Digital Image Processing.
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Lecture-38.
Image Enhancement: Mask Processing Techniques-I.

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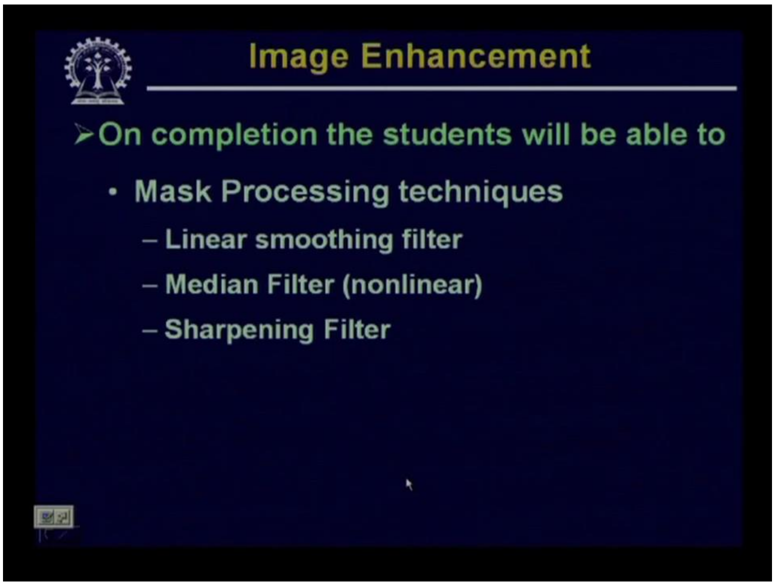

Hello, welcome to the video lecture series on digital image processing. Now in today's class we will talk about another spatial domain technique which is called mask processing technique. The previous lectures also were dealing with the spatial domain techniques, and we have said that image enhancement techniques can broadly be categorized into spatial domain techniques and frequency domain techniques, the frequency domain techniques we will talk later on.

So in today's class, we will talk about another special domain techniques, which are known as mask processing techniques and under this, we will discuss three different types of operations, the first one is the linear smoothing operation, the second one is a nonlinear operation which is based on the statistical features of the image which is known as the median filtering operation, and the third kind of mask processing technique that we will talk about is the sharpening filter.

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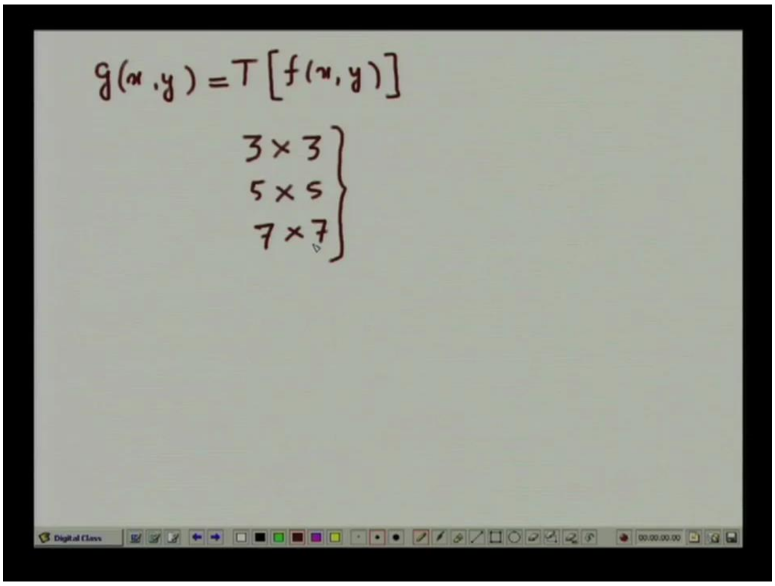

Now let us see, what this mask processing technique means. Now in our earlier discussions, we have mentioned that while going for this contrast enhancement, what we basically do is given an input image say f(x,y), we transform this input image by a transformation operator say T, which gives us an output image g(x,y), and what will be the nature of this output image g(x,y) that depends upon what is this transformation operator T.

In point processing technique, we have said that this transformation operation T, that operates on a single pixel in the image, that is it operates on a single pixel intensity value. But as we earlier said that T is an operator which operates on a neighborhood of the pixels at location x,y. So for point processing operation, the neighborhood size was 1 by 1. So if we consider, a neighborhood of size more than one, that is we can consider a neighborhood of size, say 3x3, we may consider a neighborhood of size say, 5x5, we may consider a neighborhood of (five) size 7x7 and so on.

So if we consider a neighborhood of size more than one, then the kind of operation that we are going to have, that is known as mask processing operation. So let us see what does this mask processing operation actually mean.

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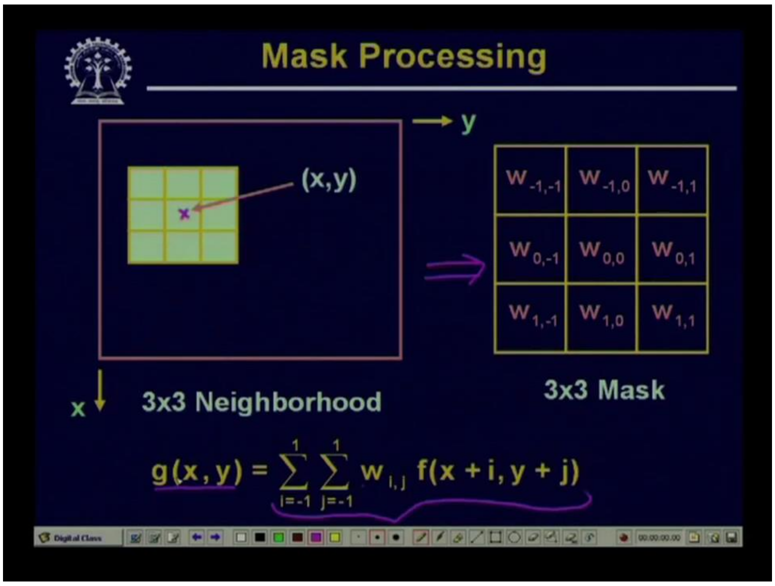

Here, we have shown a 3x3 neighborhood around a pixel location x,y, so this outer rectangle represents a particular image, and in the middle of this we have shown a 3x3 neighborhood and this 3x3 neighborhood is taken around a pixel at location x,y.

By mask processing what we mean is, so if I consider a neighborhood of size 3x3, I also consider a mask of size 3x3. So you find that here on the right hand side, we have shown a mask, so this a given mask of size 3x3 and this different elements in the mask, that is (w -1,-1), (w -1,0), (w -1,1), (w 0,-1), and so on up to (w 1,1), these elements represent the coefficients of this mask. So for all this mask processing techniques, what we do is we place this mask on this image where the mask center coincides with the pixel location x,y.

Once you place this mask on this particular image, than you multiple, multiply every coefficient of this mask by the corresponding pixel on the image, and then you take the sum of all this products, so the sum of this all this products is given by this particular expression. And whatever sum you get, that is placed at at location x,y in the image g(x,y). So by mask processing operation this is the mathematical expression we get that g(x,y) is equal to wi, j into f(x+i, y+j) you have to take the summation of this product over j varying from minus 1 to 1, and i varying from minus 1 to 1.

So this is the operation that has to be done for a 3x3 neighborhood in which case we get a mask again of size 3x3. Of course as we said that we can have masks of higher dimension we can have a mask of 5x5, if I consider a 5x5 neighborhood, I have to consider a mask of size 7x7 if I consider a 7x7 neighborhood and so on. So if this particular operation is done, at every pixel location x,y and the image, then the output image g(x,y) for various values of x and y that we get is the processed image g.

So, this is what we mean by mask processing operation. Now the first of the mask processing operation that we will consider is the image averaging or the image smoothing operation. So image smoothing is a special filtering operation, where the value at a particular location x, y in the processed image is the average of all the pixel values in the neighborhood of x and y. So because it is average, this is also known as averaging filter and later on we will see that this averaging filter is nothing but a low pass filter.

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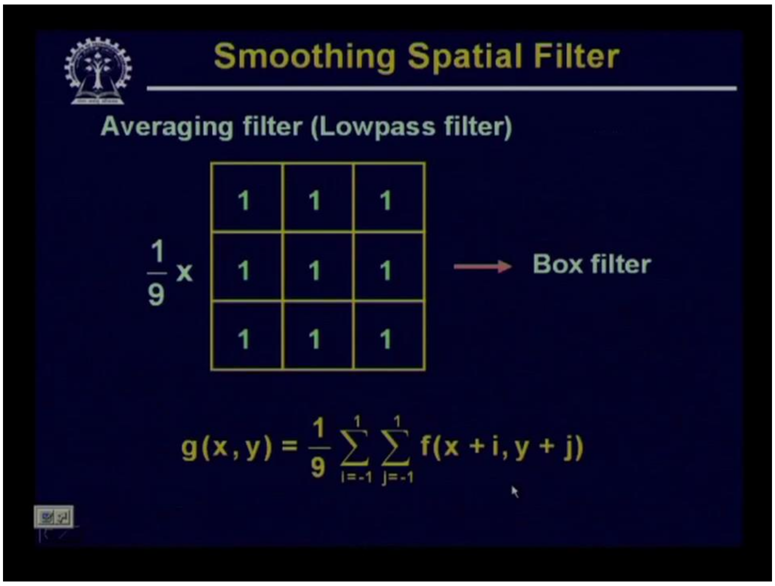

So when we have such a averaging filter, the corresponding mask can be represented in this form. So again here, we are showing a mask a 3x3 mask and here you find that all coefficients in this 3x3 mask are equal to one. And by going back to our mathematical expression, I get an expression of this form that is g(x,y) equal to one upon nine into f(x+i, y+j) take the summation over j equal to minus one to one and i equal to minus one to one.

So naturally, as this expression says you find that what we are doing, we are taking the summation of all the pixels in the 3x3 neighborhood of the pixel location x, y and then dividing this summation by nine. So which is nothing but average of all the pixel values in the neighborhood of x,y in the 3x3 neighborhood of x, y including the pixel at location x,y.

And this average is placed at location x,y in the processed image G. So this is what is known as averaging filter and also this is called a smoothing filter.

And the filter, and the particular mask, for which all the filter coefficients or mask coefficients are same or equal to one in this particular case, this is known as a box filter. So this particular filtering operation that we are getting, this particular mask is known as a box filter. Now when we perform this kind of operation, then naturally because we are going for averaging of all the pixels in the neighborhood, so the output image is likely to be a smooth image.

That means, it will have a blurring effect, all the sharp transitions in the images will be removed and they will be replaced by a blurred image. As a result, if there is any sharp edge in the image, the sharp images, the sharp edges will also be blurred. So to avoid the effect of blurring, there is another kind of mask, averaging mask, or smoothing mask which performs weighted average. So such a kind of mask is given by this particular mask.

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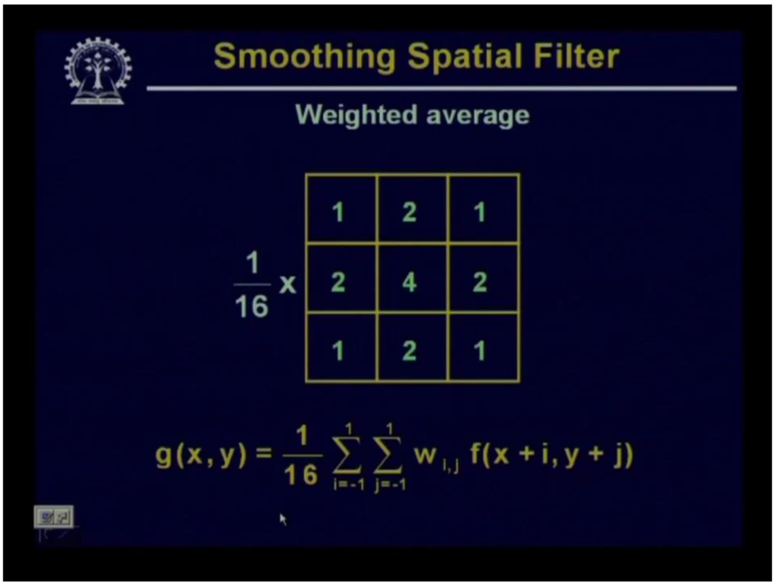

So here you find that in this mask, the center coefficient is equal to four, the coefficients vertically up, vertically down or horizontally left horizontally right, they are equal to two and all the diagonal elements of the center elements in this mask are equal to one. So effectively what we are doing is, when we are taking the average, we are weighting ever pixel in the neighborhood by the corresponding coefficients, and what we get is a weighted average. So the center pixel, that is the pixel at the location x,y gets the maximum weights, and as you move away from the pixel locations from the center location, the weights of the pixels are reduced.

So when we apply this kind of mask, than our general expression of this mask operation that is valid, which becomes wi,j f(x minus i, y minus f(x+i, y+j) take the summation from j is equal to minus one to one, and i equal to minus one to one, and take 1 up on 16 of this, and that will give the value which is to placed at location x,y in the processed image g. So this becomes the expression of g(x,y). Now the purpose of going for this kind of weighted averaging is that because here we are weighting the different pixels in the image for taking the average, the blurring effect will be reduced in this particular case.

So in case of box filter, the image will be very very blurred and of course the blurring will be more if I go for bigger and bigger neighborhood size or bigger and bigger mask; mask size. When I go for averaging, weighted averaging, in such cases the blurring effect will be reduced.

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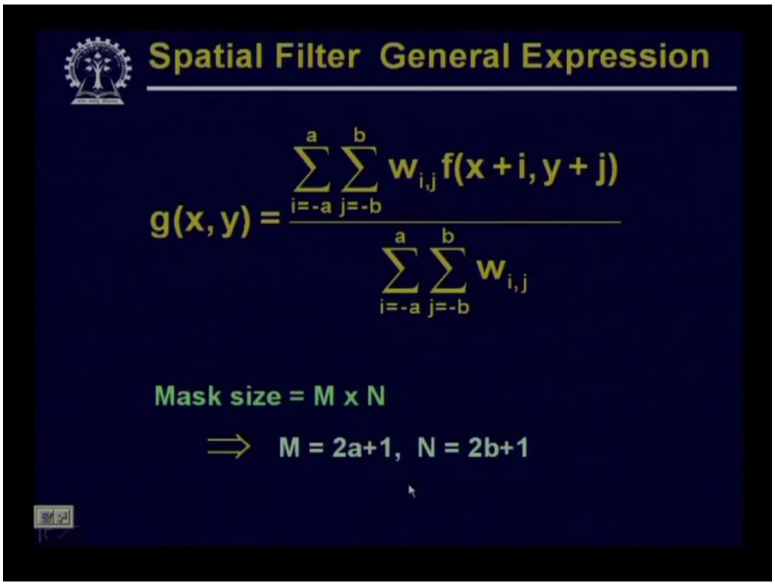

Now let us see what kind of result we get, so this gives the general expression that when we consider wi,j, we have to have a normalization factor, that is this summation has to be divided by sum of the coefficients, and as we said that 3x3 neighborhood on is on the special case I can have neighborhoods of other sizes.

So here it shows, that you can have a neighborhood of size M x N, where M = 2a+1, and N = 2b+1 where a and b are some positive integers, and obviously here you show the here it is shown that the mask is usually of odd dimension, it is not even dimension. And that is normally the mask of odd dimension which is normally used in case of image processing.

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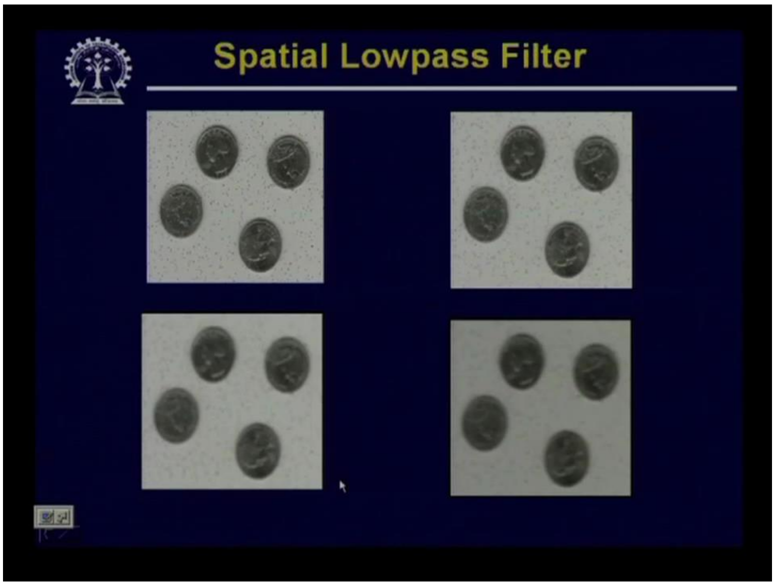

Now using this kind of mask operation, here we have shown some results, you find that the top left image is a noisy image, when you do the masking operation or averaging operation on this noisy image, the right top image shows the averaging with a mask of size 3x3.

The left bottom image is obtained using a mask of size 5x5, and the right bottom image is obtained using a mask of size 7x7. So from these images, it is quite obvious that I as I increase the size of the mask, the blurring effects becomes more and more. So you find that the right bottom image which is obtained by a mask of size 7x7 is much more blurred compared to the other two images. And this effect is more prominent if you look at the edge regions of these images, say if I compare this particular region with the similar region in the upper image or the similar regions in the original image.

You find that here, in the original image that is very very sharp, whereas when I do the smoothing using a 7x7 mask, it becomes very blurred. Whereas the blurring effect when I use a 3x3 mask is much less. Similar such result is obtained with other images also.

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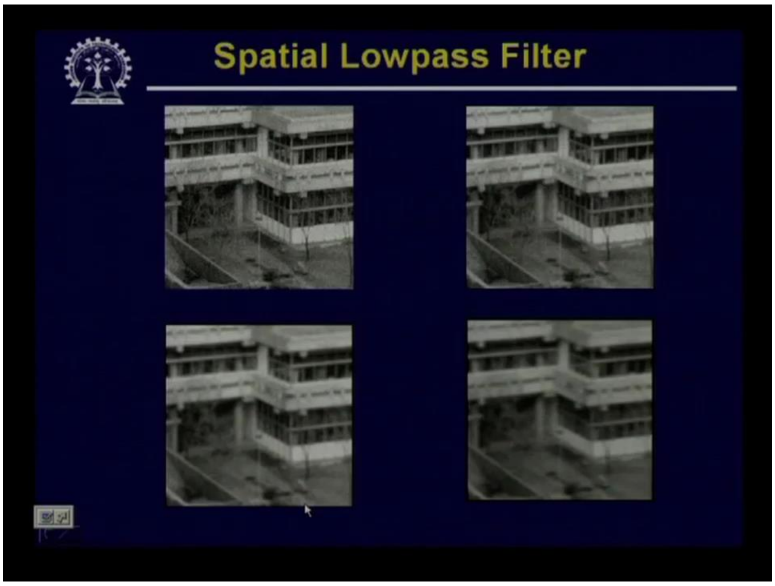

So here, is another image, again we do the masking operation or the smoothing operation which different mask sizes, on the top left we have an original noisy image, and the other images are the smooth images using various mask sizes.

So on the right top, this is obtained using a mask size of 3x3 the left bottom is an image obtained using a mask of size 5x5 and the right bottom is an image obtained using a mask of size 7x7. So you find that as we increase the mask; mask size, the reduction is in noise or the noise is reduced to a greater extent, but at the cost of addition of blurring effect. So though the noise is reduced, but the image becomes very blurred. So that is the effect of using the box filters or the smoothing filters that, though the noise will be removed, but the images will be blurred or the sharp contrast in the image will be reduced.

So there is a second kind of image, second kind of masking operations which are based on orders statistics which will reduce this kind of blurring effects.

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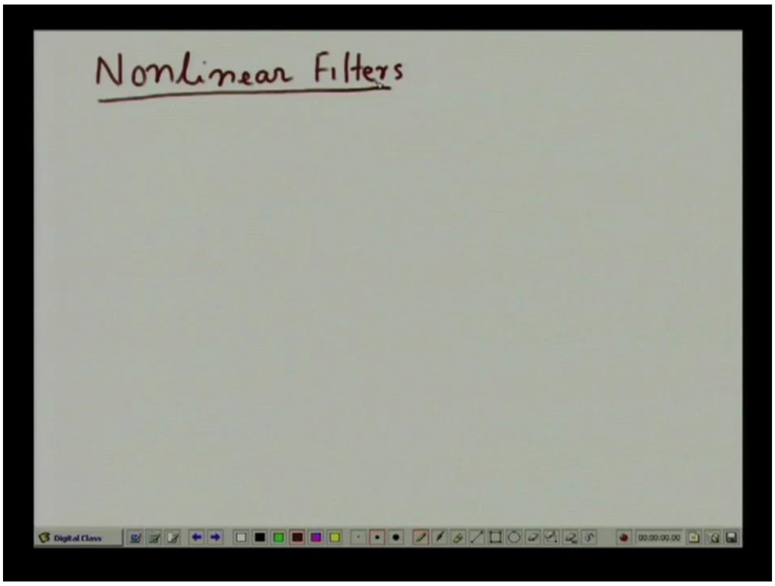

So let us consider, one such filter based on order statistics. So this kind of filters, unlike in case of the earlier filters, these filters are nonlinear filters. So here, in case of this order statistics filters the response is based on the ordering of the intensities, ordering of the pixel values in the neighborhood of the point under consideration. So what we do is, we take the set of intensity values which is in the neighborhood, which are in the neighborhood of the point x,y, then order all those intensity values in a particular order and based on this ordering, you select a value which will be put at location x,y in the processed image g.

And that is how the output image you get is a processed image, but here the processing is done using the order statistics filter. Thank you.