Digital Image Processing.
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Lecture-33.
Contrast Stretching Operation.

Hello, welcome to the video lecture series on Digital Image Processing.

So now let us see, that what are the other kind of image enhancement techniques that we can have. The next image enhancement technique is again a very very simple enhancement technique that we are going to discuss is called contrast stretching. Contrast Stretching operation.

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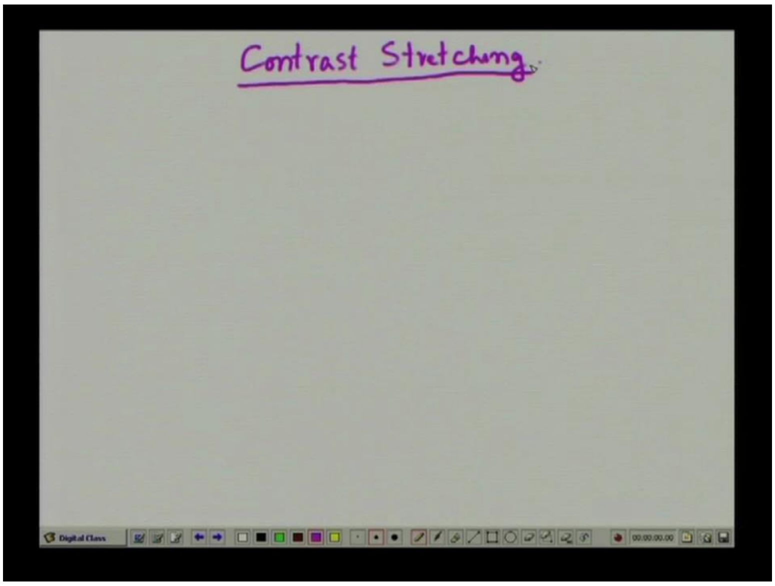

So why do we need such contrast stretching? You might have found that in many cases, the images that we get from an imaging device is very dark and this may happen because of various reasons. One of the reasons is when you have taken the image of certain object or certain scene, the illumination of the object or the illumination of the scene was very poor that means the object itself was very dark.

So naturally the image has become very dark. The second reason why an image may be dark is, the dynamic range of the sensor on which you are imaging is very small. Now what I mean by dynamic range is, it is the capacity of the sensor to record the minimum intensity value and the maximum intensity value, so the difference between the minimum intensity value and the maximum intensity value is what is the dynamic range of the sensor.

So even if your scene is properly illuminated but your sensor itself is not capable of recording all those variations in the scene intensity, that also leads to an image which is uhh very very dark. The another reason which may lead to dark images is that when you have taken the photograph, maybe the aperture of the lens of the camera was not properly set. Maybe the aperture was very small so that very small amount of light was allowed to pass to the lens to the imaging sensor.

So if the aperture is not properly set, that also leads to an image which is very very dark. So for such dark images, the kind of processing techniques which is very suitable is called the contrast stretching operation.

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Now let us see what is the kind of dark image that we can have. Here we show an image which is a low contrast image. So here obviously you find that the contrast of the image or the intensity of the image is very very poor and overall appearance of this image is very dark.

And the purpose of contrast stretching is to process such images so that the dynamic range of the image will be very high will be quite high so that the different details in the objects present in the image will be clearly visible.

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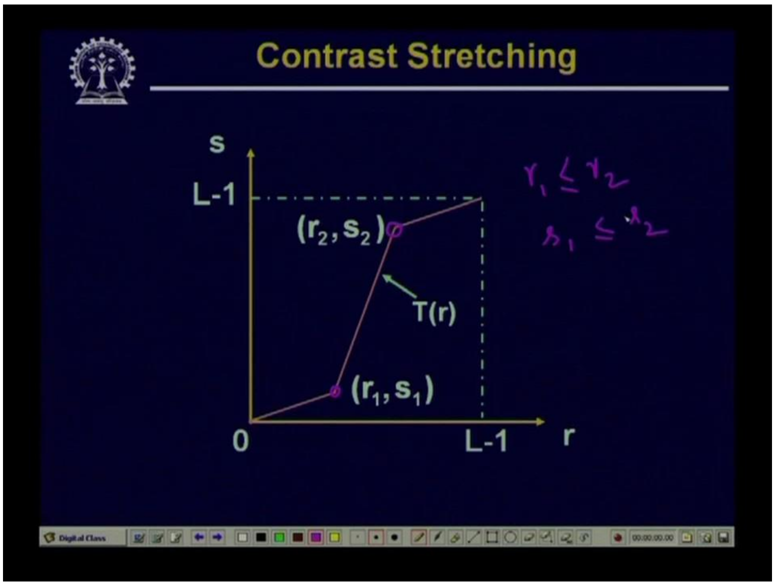

Now a typical transformation which may be applied for contrast stretching operation is shown in this particular figure. So here you find that in this particular transformation, we have indicated two different points.

One is (r 1,s 1) that is this particular point and the other point is (r 2, s 2) that is this particular point. Now it is the locations of this points (r 1,s 1) and (r 2,s 2) which controls the shape of this transformation function and accordingly influences upon that what are the defined types of contrast enhancements that we can obtain in the processed image.

Now the locations of this (r 1,s 1) and (r 2,s 2) are very very important. You will find that if we make r 1 equal to s 1 and r 2 equal to s 2 then the transformation function becomes a straight line which with a slope equal to 45 degree. That means that whatever is the intensity image we have, in the processed image we will have the same intensity level.

That means by applying such a transformation where r 1 equal to s 1 and r 2 equal to s 2 in this transformation function that we have said by applying that kind of a transformation, the processed image does not undergo any variation from the original image. For other values of other combinations of (r 1,s1) and (r 2,s 2), we really get some uhh variation in the processed image.

So the values which are mostly used is, here you will find that if I make the other extreme, if I make r 1 equal to r 2 and s 1 equal to s 2 and if i make, sorry, r 1 equal to r 2 and s 1 equal to 0 and s2 equal to L minus 1 then that leads to uhh thresholding operation. So the corresponding operation generates the binary image which is the processed image. Now for enhancement operation, usually what is used is r 1 less than r 2 and s 1 less than s 2 which gives us a transformation function as given in this particular figure.

And this transformation function generally leads to image enhancement. Now the condition that r 1 less than or equal to r 2 that is very very important. So the condition we have just said that r 1 less than or equal to r 2 and s 1 less than or equal to s 2. Now this particular condition is very very important as you find that if this condition is maintained then the transformation function that we get becomes a single valued transformation function and the transformation is monotonically increasing.

So that is very very important to maintain the order of the intensity values in the processed image. That is an image which is dark in the original image will remain darker in the processed image. And image which is brighter in the original image that will uhh a point which is brighter in the original image that will remain brighter in the processed image. But what difference we are going to have is the difference of intensity values that we have in the original image and the difference of intensity values we get in the processed image.

That is what gives us the enhancement. But if it is reversed, if the order is reversed, in that case the processed image will look totally different from the original image. And all the transformations that we are going to discuss except the negative operation that we have said initially all of them maintain this particular property that the order of the intensity values is maintained. That is the transfer of function is monotonically increasing and we will have a transfer function which is single valued transfer function.

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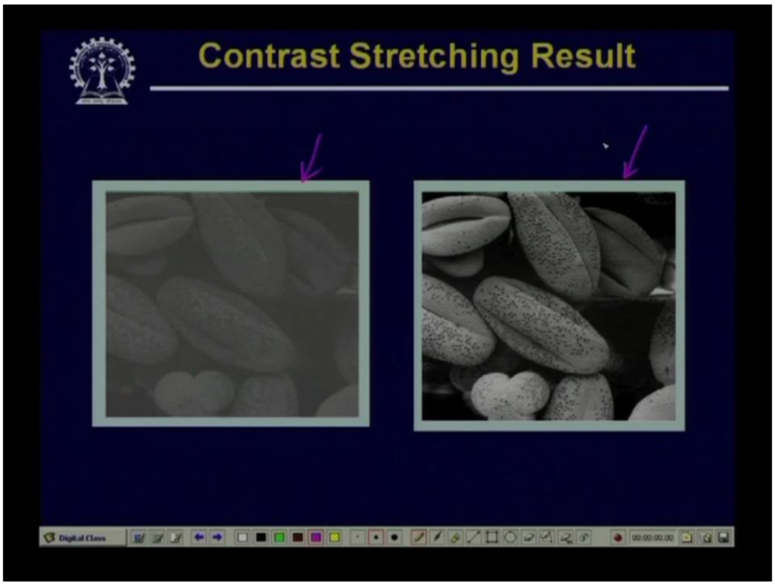

Now using this particular transfer function, let us see what kind of result we can obtain. So in our earlier slide we have shown an image which is a low contrast image as is shown on the left hand side of this particular diagram of this particular slide and so this left hand side image, this is the original image which is a low contrast image and by using the contrast enhancement operation, what we have got is an image which is the processed image shown on the right hand side.

And here you can clearly observe that more details are available in the processed image than in the original image. So obviously the contrast of the processed image has become much much higher than the contrast in the original image. So this is a technique which is called Contrast Stretching Technique which is mostly useful for images where the contrast is very very poor and we have said that we can get a poor contrast because of various reasons.

Either scene illumination was poor or the dynamic range of the image sensor was very very less or the aperture setting of the camera lens was not proper. And in such cases the dark images that we get, that can be enhanced by using this Contrast Stretching Techniques. Now there are some other kind of applications where we need to reduce the dynamic range of the original images.

Now the applications where we need to reduce the dynamic range is say for example, I have an original image whose dynamic range is so high that it cannot be properly reproduced by our display device. So normally we have a grey level display device or uhh a black and white display device which normally uses 8 bits that means it can display intensity level levels from 0 to 255 that is total 256 different intensity levels.

But in the original image, if I have a minimum intensity value of say 0 and the maximum intensity value of say a few thousands then what will happen that because the dynamic range of the original image is very high but my display device cannot take care of such a high dynamic range. So the display device will mostly display the highest intensity values and the lower intensity values will be in most of the cases suppressed.

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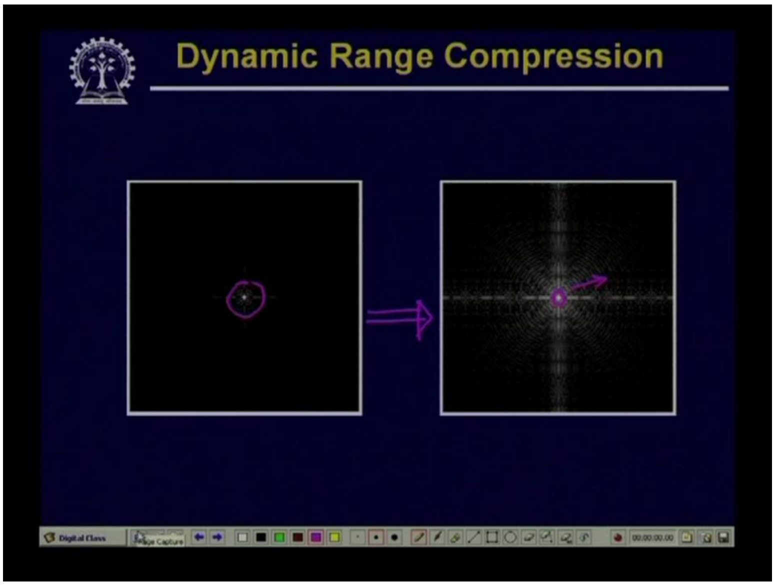

And by that a kind of image that we will get usually is something like this. So here you find that on the left hand side we had shown an image, this is basically the Fourier Transformation. The DFT coefficients of certain image. So on the left hand side, we have shown an image uhh the Fourier coefficients and here you find that only at the centre we have a bright dot and outside this the image is mostly dark or mostly black.

But actually there are a number of intensity levels between the 0 and the minimum that is 0 but uhh between this maximum and the minimum levels but which could not be reproduced by this particular device because its dynamic range is very poor. On the right hand side, we have shown the same image after some preprocessing that is after reducing the dynamic range of the original image by using the image enhancement techniques.

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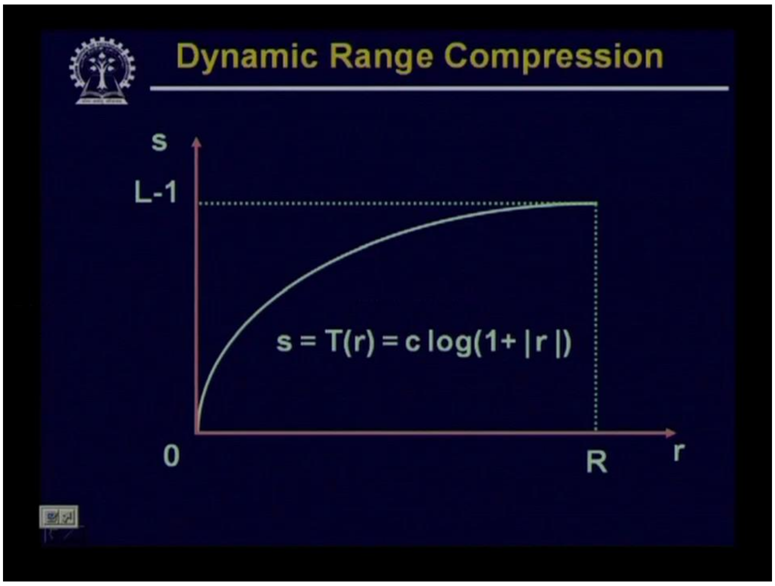

And here you find that in the processed image, in addition to the bright spot at the centre, we have many other coefficients which are visible as you move away from the centre. So here our application is to compress the dynamic range of the input image and the kind of transformations which can give us this dynamic range compression is a transformation of this form which is a Logarithmic transformation.

So here again we assume, that r is the intensity of a pixel in the original image and S is the intensity of the pixel in the processed image and the relation is S is equal to T(r) which is equal to c log into 1 plus modulus of r where, the c is a constant. This constant has to be decided depending upon the dynamic range of your display device and the dynamic range of the input image which is to be displayed.

And then log of 1 plus modulus of r is taken because otherwise whenever r is equal to 0 that is an intensity level in the input image is equal to 0. Log of 0 is not defined. So to take care of that we take 1 plus modulus of r and if you take c log 1 plus modulus of r, that gives a completion of the dynamic range and the image can be properly displayed on a display where the dynamic range is limited.

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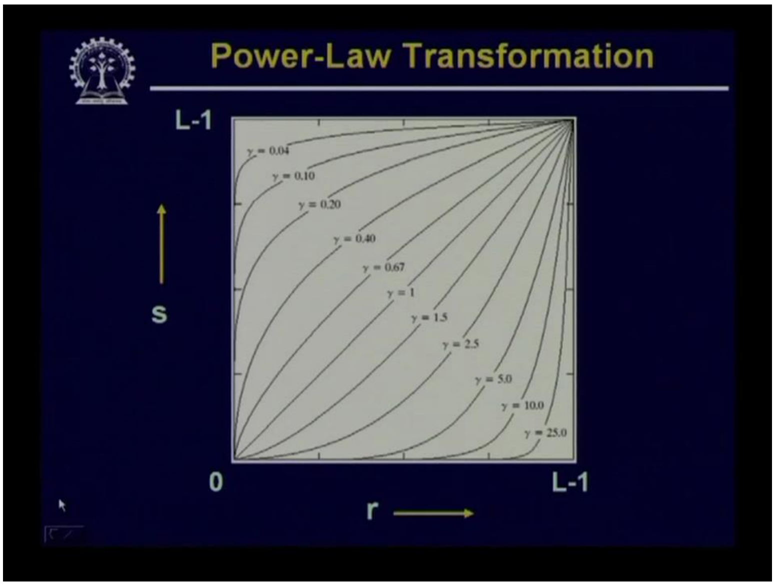

A similar such operation again for enhancement that can be used is called Power-Law Transformation. The Power-Law Transformation is normally used for different uhh imaging devices. It is used for image capturing devices, it is used for image printers and so on. In case of Power-Law devices, the transformation function between the original image intensity and the processed image intensity is given by s is equal to T(r) which is nothing but c into r to the power gamma.

So in this plot that we shown, this plot is shown for different values of gamma where c is equal to one. So you find that for value of gamma which is less than 1, Uhh this transformation function usually towards the lowered intensity side, it expands the dynamic range of a various small intensity range in the input image, whereas for a higher intensity side, a higher range of input intensity is matched to a lower range of intensity values in the processed image.

And the reverse is true for uhh values of gamma which are greater than 1. Now for this kind of uhh transformation, the exponent is conventionally represented by the symbol gamma and that is why this uhh kind of transformation, this kind of correction is also known as gamma correction. And this kind of processing is used as I said for different types of display devices. It is used for different types of printing devices. It is used for uhh different types of capturing devices.

The reason is all those devices mostly uhh follow this Power-Law characteristics. So if i give an input image that will be converted by Power-Law before the image is actually produced.

Now so compensate for this Power-Law which is introduced by the device itself if I do the reverse operation beforehand then the actual image that I want to display that will be displayed properly.

Say for example, in case of a CRT display, the relation between the intensity to voltage that follows the Power-Law with the value of gamma which varies normally from 0.8 to 2.5. So if I use the value of gamma equal to 2.5 and if I come to this particular figure, then you find that with gamma equal to 2.5, this is the curve or this is the correct transformation function that will be used.

So whichever image I want to display, the device itself will transform the image using this particular curve before displaying the particular image. And as this curve shows that the image which will be displayed will normally be darker than the original image that we intend to display. So what you have to do is, we have to take some corrective measure before giving the image to the CRT for the display purpose.

And because of this correction we can compensate this Power-Law so that our uhh image will be displayed properly. So coming to this next slide, you find that here we have shown an image which is to be displayed and the image is on the top left corner. The monitor has a characteristics of Power-Law. It has Power-Law characteristics which is given by s equal to r to the power 2.5.

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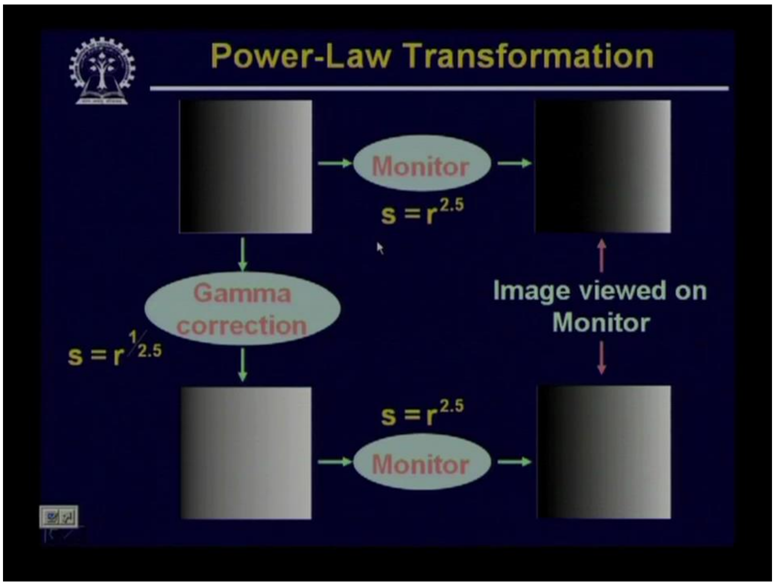

And as we said that because of this Power-Law characteristics, the image will be darker and which is obvious that the image as displayed on the device is given on the right hand side. And you will find that this image is darker than the original image. So to compensate for this what I do is before giving this image to the CRT for display, we go for a gamma correction. That means you transform the image using the transformation function s equal to r to the power 1 upon 2.5.

So by this transformation and if you refer back to our Power-Law curves, you will find that the original image now becomes a brighter image, that is the lower intensity ranges in the input image has now been mapped to a larger intensity range in the processed image. So as a result, the image has become brighter. And when this brighter image is given to the CRT display for display operations, the monitor will perform its characteristic power law that is s equal to r to the power 2.5.

And because of this characteristics the earlier correction that gamma correction that we have incorporated that gets nullified and we get the image and now we find that the right bottom, this is the actual image now which will be displayed on the CRT screen and this image now appears to be almost same as the original image that we want to display.

So this is a sort of enhancement because if I do not use this kind of correction, then the image that we are going to display on the CRT screen that will be a distorted image but because of the Power-Law correction or the gamma correction as it is called the image that we get on the CRT screen will be almost same as the original image that we want to display.

Now this kind of uhh Power-Law Transformation, it is not only useful for imaging devices like CRT display or image printer and so on. Similar Power-Law Transformations can also be used for enhancing the images. Now the advantage that you get in case of Power-Law Transformation is that the transformation curve gets various shapes depending upon different values of gamma.

And as we have shown in our previous slides, that if the value of gamma is less than 1, then on the darker side, the lower range of intensity values will be mapped into a larger range of intensity values in the processed image, whereas on the brighter side, a larger range of intensity values will be mapped into a lower range of intensity values in the processed image. And the reverse is true when gamma is greater than 1.

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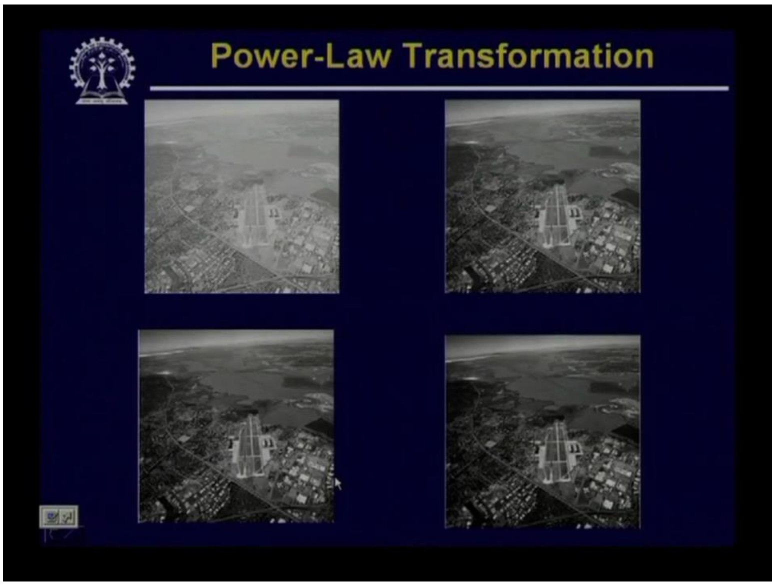

So by using different values of gamma, I can have different Power-Law Transformations and as a result what I can have is a controlled enhancement of the input image. So as is shown in this particular case, here you find that on the top left, we have shown an aerial image and you find that the most of the intensity values of this aerial image are on the brighter side. So as a result what happens is you find that most of the portions in this image are almost washed out.

We cannot get the details of the image very easily. Now if we process this image using the Power-Law Transformation then you find that the other three images that is the uhh right top image is obtained by using the Power-Law Transformation with certain value of gamma. Similarly the bottom left image using some other value of gamma and the right bottom image is also obtained by using some other value of gamma.

And here you find, that for the first image that is right top image has been corrected with a value of gamma which is less than the value of gamma used for the image shown in the left bottom image which is again less than the value of gamma used getting obtaining the image shown in the right bottom side.

And as it is quite obvious, all in all these cases, you find that the washed out characteristics of the original image have been controlled that is in the processed image we can get much more details of the image content. And as you find that as we increase the value of gamma the image becomes more and more dark and which is obvious from the Power-Law characteristic uhh the Power-Law Transformation function plot that we have already shown.

So this is another kind of processing operation, the Power-Law Transformation that can be used also used to enhance some features of the input image. The other type of transformation, that we can use for thisimage enhancement is called grey level slicing. So in case of grey level slicing, some applications may need that application may not be interested in all the intensity levels but the application may be uhh may need the intensity levels only in certain uhh grey level values.

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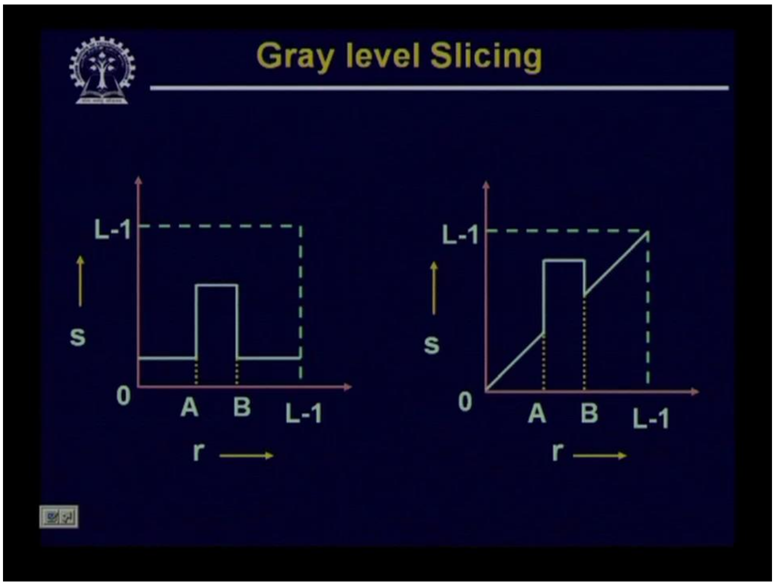

So in such cases, for enhancement what you can use is the grey level slicing operation and the transformation function is uhh over here. Here the transformation function on the left hand side says that for the intensity level in the level A to B, the image will be enhanced for all other intensity levels, the pixels will be suppressed. On right hand side, the transformation function shows that again within A and B the image will be enhanced, but outside this range, the original image will be returned.

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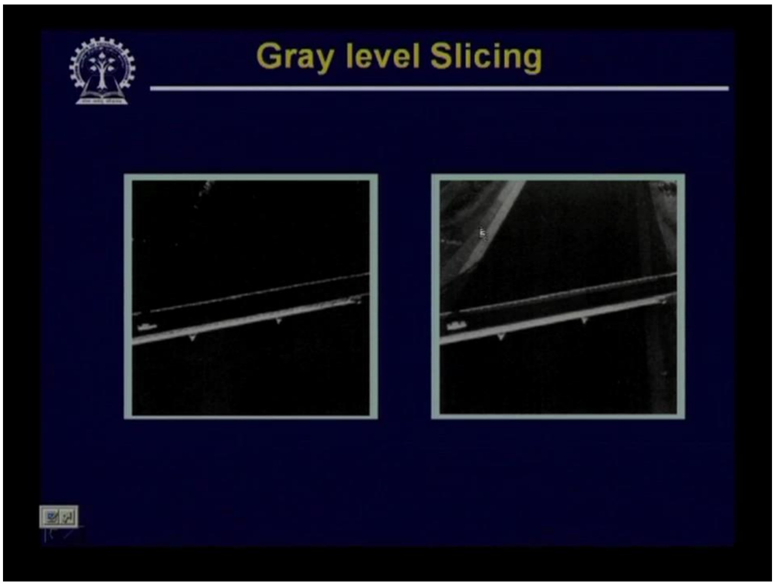

And the results that we get is something like this. The first image shows that only the desired intensity levels are obtained or retained with enhancement all other regions they have been suppressed. The right hand image shows that the desired range of intensities have been uhh enhanced but other intensity levels have remained as it is.

So with this we stop our today's discussion on point processing. We will continue with this topic in our next lecture. Thank You.