Digital Image Processing.
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Lecture-40.
Image Enhancement: Mask Processing Techniques-III.

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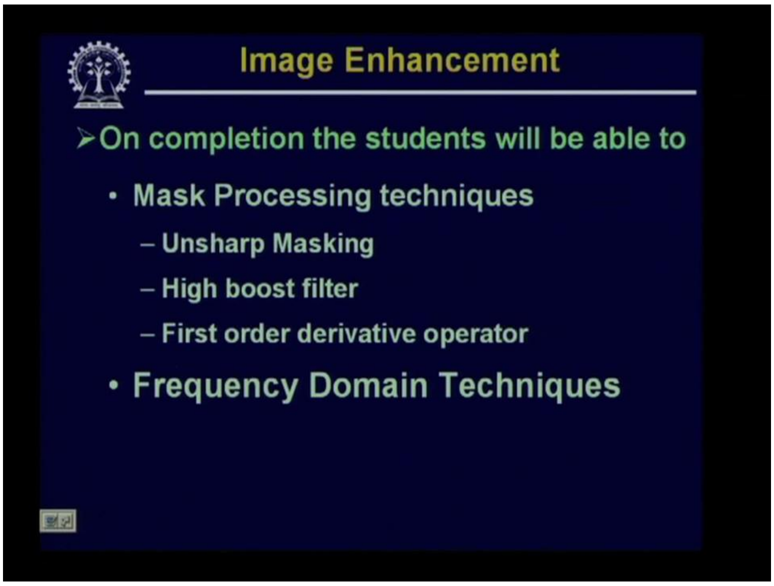

Hello, welcome to the video lecture series on digital image processing. So today, we will talk about some more mask processing techniques, like we will talk about unsharp masking, we will talk about high boost filter, and we will also see that how the first order derivative operators can help in enhancement of image content particularly at the discontinuities and edge regions of an image. And then we will go to our today's topic of discussion which we say is the frequency domain techniques for image enhancement.

And here again we will talk about various types of filtering operations, like low pass filtering, high pass filtering, then uhh equivalent to high boost filtering and then finally we will talk about homomorphic filtering and all this filtering operations will be in the frequency domain operations.

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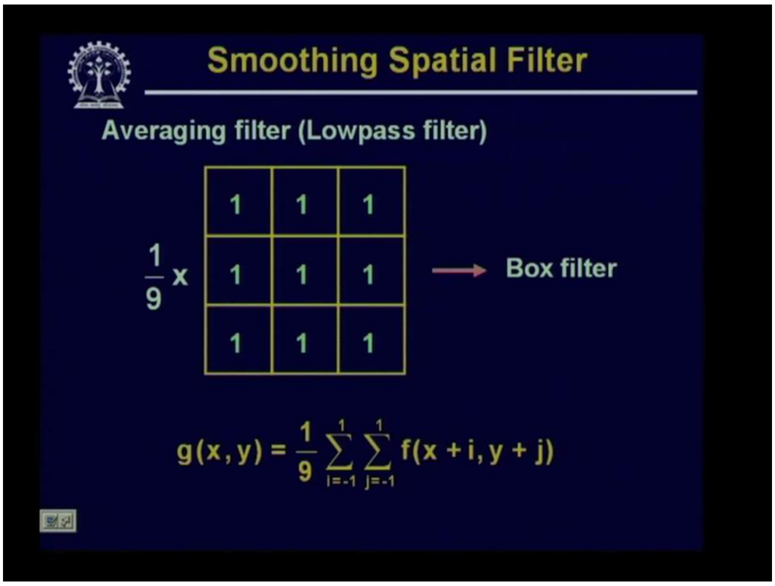

So let us first quickly see that what we have done in the last class. So in the last class we have talked about the averaging filters or low pass filters and we have talked about two types of spatial masks which are used for this averaging operation.

One we have said as box filter and we have said that in case of box filter all the coefficients in the filter mask, they have the same value and in this case all the coefficients have value equal to one. The other type of mask that we have used is for weighted average operation and here it shows the corresponding mask which gives the weighted averaging and we have said that if you use this weighted average mask instead of the box filter mask, then what advantage we get is this weighted average mask tries to retain the sharpness of the image or contrast of the image as much as possible.

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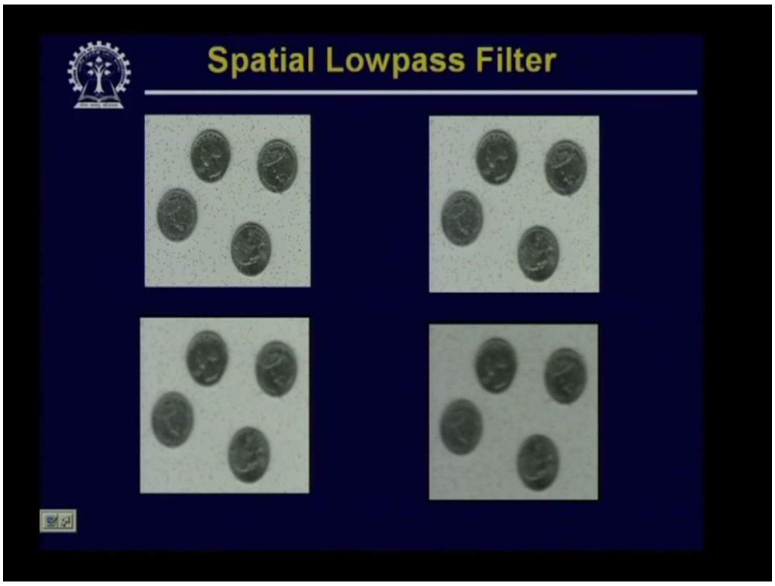

Whereas, if you simply use the box filter then the image gets blurred too much. Then these are the different kinds of results that we have obtained, here the result is shown uhh for an image which is on the top left, on the top right the image is averaged by a 3x3 box filter, on the uhh uhh bottom left , this is an averaging over 5x5 filter, and on the bottom right this is an image with averaging over 7x7 filter. And as it is quite obvious from this results that as we take the average or smooth out the image with the help of these box filters, the images get more and more blurred.

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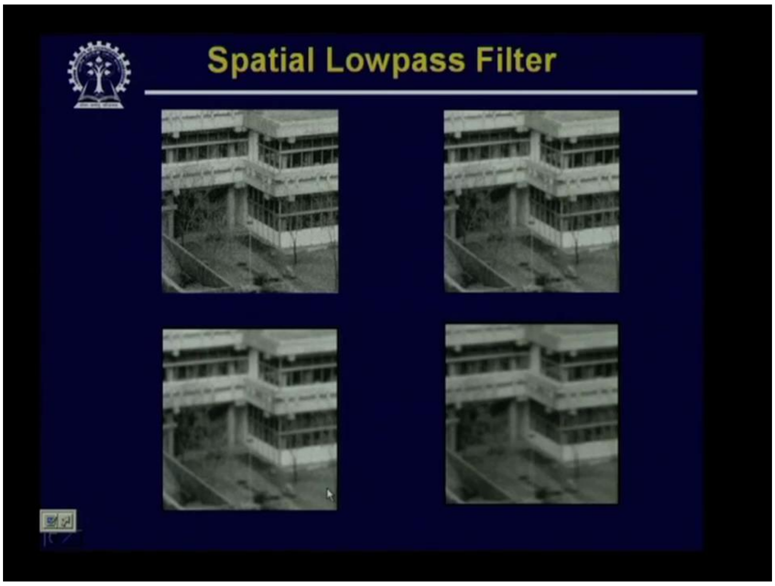

Similar such results are also obtained and as has been shown in this particular case here also you find that using the low pass filter uhh the content, the noise in the image gets removed but at the cost of the sharpness of the image, that is when we take the average over a larger mask, a larger size mask, then the it helps to reduce the noise, but at the same time a larger mask introduced large about of blurring in the original image.

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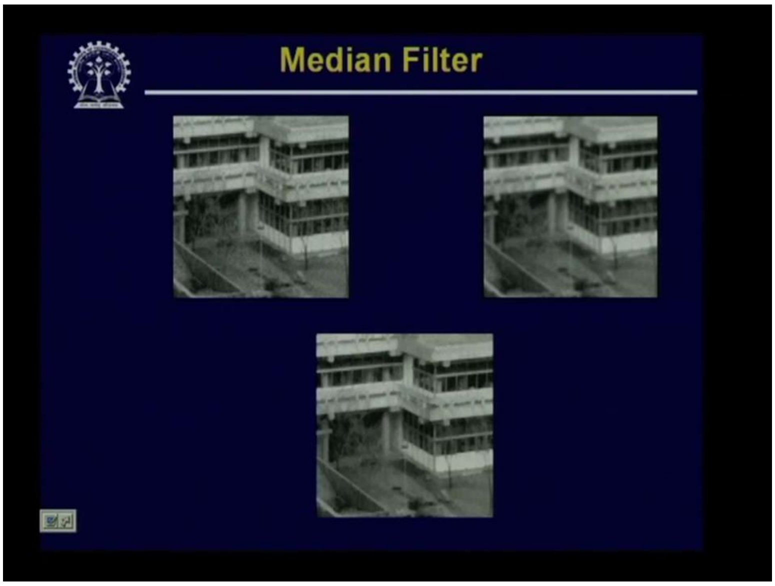

So there we have said, that instead of using simple box filter or the simple averaging filter, if we go for uhh order statistics uhh go for filtering based on order statistics like median filter where the pixel value at a particular location in the processed image will be the median of the pixels in the neighborhood of the corresponding location in the original image. In that case, this kind of filtering also reduces the noise, but at the same time, it tries to maintain the contrast of the image.

So here, we have shown one such result uhh on the top left is the original noisy image, on the top right is the image which is obtained using the box filter and the bottom image is the image which is obtained using the median filter. And here it is quite obvious that when we go for the median filtering operation, the median filtering reduces the noise, but at the same it maintains the sharpness of the image. Whereas, if we go for box filtering of higher dimension, of higher size then the noise is reduced, but at the same time the image sharpness is also reduced, that means the image gets blurred.

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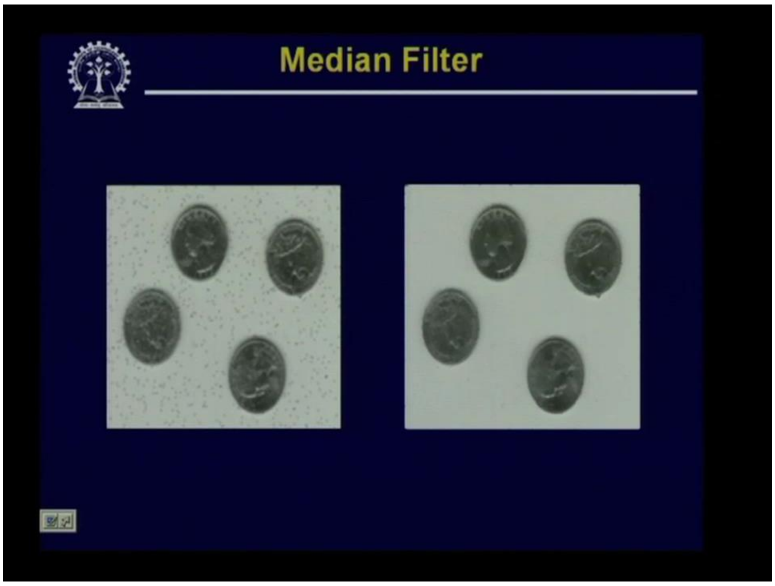

This is another set of results where you find that if you compare the similar result that we have shown earlier using the median filter, the noise is almost removed, but at the same time the contrast of the image is also maintained. So this is the advantage of the median filter that we get, that in addition to removal of noise, you can maintain the contrast of the image. But uhh this kind of median filtering as we have mentioned that this is very suitable form, a particular kind of noise, removal of a particular kind of noise which we have said the salt and pepper noise uhh the name comes because of the appearance of these noises in the given image.

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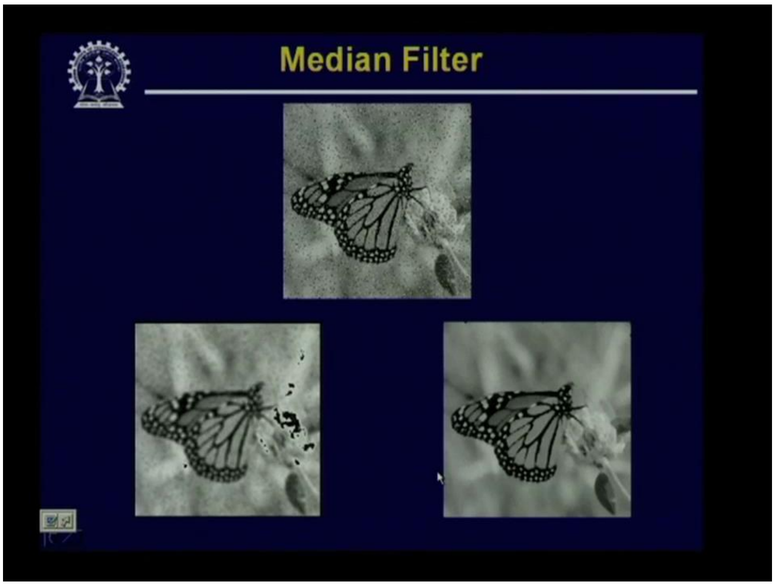

Then, this shows another median filter output result uhh the bottom two images on the left side it is the image obtained using the box filter, on the right hand side it is the image obtained using the median filter. The enhancement using the median filter over the box filter is quite obvious from this particular image.

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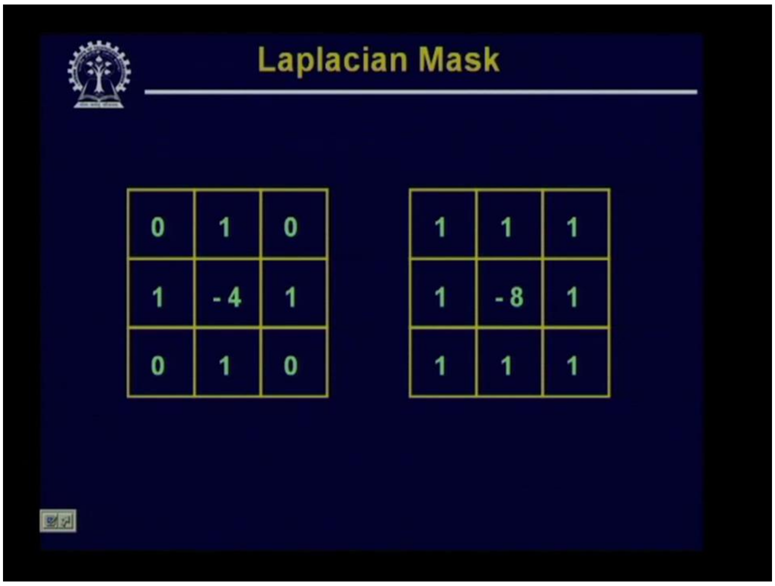

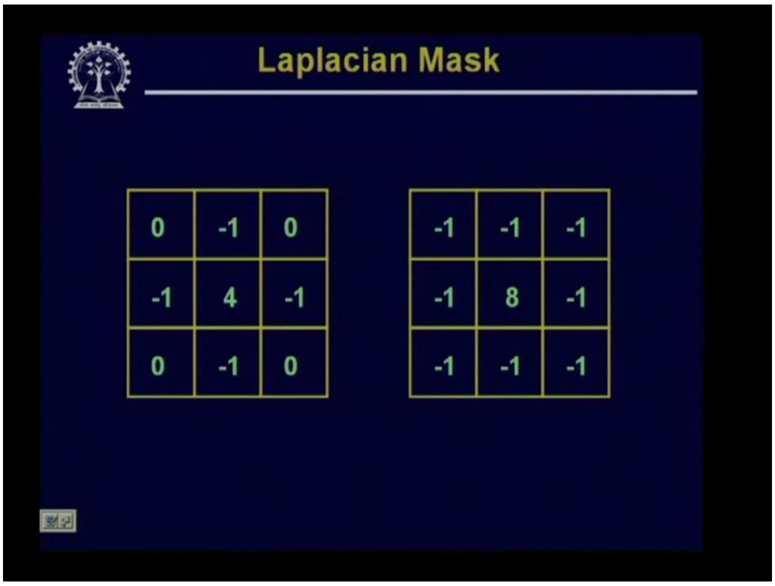

Then we have said that uhh for enhancement operation we use the second order derivatives and the kind of mask that we have used for second order derivative is the laplacian mask and for the laplacian mask uhh this are the two different masks which we have used for the laplacian operation, we can also use another type of masks where center coefficients are positive.

You find in case earlier masks, the center coefficients are negative, whereas all the neighboring coefficients are positive in the laplacian mask, in this case the center coefficient is positive, whereas all other neighboring coefficients are negative.

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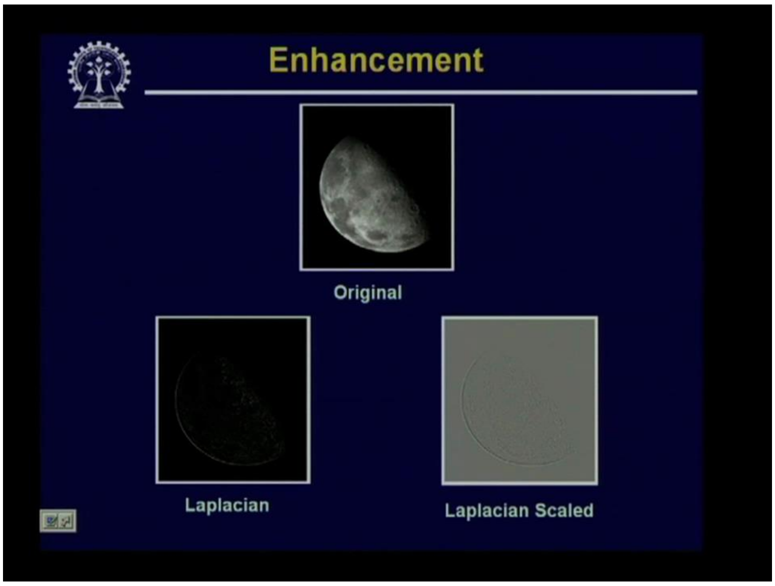

Now using this laplacian mask, we can find out the high frequency the detailed contents of an image, as has been shown in this particular one, here you find that the original image when it is a uhh processed using the laplacian mask that details of the image are obtained on the left hand side bottom left, we have shown the details of the image.

On the bottom right, what uhh we have done is it is the same image which is displayed after scaling so that the details are displayed properly on the screen. Now here what has been done is, we have just shown the details of the image, but in many applications what is needed is, if this detailed information is superimposed on the original image, then it is better for visualization. So these detailed images are to be added to the original image so that we can get an enhanced image.

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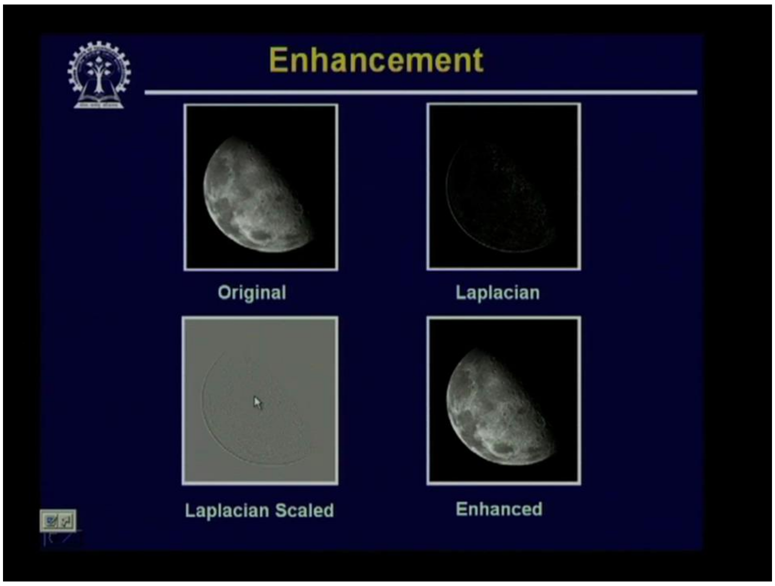

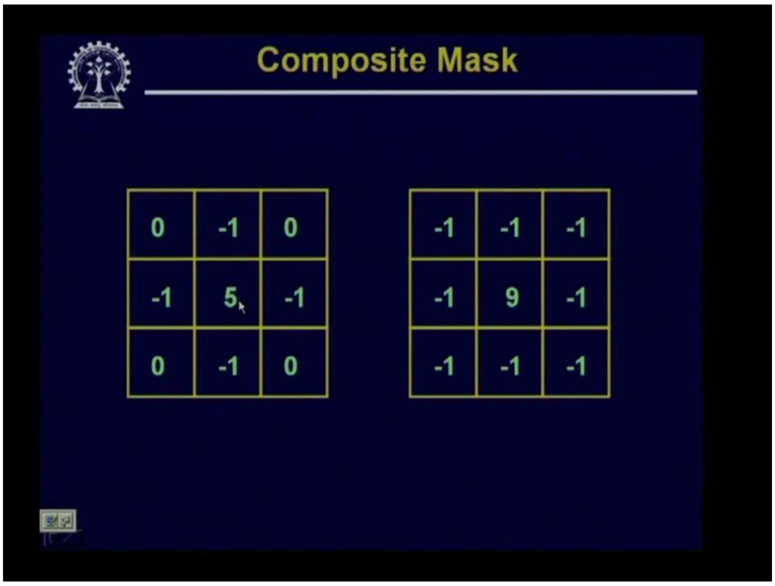

So the next one shows, that if we have this original image, this are that same detailed images that we have shown earlier, on the right bottom you have the enhanced image, or the detailed images are added to the original image. And for performing this operation, we can have a composite mask, where the composite mask is given like this, here you find on the center pixel we have uhh the center coefficient of the mask is equal to five, whereas if you remember, you recollect that in case of laplacian mask the center pixel of the corresponding mask was equal to four.

So if I change from four to five, that means f(x,y) value, the original image is going to be added with the detail image to give give us the enhanced images. So that is what is done by using this composite mask.

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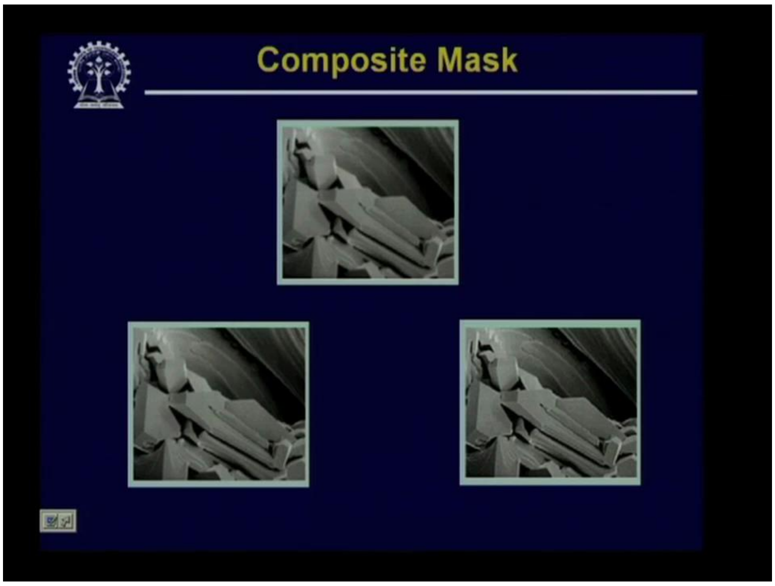

And this is the result that we obtained using the composite mask uhh similar to the one that we have shown earlier, you find that on the top we have the original image and on the bottom right we have the enhanced image, bottom left is an enhanced image when they, when we use a mask where only the horizontal uhh and the vertical neighbors are non-zero values.

Whereas, the bottom right is obtained using the mask were we consider both the horizontal vertical and diagonal coefficients to be non-zero values. And as it is quite clear from this uhh particular result that when you go for this kind of mask having both horizontal vertical and the diagonal components as non-zero values that enhancement is much more. Now today we will talk about some more special domain or mask operations. The first one that we will talk about is called an unsharp masking.

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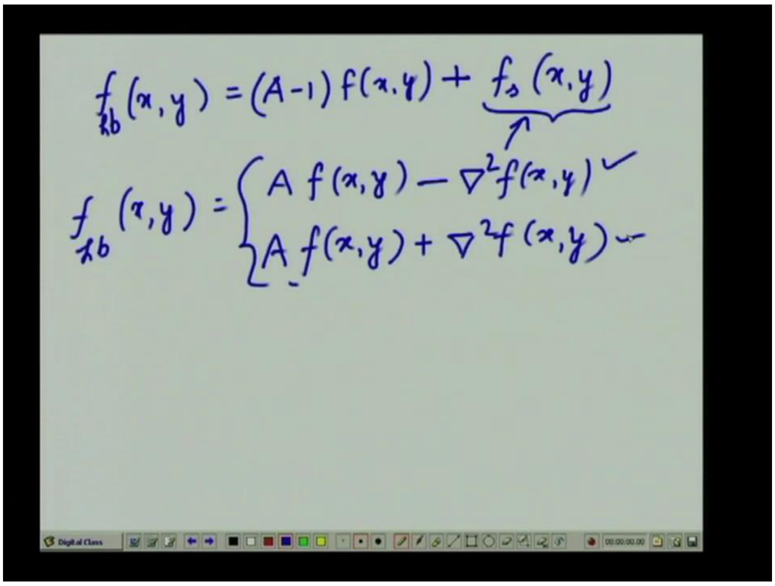

So by unsharp making we mean uhh you know that uhh for many years the publishing companies were using a kind of enhancement, or the enhancement in the image was obtained by subtracting a blurred version of the image from the original image. So in such cases, the sharpened image was obtain as fs(x,y) if I represent it by fs as the sharpened image, then this was obtained by subtracting f(x,y) and f bar(x,y).

So this f bar(x,y) is nothing but a blurred version or blurred f(x,y). So if we subtract the blurred image from the original image, what we get is the details in the image or we get a sharpened image. So this fs(x,y) is the sharpened image and this kind of operation was known as unsharp masking. Now we can slightly modify this particular equation to get an expression for another kind of masking operation which is known as high boost filtering.

So high boost filtering is nothing but a modification of this unsharp masking operation, so we obtain high boost filtering as, we can write it in this form fhb(x,y) which is nothing but A times f(x,y) – f bar(x,y) for A greater than or equal to one. So we find that if I set the value of this constant A equal to one, then this high boost filtering becomes same as unsharp masking. Now I can rewrite this particular expression, I can rewrite this in the form (A - 1) f(x,y)+f(x,y) -f bar(x,y).

Now this f(x,y) - f bar(x,y), this is nothing but the sharpened image fs(x,y). So the expression that I finally get for high boost filtering is fhb(x,y) = (A - 1)f(x,y) + fs (x,y). Now it does not matter in which way we obtain the sharpened image. So if I used the laplacian operator to obtain this sharpened image, in that case the high boost filtered output fhb(x,y) simply becomes Af(x,y) minus the laplacian operator on f(x,y) and this is the case when the center coefficient in the laplacian mask will be negative.

Or I will have the same expression which is written in the form Af(x,y) + laplacian of f(x,y) when the center coefficient in the laplacian mask is equal to positive. So as we have seen earlier, that this first expression will be used if the center coefficient in the laplacian mask is negative, and this second expression will be used if the center coefficient in the laplacian mask is positive.

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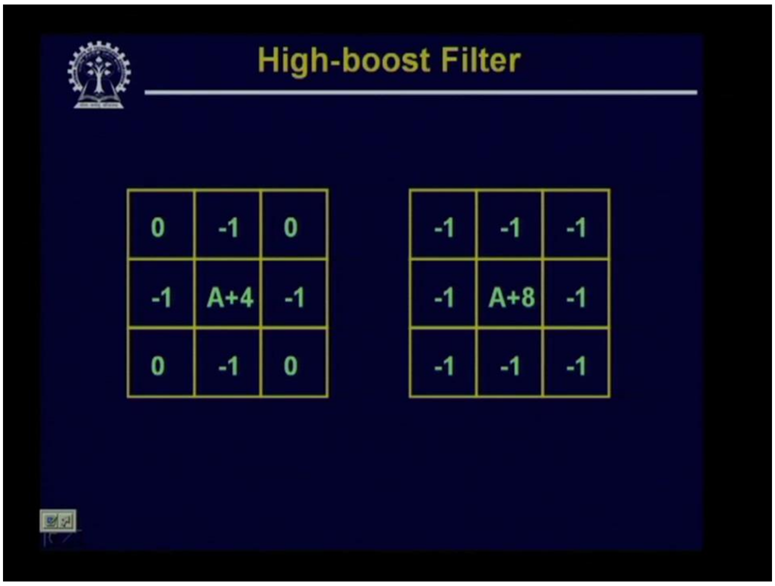

So using this we can get a similar type of mask, where the mask is given by this particular expression. So using this masks we can go for high boost filtering operation and if I use this high boost filtering, uhh I get the high boost output as we have already seen earlier.

Now so far, the kind of derivative operators that we have used for sharpening operation all of them are second order derivative operators. We have not used first order derivative operators for filtering so far. But first order derivative operators uhh are also capable of enhancing the content of the image, particularly at discontinuities and at uhh region boundaries for edges.

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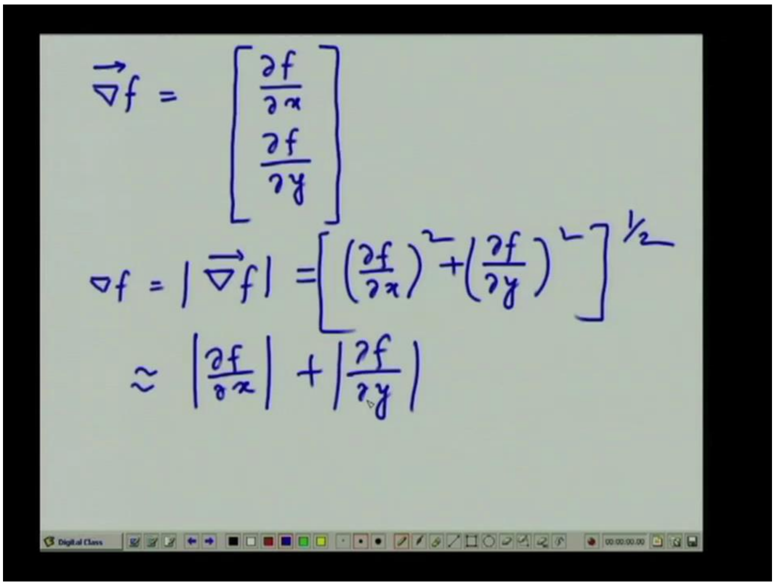

Now the way we obtain the first order derivative of a particular image is like this, what you use for obtaining the first order derivative is by using the gradient operator, where the gradient operator is given like this, gradient of a function f, as the gradient is a vector, so we will write as a vector, is nothing but del f del x and del f del y.

So this is what gives the gradient of a function f, and what we are concerned about for enhancement is the magnitude of the gradient, so magnitude of the gradient we will write it as del f, which is nothing but magnitude of the vector, grad f, which is usually del f by del x square + del f by del y square and square root of this. But you find that this particular expression if I use, this leads to some computational difficulty in the sense that we have to go for squaring and then square root and getting an square root in the digital domain is not an easy task.

So what we do is, we go for an approximation of this and the approximation is obtained as del f del x magnitude + del f del y magnitude of this.

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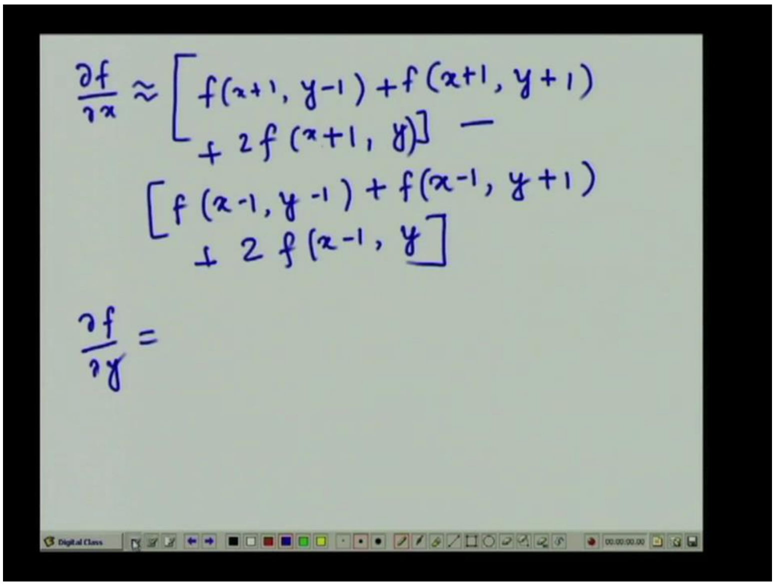

So this is what gives us the first order derivative operator on an image, and if I want to obtain del f del x, you find that this del f del x can simply be computed as [f(x+1), (y -1)+f(x+1,y+1)+2f(x+1,y)] – [f(x -1, y -1)+f(x -1,y+1)+2f(x -1,y)]. So this is the first order derivative along x direction and in the same manner we can also obtain the first order derivative in the y direction.

Now once we have this kind of discrete formulation of the first order derivatives, so similarly I can find out del f del y which will also have a similar form. So once I have such discrete formulations of the first order derivatives, we can have a mask which will compute the first order derivative of an image.

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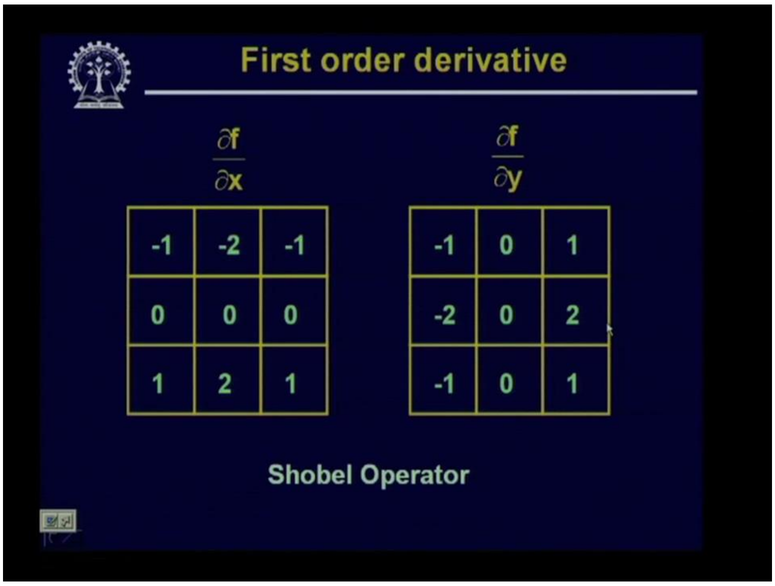

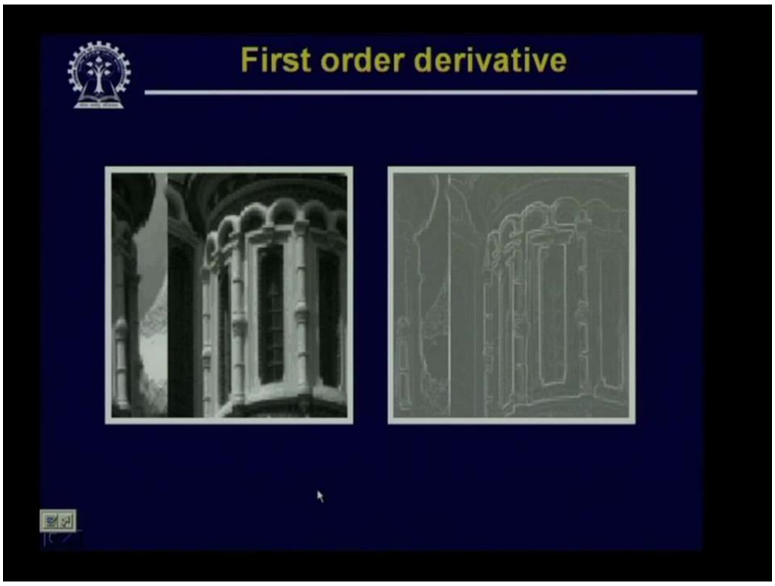

So for computing the first order derivative along x direction, the left hand side shows the mask and for computing the first order derivative along y direction, the right hand side shows the mask, and later on we will see that these operators are known as Shobel operators.

And using these first order derivatives, when we apply this first order derivatives on the images, the kind of processed image that we get is like this. So you find that on the left hand side, we have the original image and on the right hand side we have the processed image and in this case you find that this processed image is an image which highlights the edge regions or discontinuities regions in the original image. Now, in many practical applications, such simple derivative operators are not sufficient, so in such cases what we may have to do is we may have to go for combinations of various types of operators which gives us the uhh enhanced image.

So with this, we come to the end of our discussion on spatial domain processing techniques, thank you.