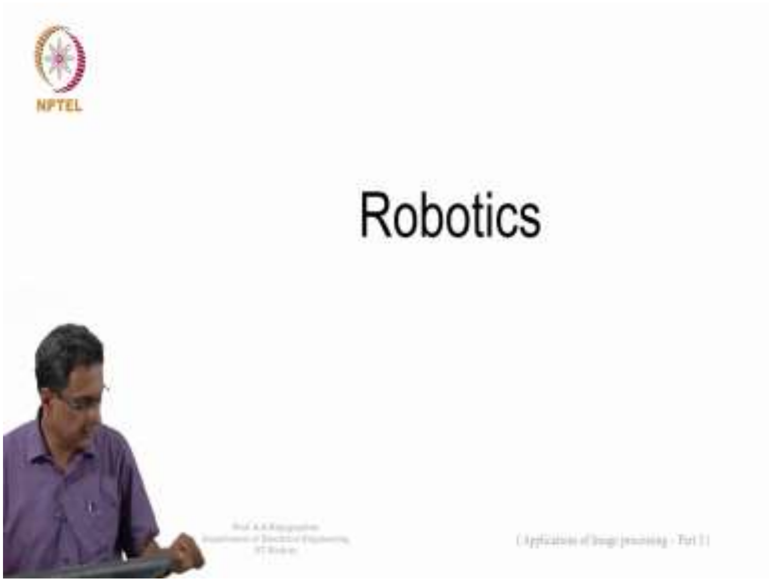

So let us go back to that ppt and okay, oops, what happened? So robotics, I did not show you an example, right. So it is like this, you capture a pair, pair of images which is called a stereo pair and you want to be able to build a depth map. A depth map wherein each intensity in this image will tell you whether an object is farther off from the camera or it is actually closer. Again, these are not solved problems.

Especially, when there is no seen texture, for example, and if you have very smooth wall like this and a little struggle because these things try to match features and whether no features, they will struggle. So it is not like these are solved yet. I will talk about what issues are typically involved especially if you have a light source that is creating peculiarity and so on, you will have issues.

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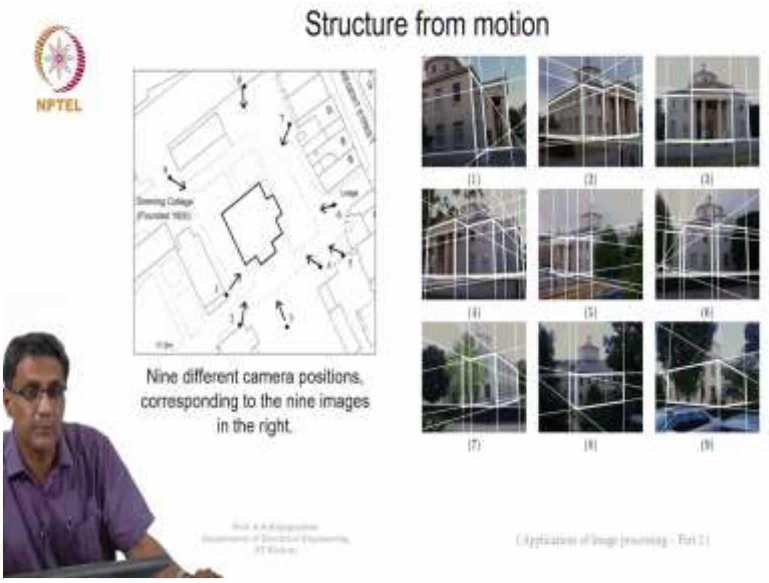

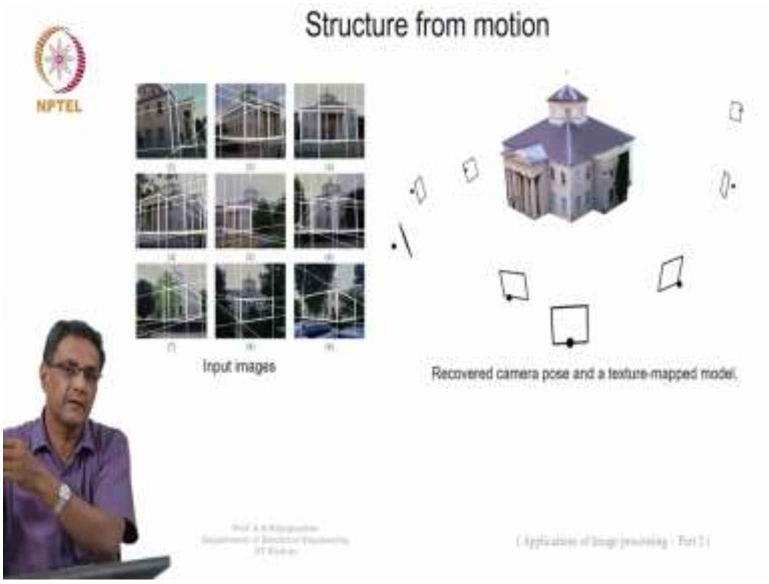

Then there is something called structure from motion which is like taking a camera and try to move around with it and then try to build a kind of point cloud of the scene of your 3D object.

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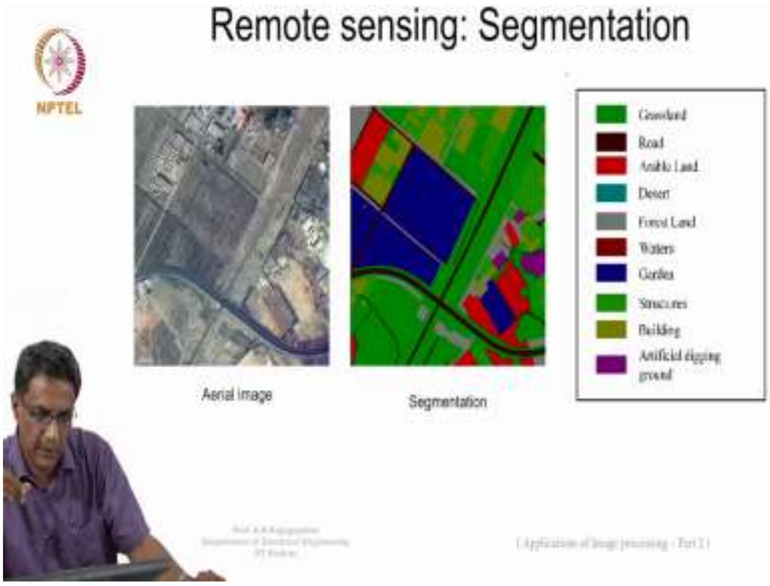

Then remote sensing dimension is like a segmentation problem where you want to tell what is what. Something is water, something is garden, something is some other structure, building and all this. You want to be able to label them.

This is more like a labeling problem. And you have n number of labels and you want not to assign to each of these image intensities. You want to tell to which label should that actually belong.

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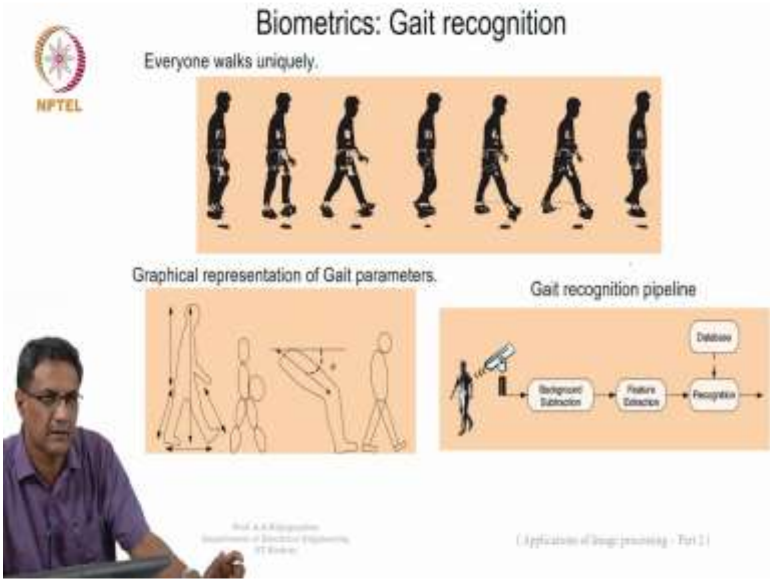

Then biometrics, I already said gait is one thing. This depends on the way people walk. This is typically a dynamic thing. Gait is never like a static thing. You cannot take one guys one picture and then start talking about gait. So gait is typically a dynamic activity.

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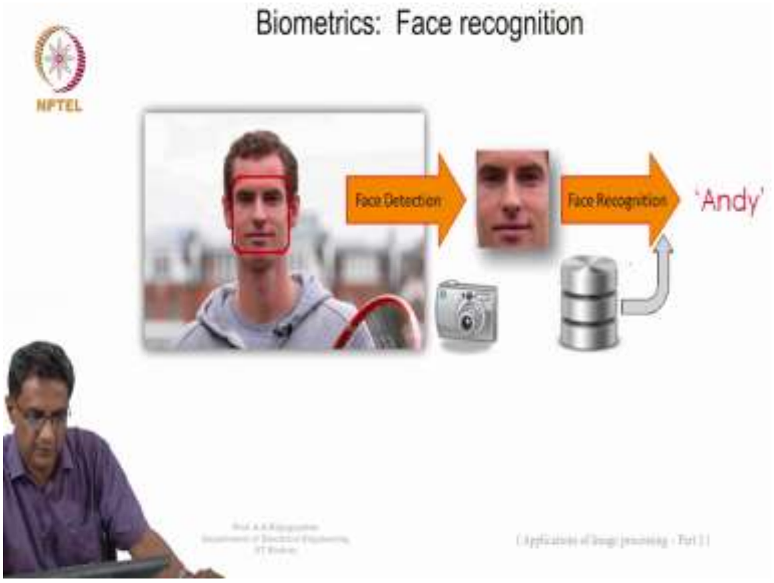

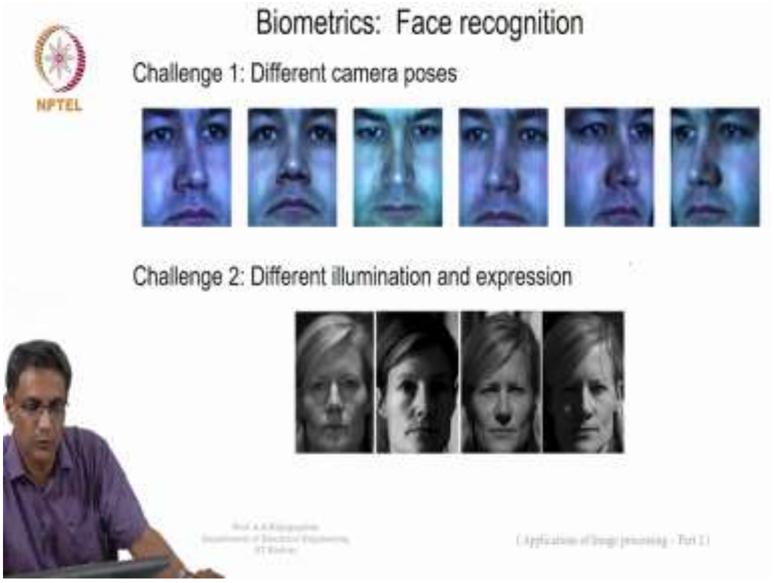

Then face, of course you all know. This is face recognition not from my lab obviously. This is something taken from the net. And then this is another, then you do face recognition again there are several other issues that come up. This is like different camera poses, different illumination, different expression, then blur. This is from my lab. Again occlusion, blur, illumination all that. These are all students that have done wonderful work in the past.

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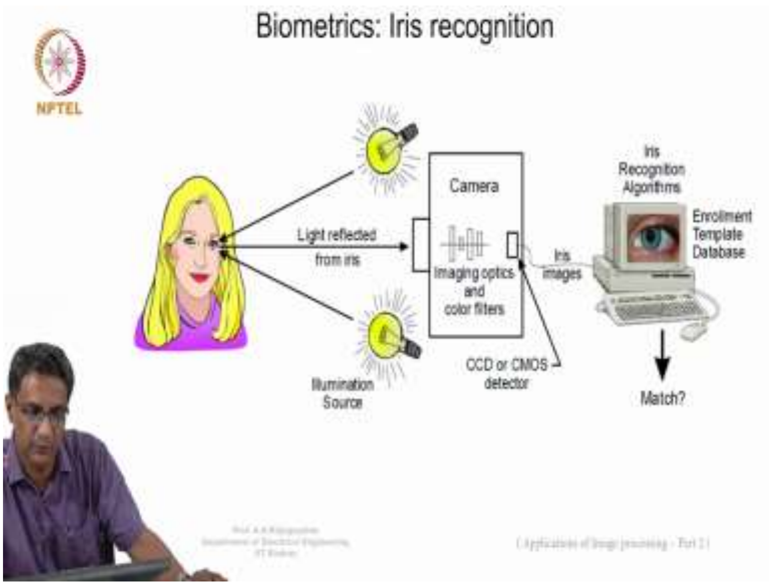

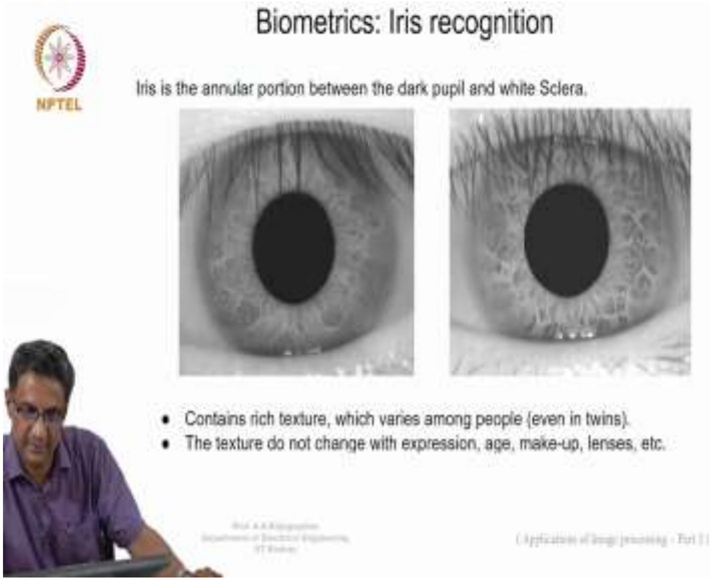

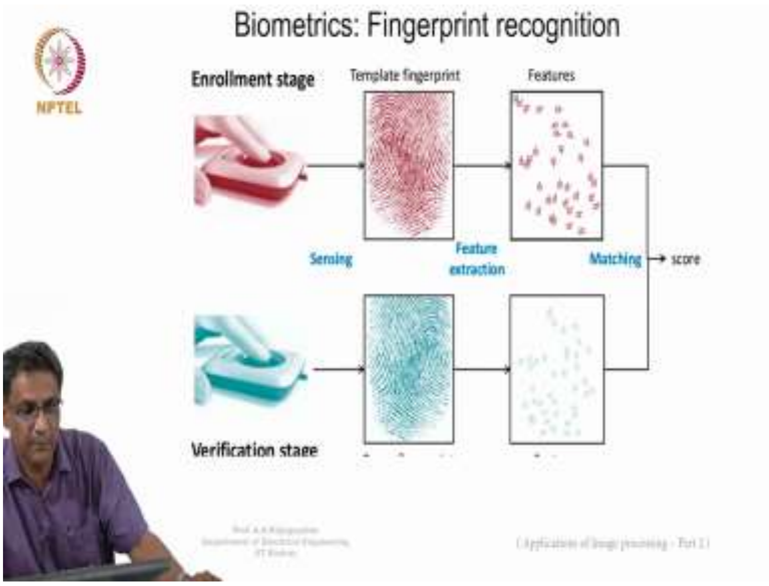

Biometrics Iris, I am just showing these examples so that, fingerprint again, it is again unique. And what do you think in this fingerprint do they sense? I have shown a fingerprint now. What do you think they sense there in order to tell who is who? How do they get nail a guy and say that you are this guy? How do they do that? What do you see in that image that actually tells you?

Student: Curvature.

Professor: Curvature, yeah, they are kind of curves. Yeah, curvature, yes but there is something more unique than that. Can you spot those? See these guy, see this fork here, this is called a fork. See there and I do not know whether you can make out there. See here, see this thing, there is a kind of a triangle. There are three arms meeting here. If you zoom into that image, you will know that is a fork. And then for some people they will have islands.

Then the forks mutual angles you know the kind of mutual angles they make with each other. Then see there is another fork. Then how these forks are interspaced within somebody's and then there is some people have islands. They will have circles in the middle. You might know whether, see here that is an island. So all these things, so these are called minutiae and these are the things that actually nail a person.

Not so much the angle of this bend and all that. It just typically (())(15:12) points but they are the ones that really tell who is who, it is interesting.
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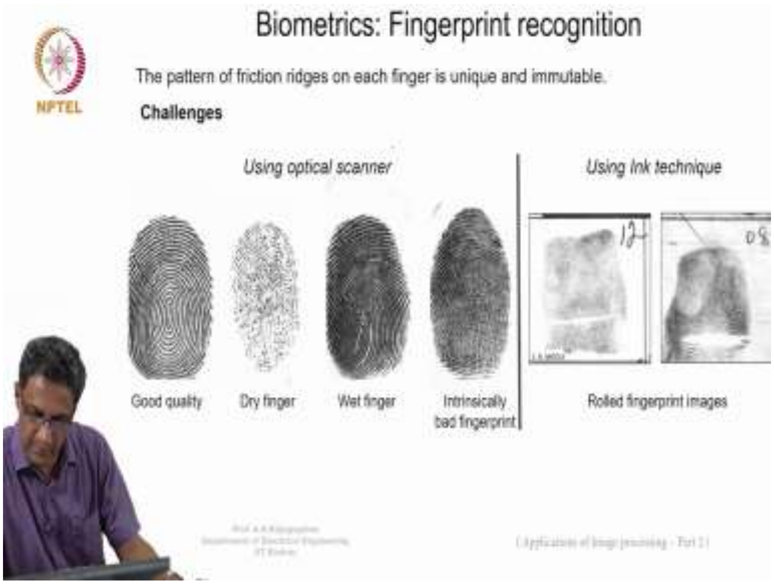

Biometrics, okay. Well, here again, you can, anyway when you have time, just go through these images and you will get a feel for what I am saying.

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Surveillance, like I said, you might want to tell what is happening, what is changing in a scene. And then change becomes even more hard when you have a camera that is actually moving. A still camera, it is easy to tell what has changed. Suppose it is a camera here, somebody comes and gets out. I know something is going on, suppose the camera itself moves. Then it makes it a complicated problem.

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Then change right here, for example, between these two images what has changed? Only this but if you notice intensities are not the same and you still want to be able to pick exactly what has changed. So all this again here, the viewpoint is not the same. See the way this has been captured.

These two images do not have the same viewpoint and you want to be still able to, and also notice that the, this is slightly blurred. This picture is slightly blurred as compared to this. And you still want to actually pick out what has changed.

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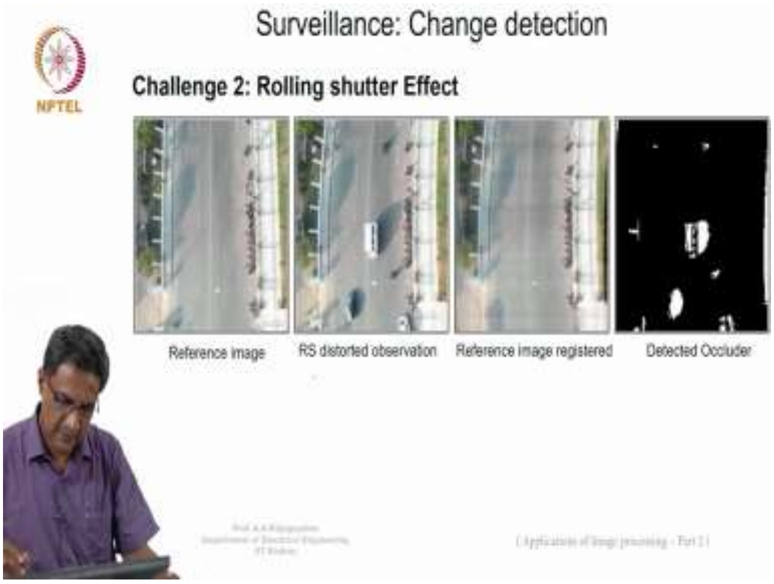

Then this is a rolling shutter effect. So when you took the picture with a still camera, these lines are all lines when you took it with a moving camera. Ofcourse, there is this van that has come in which is a change. But then you also notice that this guy has become bent now. Now if you just subtract even if your camera, even if you say that the camera motion is very small, therefore, can I just go ahead and subtract?

What will happen is you will say that somebody relate this bar. You will think that somebody actually changed the bar itself which is wrong. What has changed is only this guy. So what you have to do is you have to find out what is a camera motion that has happened and then get a, wop images such that only whatever has actually changed should emerge as a change.

Other thing should not be construed as a change. So again all these are interesting effects. Then okay, this is something else.

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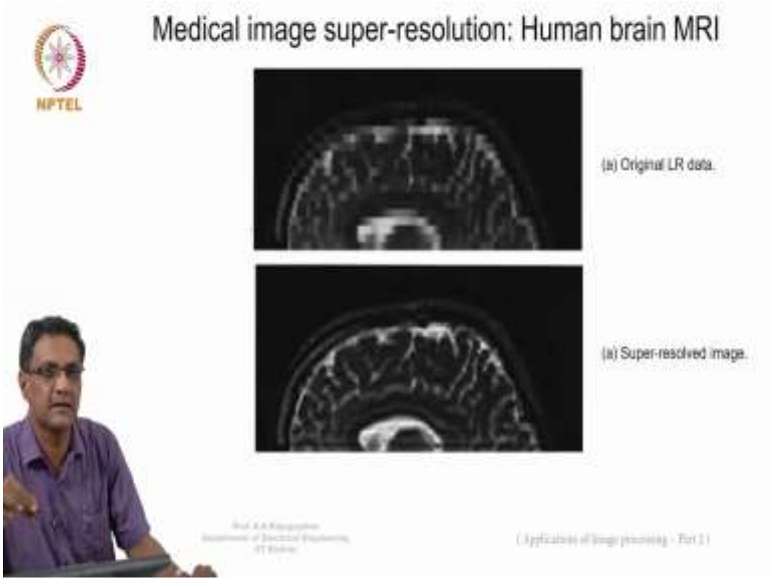

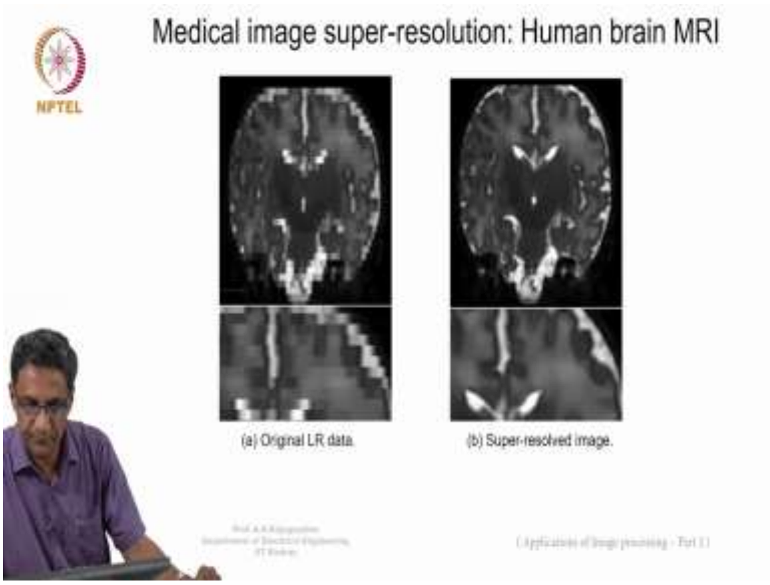

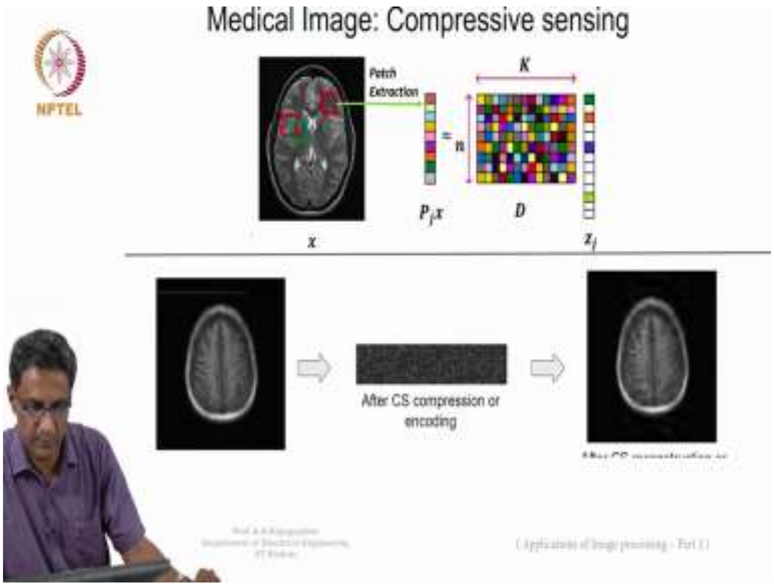

Medical imaging. This is what I mean by super-resolution. You have an image, you have a camera let us say that was a low quality. All of us would like to buy a cheap camera. We all like this word cheap because it makes sense. I do not spend too much money but then you also suffer because the images are of low quality.

And then if you had an algorithm, that would actually pick those low images, low resolution images and give you high resolution, you would like it. All of us love that. So here is that, here is an example like that. Here is another example for medical imaging.

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Then heritage. This is Hampi. How many of you have been to Hampi? Nobody. Okay. So two of them have been to Hampi and so we had a DST project on this. So the idea was that if you go to Hampi, all those rocks are beautiful, the way those sculptures all have been made. But then unfortunately, due to some act of vandalism, people have actually broken the, so it is not, so what has happened is, see for example here, the whole shoulder is broken and then here the whole this entire structure which is like a banister is broken.

Similarly, something is broken here. So here, so the idea is that can you do something in order to be able to show these, in order to be able to fill these regions, that is called inpainting. So it is not like you go and you will not fill it up that, because it is a UNESCO heritage site you cannot do anything there.

But you capture these images and then you try to see visualize how this might have looked like had it not been broken, that is what I mean by a virtual walkthrough. So you might be able to give people a sense for, some of these images I will show you because we have these things. We actually build as a 3D model by inside the campus. This is like a huge 3D printer. So you actually build this 3D model, you fill it up all algorithmically.

Then you print the 3D model so that you get a sense for how that filling has happened and so on. So again this is a very-very important problem. Similarly, you can also, it does not just apply to broken structures. Even structures that are good you can take images today and give people and kind of store it forever because even tomorrow something else happens, a natures fury whatever, you still have all of that intact with you for the future.

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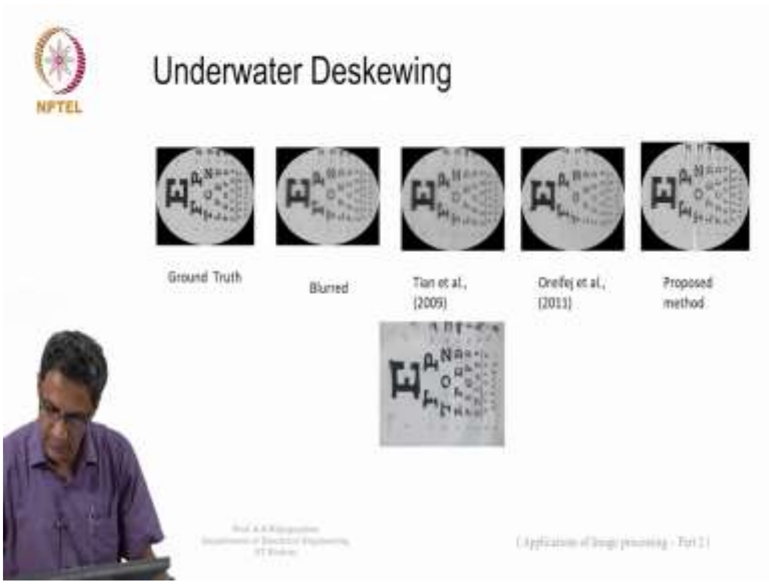

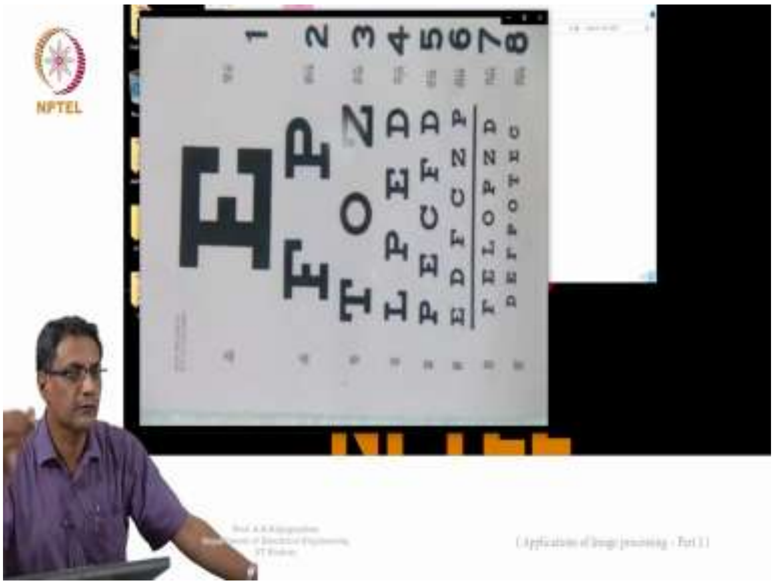

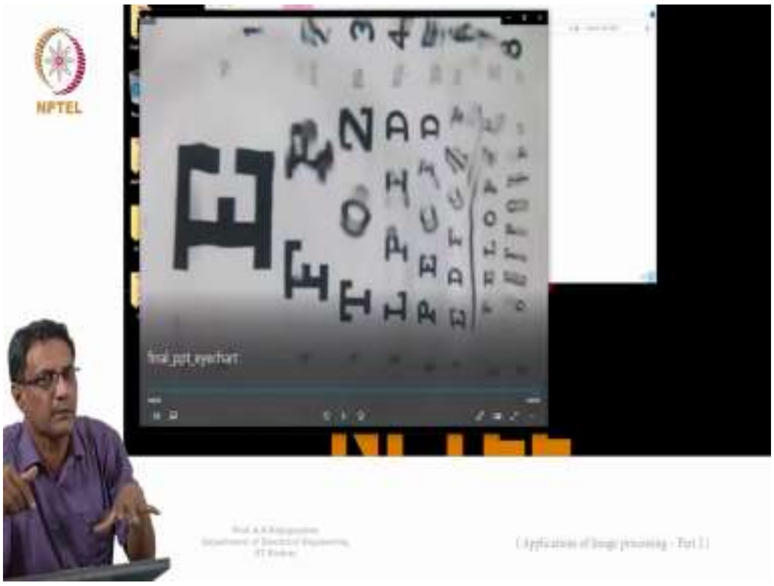

And then underwater imaging. So here you see that, let me see this video place. So you see, I mean few drops, this is inside an, this is an aquarium in my lab. So if you drop a stone and there is an eye chart just kept at the bottom of the aquarium. So you see that there is a skew effect.

You see the last frame, this gives you a feel for what happens to those alphabets. So when there is water, motion of the water, even though the underlying thing is still but then when this water, when the flowing water will create what is called a skewing effect, and the idea is that how do you actually de-skew and so on.

That is like underwater imaging. And finally, industrial applications are many-many, they are many, especially what is called inspection and so on.