Digital Image Processing.
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Lecture-32.
Image Enhancement : Point Processing Techniques.

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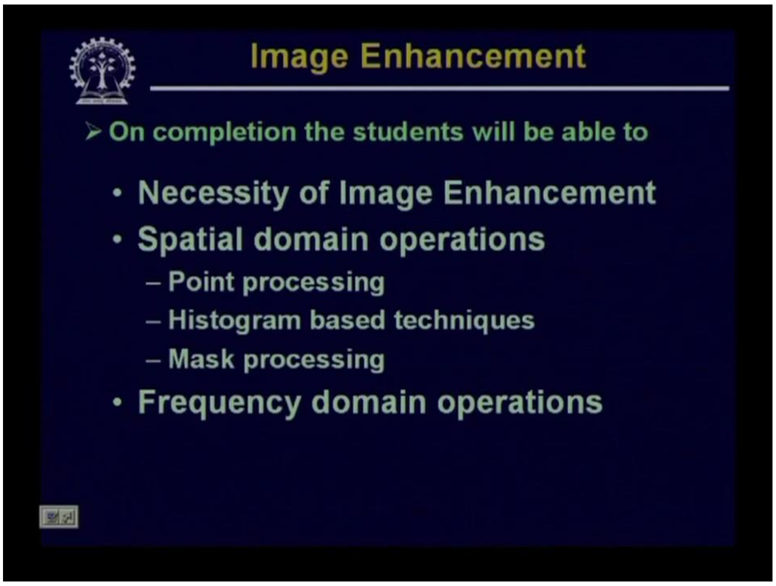

Hello, welcome to the video lecture series on Digital Image Processing. Today and for coming few lectures, we will be talking about Image Enhancement Techniques. First we will see that what is the necessity of the image enhancement. Then we will see that image enhancement techniques fall under two broad categories; one of the categories is Spatial domain operations. In spatial domain operations, the enhancement techniques work directly on the image pixels.

And these spatial domain operations can have three different forms. One is the point processing, other one is the histogram based processing techniques and the third one is mask processing techniques. Of course histogram based processing technique is also a form of point processing technique. For these spatial domain operations we said that we do not do any peak processing on the images.

The images are directly operated in their spatial domain to give us the transformed images which are the enhanced images. The other category of this image enhancement techniques, they work on normally the Discrete Fourier Transformation coefficients of the images. So they are called as frequency domain operations and you will see later that there are different operations which can be done in frequency domain like low pulse filtering, band pulse filtering, high pulse filtering and so on.

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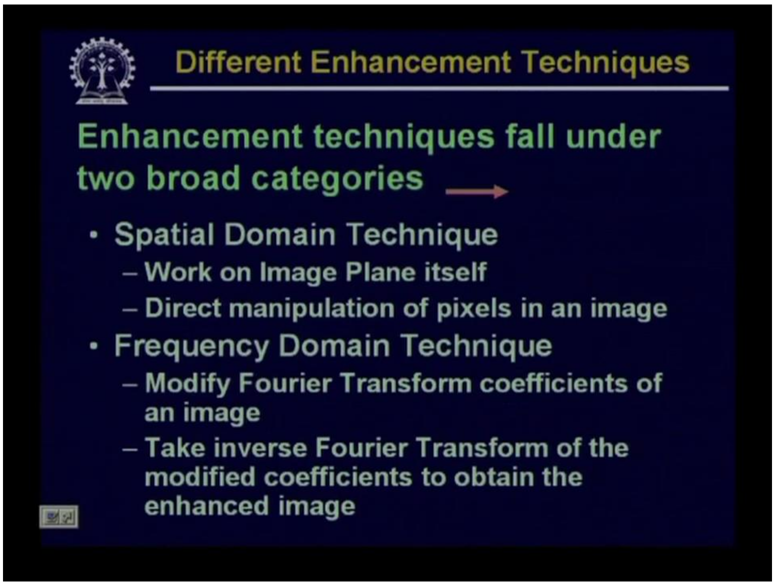

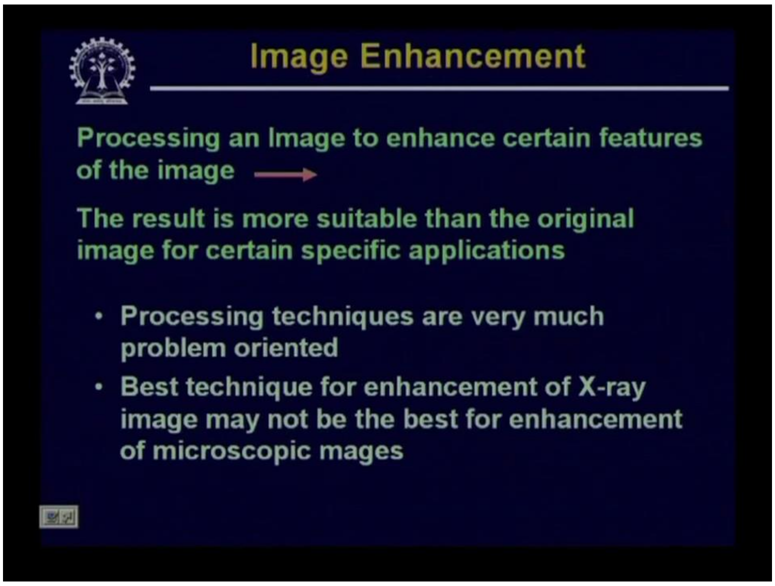

And then also we have different forms of these different filters. Now let us see that what is meant by image enhancement. By image enhancement, what we mean is it is a technique of processing an image to enhance certain features of the image. Now as it is said that it is for the enhancement of certain features of the image. So obviously, depending upon which feature we want to enhance, there are different forms of enhancement techniques.

Some applications may demand that our input image is noisy so we want to reduce the noise so that the image becomes better visually. So reduction of this noise or removal of the noise from the images is also a form of image enhancement. In many cases, we have found that the images which are captured by image capturing devices for example camera, they are very dark and an image may become very dark because of various reasons.

So for such kind of applications, the image enhancement technique may need to increase the contrast of the image or to increase the intensity of the image. So for that kind of application, we will have some other type of image enhancement techniques. Some applications may need that the applications need that the edges of the objects present in the image, those should be highlighted.

So again in such cases, the image enhancement techniques should be able to highlight the edges of the objects present in the image. So you find, that the image enhancement techniques, these techniques vary depending upon the application, different types of applications need enhancement of different types of features in the image.

So, the result, the ultimate aim of the image enhancement techniques is such that we want to process an image so that the result becomes more suitable than the original image for certain specific applications. So as we have already said, obviously the processing techniques are very much problem oriented because different kinds of problem demand enhancement of different kinds of features in the image.

So obviously, the processing techniques will be application dependant and naturally a technique which is best suitable for one kind of application is not best suitable for some other kind of applications. So a technique for enhancement of X-ray images may not be the best for enhancement of microscopic images. So this is broadly what we mean by enhancement of an images and obviously these are application dependant.

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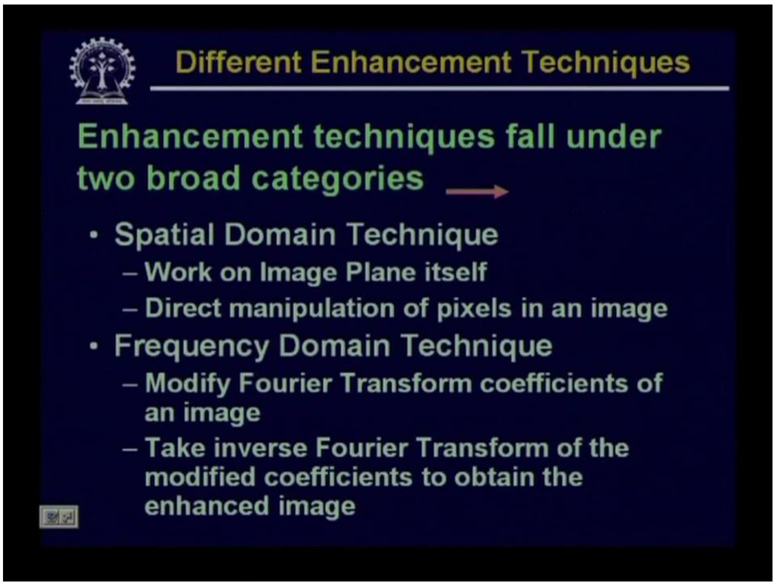

Now as we have already said that image enhancement techniques, fall under two broad categories. The first category is the spatial domain technique where the image enhancement processes, they work directly on the image plane itself. That means these techniques try to directly manipulate the pixels in the image. The other category of the image enhancement techniques are frequency domain techniques.

So in case of frequency domain techniques, first we have to take the Fourier Transformation of the image, then whatever is the fourier transformation coefficients that we get, you modify those fourier transformation coefficients and these modified set of coefficients, you take the inverse fourier transform of that to obtain the enhanced image or the modified image as need. So first, we will be talking about the image enhancement techniques in the spatial domain.

So let us see that what are the different spatial domain image enhancement techniques that we can have. So as we said, that the spatial domain techniques work directly on the image pixels. So naturally we have to define a transformation function which will transform an image pixel from the original image to a pixel in the enhanced or processed image. So such a function, can be defined in this form.

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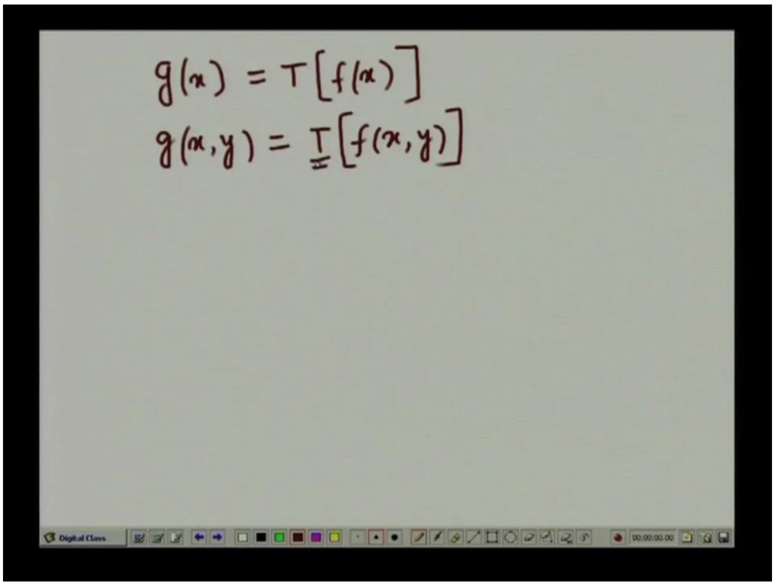

We can write that g(x) is equal to some transformation T into f of (x) or because in this case we are dealing with the 2 dimensional images. So we will write the expressions as g(x,y) is equal to some transformation T of the image f(x,y). So in this case f(x,y) is the original image. T is the transformation which is applied on this original image to give us the processed image g(x,y).

Now as we said, that in case of spatial domain techniques you will find that this transformation T is walking directly on f(x,y) that is in the spatial domain or in the image plane to give us the processed image g(x,y) where T is an operator which is to work on the original image f and this operator is defined over a neighborhood of the point (x,y) in the original image f(x).

And later on we will see that this operator T this transformation operator T can also operate on more than one images. So for the time being, we are considering the case that where this operator T the transformation operator T works on a single image and when we want to find out a processed image at location x,y then this operator T woks on the original image F at location x,y considering certain neighborhood of the point (x,y) to determine what will be the processed pixel value at location (x,y) in the processed image g.

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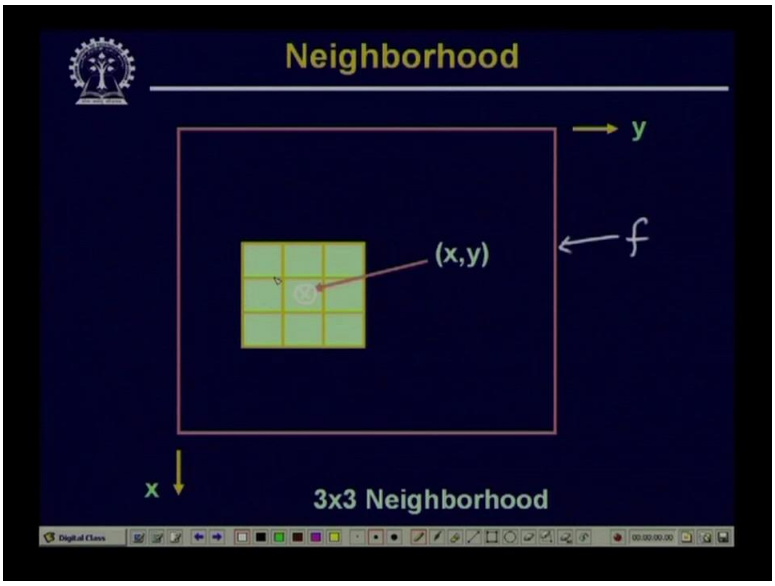

Now the neighborhood of a point(x,y) is usually a square sub-image which is centered at point (x,y). So let us look at this particular figure. Here, you will find that we have taken a rectangular image f. So this outer rectangle represents the image f and within this image f we have taken pixel at a particular location (x,y). So this is the pixel location (x,y). And the neighborhood of point (x,y) as we said that it is usually square sub- image around point (x,y).

So this shows a 3 by 3 neighborhood around the pixel point (x,y) in the image f. Now what happens in case of point processing, we said that this operator, the transformation operator T operates at point (x,y) considering a certain neighborhood of the point (x,y) and in this particular case we have shown a neighborhood size is of 3 by 3 around point (x,y). Now for different application the neighborhood size may be different.

We can have a neighborhood size of 5 by 5 7 by 7 and so on depending on the type of the image and the type of operation that we want to have. Now in case of point processing, the neighborhood size that is considered is of size 1 by 1.

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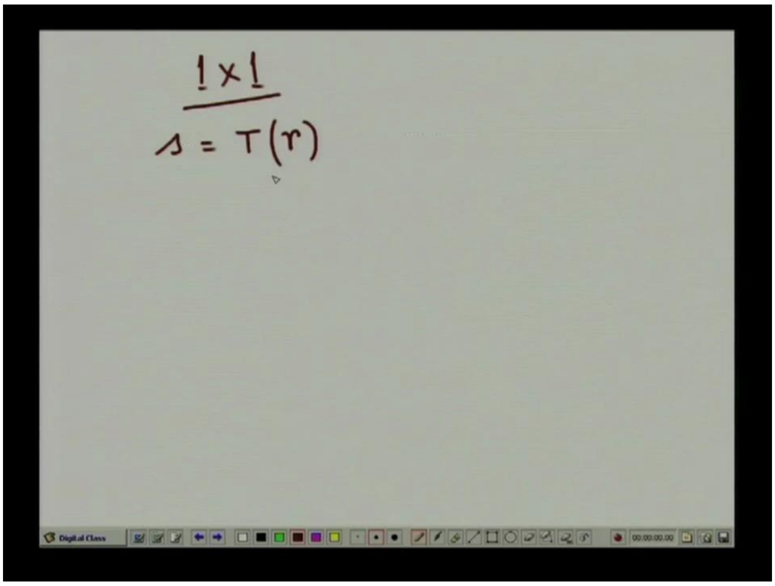

So the neighborhood size of a point in case of point processing is of size 1 by 1. So that means that this operator T now works on the single pixel location. So it works on only that particular pixel location (x,y) and depending upon the value, depending upon the intensity value at that location (x,y), it determines what will be the intensity in the corresponding location in the processed image g. It does not consider the pixel values of its neighboring locations.

So in such cases we can write the transformation function in the form s is equal to some transformation T of (r) where this r is the pixel value in the original image and S is the pixel value in the corresponding location in the processed image. So this transformation function, it simply becomes of this form s is equal to T and T of (r) where s and r are independent pixel values at different locations.

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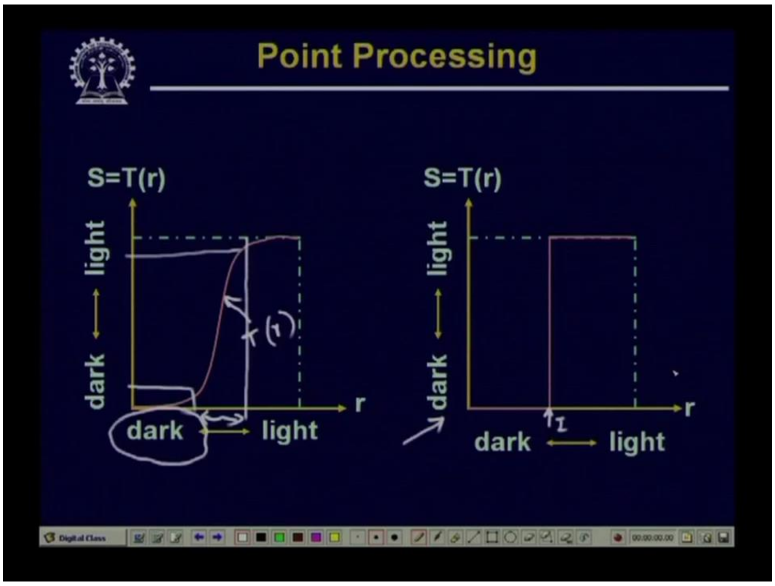

Now these transformation functions can be put in the form of these two figures. So in this particular case, the first figure shows a transformation function where you find that here in this case along the x axis or along the horizontal axis we have put the intensity values or of the original image and along the vertical axis we have put the intensity values of defines pixels in the processed image g and obviously they are related by s equal to T(r).And the transformation function is given by this particular curve.

So this is our T of (r). And in this particular figure as it is shown, that the point so the pixel values near 0 has been marked as dark regions. So it is quite obvious, that in an image, if the intensity values of the pixels are near about 0 that is very small intensity values, those regions appear as very dark and the intensity values which are higher in an image those regions appear as light regions.

So this, first one, the first transformation function shows that in this particular range, a very narrow range of the intensity values in the original image is matched to a wide range of intensity values in the processed image g. And effectively this is the operation which gives enhancement of the image.

In the second figure that we have shown, here you find that this particular transformation function says that if I consider say this is some intensity value say I, so for all the pixels in the input image if the intensity values are less than I then in the processed image, the corresponding pixel will be replaced by value 0, whereas a pixel where the intensity value is greater than I, the corresponding pixel in the processed image will have a maximum value.

So this second particular transformation operation, it actually generates a binary image consisting of only the low values and the high values and this particular operation is known as thresholding operation. Now what happens in case of, so this is the kind of operation that will be done for point processing. Now the other kind of special domain operation where the neighborhood size is larger than one.

So neighborhood size of 3 by 3 or 5 by 5 and 7 by 5 7 and so on. That kind of operations is usually known as mask operations. So in case of mask operations what we have to do is we have to define a neighborhood around every pixel (x,y) at which point we want to get the intensity value in the processed image.

And for doing this, it is not only the intensity value of that particular pixel but also the intensity values of the pixels around that point which is within the neighborhood of that point. All of them take part in deciding what will be the intensity value at the corresponding location (x,y) in the processed image g.

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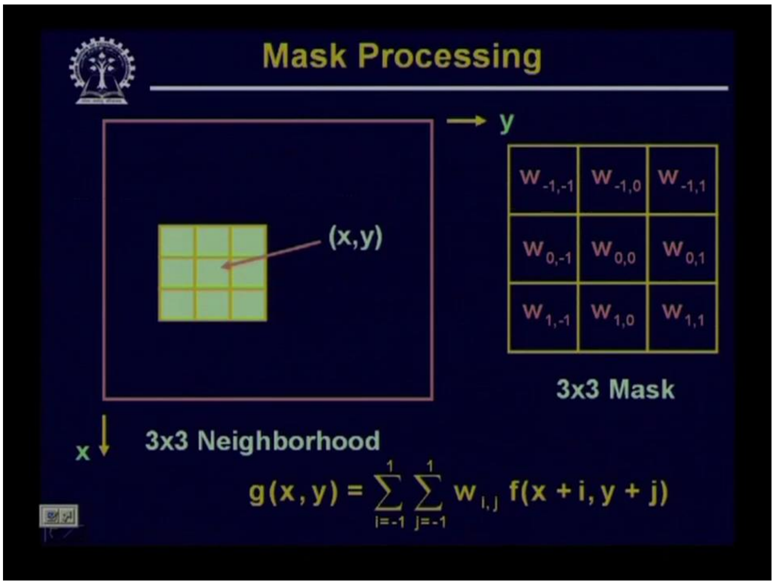

So let us see that how that operation is done. So here, again we have copied the same 3 by 3 neighborhood what we have seen in our previous slide. So if I consider a 3 by 3 neighborhood, then for mask processing what you have to do is? We also have to define a 3 by 3 mask and in this particular case you will find that on the right hand side of the figure. We have defined a mask where the values in the mask are represented as W minus 1 minus 1, W minus 1 0, W minus 1 1. W 0 minus 1, W 0 0, W 0 1, W 1 minus 1, W 1 0 and W 1 1.

So these are the different values which are also known as coefficients which are present in this 3 by 3 mask. Now to generate, the intensity value at location (x,y) in the processed image. The operation that has to be done is given by the expression at the bottom where it says that g(x,y) is equal to double summation W i j into f(x plus i, y plus j) and you have to take the summation over j equal to minus 1 to 1 and i equal to minus 1 to 1.

So what does this actually mean? This means that if I place this mask on the image centered at location (x,y), then all the corresponding pixels under this mask of the image and the corresponding mask coefficient, they have to be multiplied together, then take the sum for all such mask locations. And what I get that gives me the processed image, the intensity value of the processed image g at location (x,y).

So this is what is meant by mask operation and depending upon the size of the mask that we want or the size of neighborhood we consider, we have to define the 3 by 3 mask or 5 by 5 mask or 7 by 7 mask and so on. And the coefficient values, these defined W values in the mask, that determine that what kind of image enhancement operations that we are going to do.

Whether this will be a image sharpening operation, image averaging operation, edge enhancement operations and so on, all of them depend upon the mask values that is the W i j present in this particular mask. So this is the basic difference between the point processing and the mask processing and obviously both these processing techniques fall under the category of spatial domain techniques because in these cases we have not considered the Discrete Fourier Transform coefficients of the original image which is to be processed.

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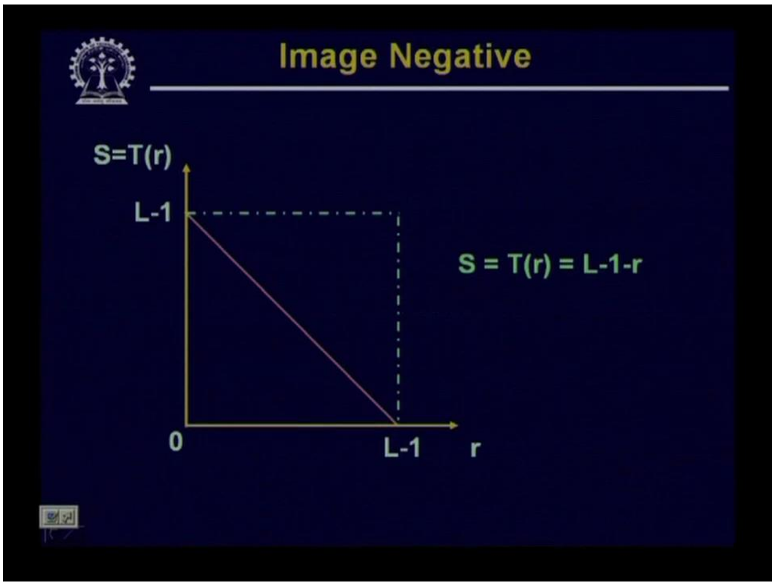

Now let us come to the point processing techniques. The first one that we will consider is a point processing techniques which we will call the negative image. Now in many of the cases the images that we get they contain white or grey level informations embedded in black pixels or very very dark pixels and the nature of the information is such that we have very few white or grey level informations present in a white background which is very much dark.

So in such cases, finding out the information from the images from the raw images, input images becomes very very difficult. So in such cases, it is beneficial that instead of considering that raw image, if I just take the negative of the image that is all the white pixels that we that we had in the image or the larger intensity values that we have in the image, you make them darker and the darker and the darker intensity values, you make them lighter or brighter.

So in effect what we get is a negative of an image and within this negative image we will find through result that visualisation or extracting information which we want will be more convenient that than in the original image. So the kind of transformations that we need in this particular case is shown in this figure. So here we consider that the digital image that we are considering that will have capital L number of intensity levels represented from 0 to capital L minus 1 in steps of 1.

So again along the horizontal axis, we have put the intensity values of grey level values of the input image and along the vertical axis we have put the intensity values or grey level values of the processed image. And this corresponding transformation T now can be represented as

S is equal to T(r) which is nothing but L minus 1 minus r. So you find that whenever r is equal to 0 then s will be equal to L minus 1 which is the maximum intensity value within our digital image.

And when r is equal to capital L minus 1, that is the maximum intensity value in the original image. In that case s will be equal to 0. So the maximum intensity value in the original image will be converted to the minimum intensity value in the processed image. And the minimum intensity value in the processed image will be converted to maximum intensity value in the minimum intensity value in the original image will be converted to maximum intensity value in the processed image.

So what, in effect what we are getting is a negative of the image and graphically this transformation can be put in the form of this figure. So here you find that this transformation is a straight line with a slope of minus 45 degree and passing through the points (0,L minus 1) and (L minus 1,0) in this r-S Plane.

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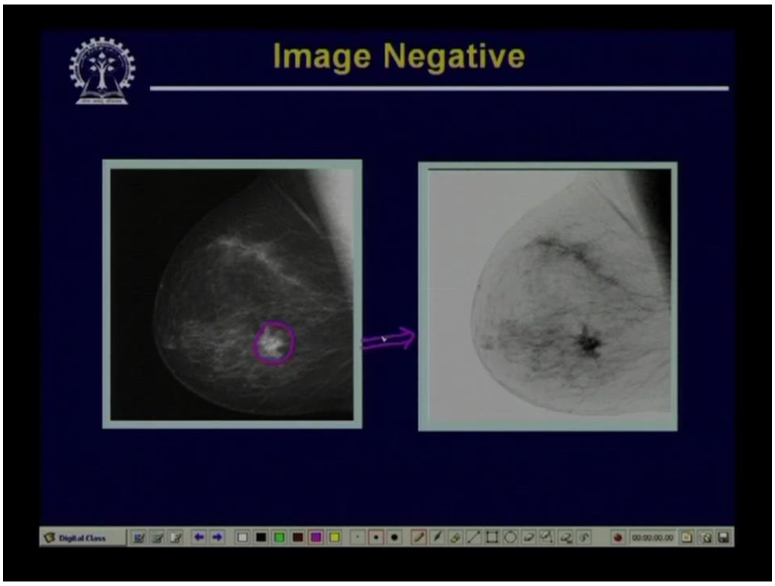

Now let us see what is the kind of result that we will get by applying this kind of transformation. So here we have shown two images. On the left hand side we have a digital mammogram image and on the right hand side we have the negative of this image which is obtained by the transformation that we have just now discussed. So you find that in this original image, we have some white grains and there is a white patch which indicates a cancerous region.

And to this grains corresponds to the issues corresponding to the tissues, they are not very prominent. I mean it is very difficult to make out which is what in this original image. Now if I take a negative of this particular image, from the right hand side we have got this negative. So here you find that all the darker regions in the original image has been converted to brighter regions in this process image.

And the brighter regions in the original image has been converted to darker regions in the processed image. And now it is very convenient to see what information we can get from this negative image. And this kind of transformation, the negative transformation, is very very useful in medical image processing. And as this is just an example, which shows that understanding of this particular digital mammogram image, the negative transformation gives us much more information than that we have in the original.

And as we said maybe this is the transformation which is best suited for this particular application. But this transformation may not be the best transformation for other kind of applications. Thank You.