Biometrics
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Lecture No. # 04

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Different types of operations, we like to perform on our images. Now, usual basic operations, we have discussed right that addition, subtraction or rotation something like that. Now, these are the operations you like to perform on every image to get a better image, better image means as I told you that the sometimes you will be getting the image which may have something, which you do not like you want to suppress those thing and you want to get the better results or you like to get the good features out of it?

Suppose you see your palm there is a some of some are line are there, these lines are available on your image, but not may not be in good quality you need to extract something. So or you need to do some of the operation only. So, that you get a good quality image and at the same time you have to ensure that. That you are not playing with the features. So, that in the coat of law you can justify that all these features, were available only you have highlighted that those features. So, the first one is convolution.

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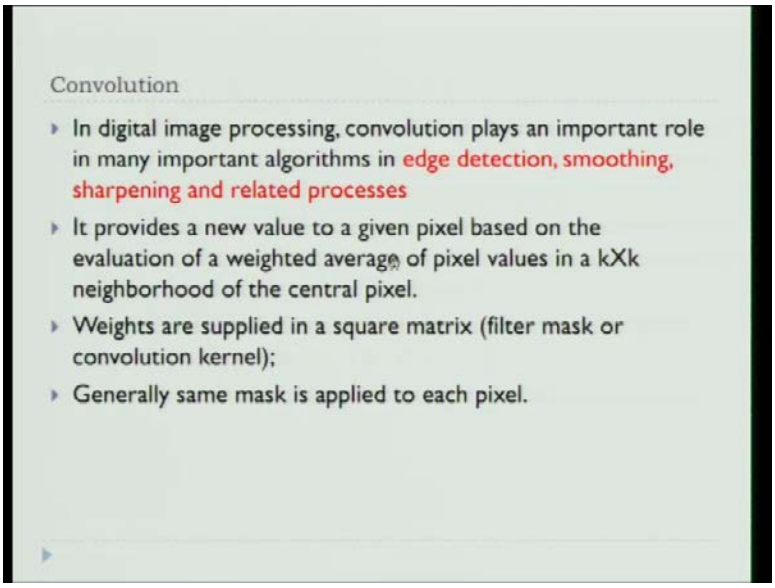

Now, the convolution is a method only it is not any operations through, which you will be getting something, increase a method through which will be use by the other operation. So, what is convolution you remember this convolution is in digital image processing it is mainly use to get the proper edges? That will be edge detection smoothing the images or sharpening the images. This type of operation when you want to perform on an image you will be taking the help of convolution. Now, is what is convolution basically?

It you will be taking a k cross k sub image, this sub image will be put on the centre pixel whose data you want to modify take the help of the neighbouring pixels and perform some operations on the neighbouring pixels and put the result in the centre pixel. That is convolution you have a sub image size may be k cross k, it did not be k cross, it can be m cross n and this sub image will have some weights may be positive weights, may be negative weight.

This you will be putting on the centre pixel, whose data you want to modify and the neighbouring pixel information along the weight. You will be performing some operations and centre pixel value you will be computing, that is convolution. Generally we issue that sub image size is an m cross m, but it is not necessary that it should be m cross m it can be variable. Now, the question is that you got a mask of sub image you are moving from one corner for to compute the value of the centre pixel.

Now, the next pixel you want to compute are you going to use the same mask. It should be you should use a same mask otherwise you are not the same idea to enhance that image to enhance or to sharpen the image. It cannot be that a mask you are using on some area and another mask, you are using on another part of the same image does not have meaning.

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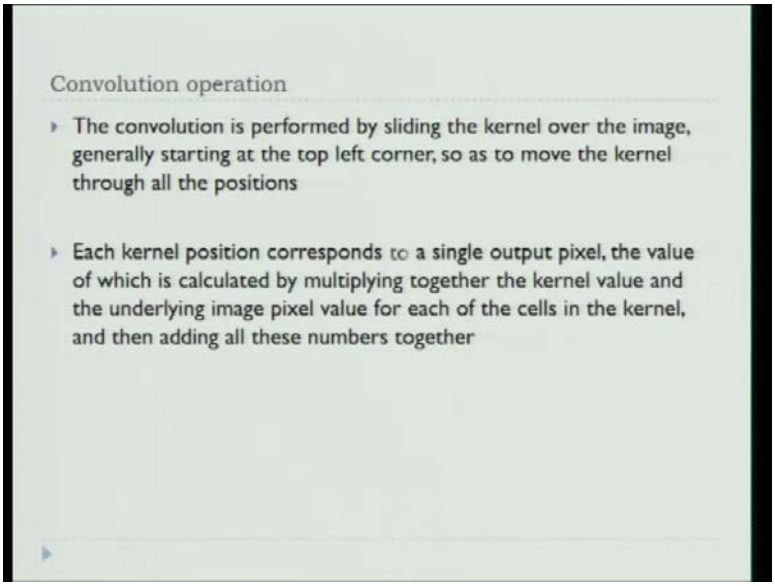

So, generally same mask or same sub image you will be performing from one corner to another corner. So, that is the thing we have written here, that convolution is performed by sliding the kernel. Kernel is your sub mask over the image generally staring the top left corner so, as to move the kernel to all the positions. Now, this masks this sub image. So, once you are moving from one corner to another corner. This is the sub image and this is an image so, this image you remove it. So, first you will bringing it here and you will be competing this value using this neighbour pixels and the values here the coefficients here.

So, maybe this will be multiplied by this and this will be multiplied by this and so on. And add it and that value you have to put it here that is the idea. So, each kernel positions correspond to a single output pixels value for, which is calculated by multiplying together. The kernel value and underlying image pixel value for each of the cell in the kernel and then adding together all these number to give you the pixel value. This is an example, this is an image and supposes this is mask 3 cross 3 and this pixel I

will want to modify. So, what I have done this into this plus, this into this plus, this into this plus and this into this plus and so on. And you will be getting some modified value of this centre pixel.

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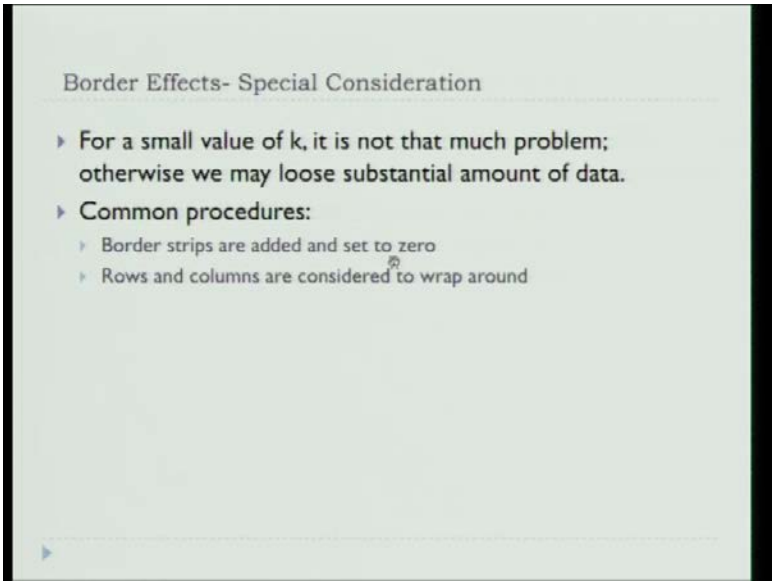

So, the algorithm is not very simple for a pixel p. What I do I place the kernel on the centre pixel and then you multiply it and add it get the output of that this is the and you have to for all pixels. Now, the way question is coming what should be my size of k like you are taking the sub image k cross k. You have to be very careful what happens k must be odd am I right otherwise you have to be very careful, which part you will be taking this side and which part will be in the bottom and so on. If k is not odd you will find that either this side is even and this side, this side will be odd and this side will be odd and there is a centre line agreed. So, k must be odd k cross k, k must be odd suppose it is 4 cross 4. So, to obtain this let us assumed that 4 cross 4 means what 1 2 3 4 5 6 this is a 4 cross 4.

Now, which one will be the centre pixel if you put this is centre pixel then you are giving the weight age to this two columns right in a image. What we are computing? We are computing the value of the centre pixel with the help of the neighbouring pixels reason is the neighbouring pixel also, because any image if you see suppose this slab you see the neighbouring pixels are also having the similar behavior right. So, this weightage I want

to make use. Now, I suppose I gave the weight age here on this pixel there are 1 1 pixel on the left, but two pixel on the right, then you are doing something wrong.

You are giving more weight age this side n this side or more weight age to this side instead of doing that. I want to give equal weight age to both the sides. So, k must be odd now, what happens if k yes no same way you are moving. No modified values original image is here you perform it and do it. Right now, what happens? What should k can be very small agreed. If k is small what is happening? I am giving the weight age only the smaller area right and if I give the smaller area and may be the smaller area is itself the affected area.

So, that resulted will also be also affected area now, if k is large again there is a big problem. That means, what will be suppose if k very large then whole image suppose I do the operation or average of it. That this plus, this plus just weight I have given one and then what will happen the centre pixel will nothing, but the average of this image. That means, I am not also giving the full importance on my centre pixel even though the centre pixel I can assume that it is affected one, but all centre pixel are not affected one only one or two or some of them will be affected one. So, our target is not to consider only the not to consider the value of k very large at the same time very small.

Now, this is first part. Second part is that once you are moving this sub image over this, then there is a you will be seeing the top k they you do not have the any values, because you have started computing the value from here onwards. So, similarly, this side also you cannot get the value. Similarly, you cannot get the value of this side similarly, you cannot get the value of this side so, agreed or not. So, basically your sides will be reduce this side k, side this side k, this side k, this side k and this side k size of the image will be reduced. And you know people may not accept this one, because I have given you say 2 k cross 2 k image and you are giving no it is not 2 k cross 2 k it may be say 2000 cross 2000 image.

So, people what happen I have given you 2 cross 2 k cross 2 k image, but you are giving the less size image. So, you have to do some operation, one operation could be keep the value as it is do not touch the values, this is possible. Another possible is that I can assume that this image is wrap around. So, use this data to compute this one also or use

this data to compute those it is not a big size the finger print will be data it is not a big size data so, by doing that you will not be losing great information.

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Agreed agreed, but you know how what that is for visibility point of view our operations, you have while you are computing you know what you have done. So, you will be computing the data one from here only that is for visibility point of view people should not feel that any convolution. You operation you do that some of scripts will be there that scripts you have to manipulate otherwise it will not be saleable. But while you perform the operations you will be performing operations on this area only the border line we do not consider. We will assume that they are all false minutiae whatever minutiae will be there they are all false.

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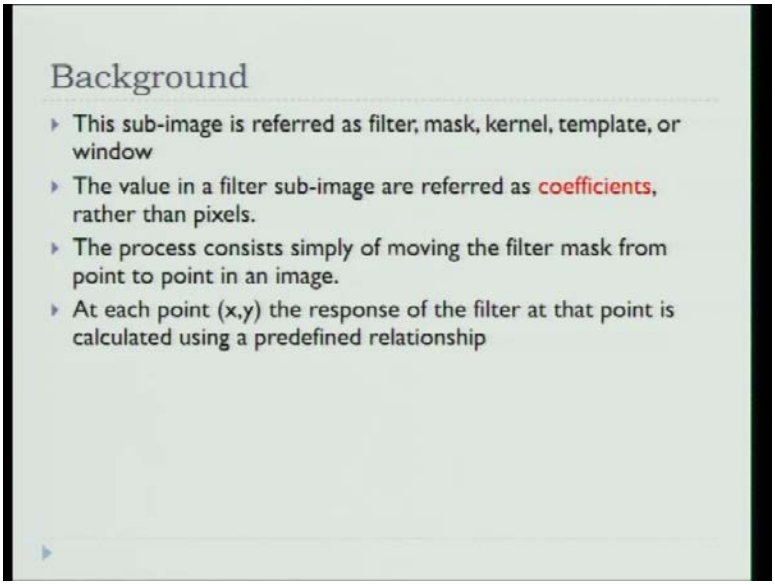

So, the words I have use the sub image. Now, the sub image is sometimes you will find in some book find it is called filter, some book you will get the mask, some book you will find the template kernel or window. So, it is not necessary that it will be called mask or kernel or something it may be called as window also. Now, the value of this sub image is do not tell it is a pixel they call as coefficients. The coefficients are either positive or negative or 0, but pixel value is always positive. Pixel value is always integer positive integer, but the coefficient did not will the process consists simply of moving the that I have told you from one corner to another corner.

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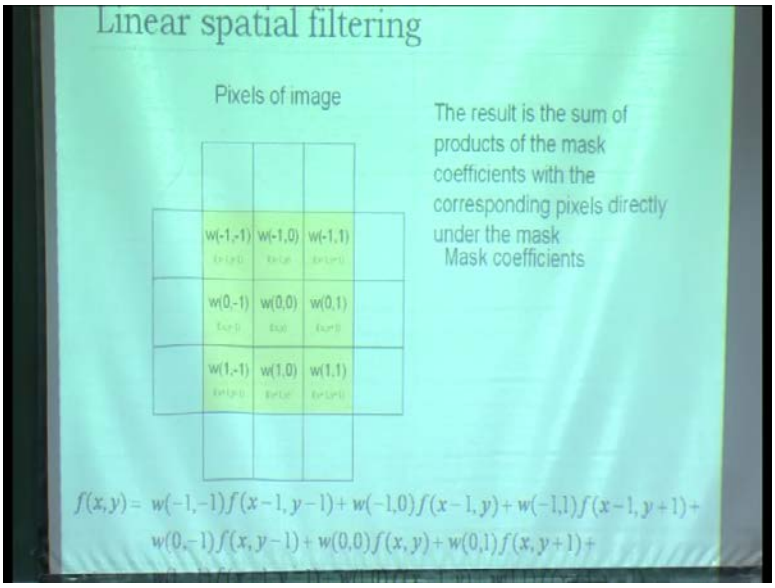

You have to do it and this also I have told whatever relationship will be telling same this relationship you have to follow. So, this is supposing the image. So, that was the mask you have this is the mask or weight you want to do and you want to compute this value. So, you perform the operations this into this plus I think it is written. So, perform this operation this into this plus, this into this plus and this into this plus and so on. That will be you're the next value of this.

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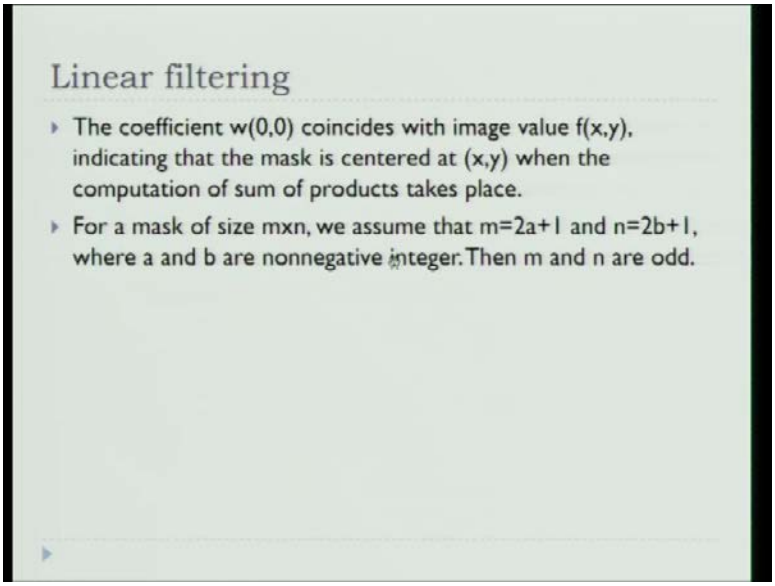

Now, there are two you will be finding that we are using one of them is known as linear filtering, another one is non-linear filtering. The linear filtering is nothing, but as I told you that you will be considering the coefficient values and the pixel value. You will be performing the operation multiplication operations and then add them that is your linear you will filtering that you are moving one corner to another corner. And then you multiply and add them that will give you the result of the centre pixel. Right and size of the pixel what size of the window is m cross n here assuming that 2a plus 1 and 2 b plus 1, where a and b are nonnegative integer and obviously, M and N are odd.

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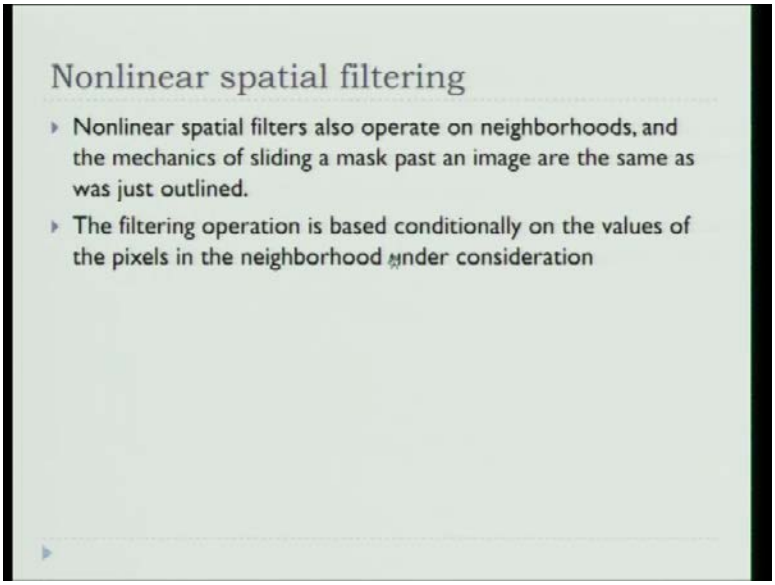

So, this general formula here, I will assume that a and b and 2 a plus 1 2 and 2 b plus 1 and this is the formula for computing a centre pixel. So, that one we are just simplified way, we have written here the next term I am telling that non-linear filtering what does it mean. In the case of linear filtering what I did I have considered is pixel and multiplied by the coefficient add them to get the value of centre pixel. In the case of non-linear filtering I am not considering that multiplied and so on. I am just taking the pixel values, pixel values and I do some operation on the pixel values to get the centre value of the pixel.

Centre pixel structure is same that you have the k cross k mask you remove it. But I will not multiply this coefficient with the pixel plus coefficient the next pixel and add them to get the centre pixel. What are you would be doing that mask will move it. Will get the

pixel values of that mask all the pixel value of the sub image and then you will perform some operations to get the positive or get the estimated value of the centre pixel. That is the non-linear filtering am I is it clear. Say for example, the operation can be the minimum of the sub image. Here I am not doing anything I am just finding all the element pixel values of the sub image and I am finding the minimum value is it clear.

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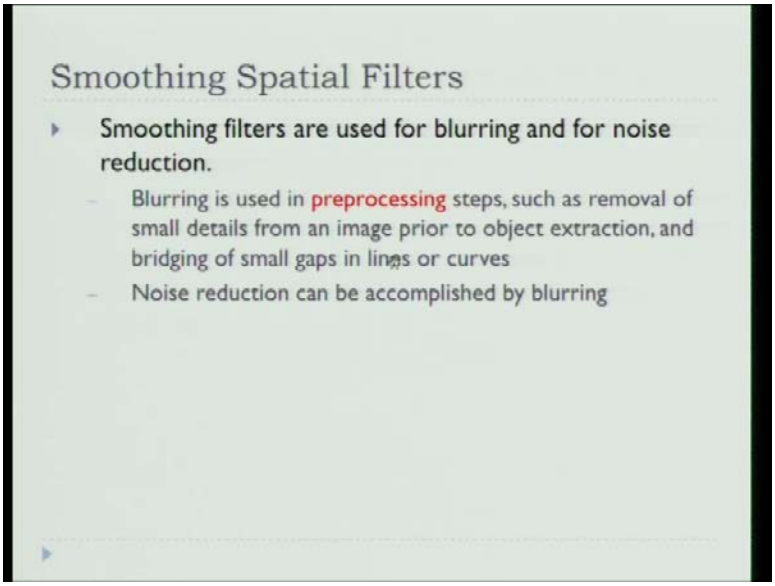

Now, let us come to the linear filtering first, these are used for blurring and for noise reduction see I have an image why I should I want to make it a blur image. Blur means what that will become a dull finish image. But why I want to do it because you may find that in image there are some pixels they are keeping some of the details which visible that they are not belonging to my image something else. So, I suppose these pixels there are several such type of things are there. So, these are not these are not your image content there is something else you do not want them right.

So, if I do the linear filtering on it. What I will be doing I will be taking the neighbouring pixel values and then I put the replacement of this one. What will happen that image becomes dull, because the sharp part that the special information. That will go and that will be replaced by the average value or something like that. So, it will become the dull, it will become the blur. You to look soft right and generally, we do it before we extract the features the otherwise this will be given you as a feature this is a false feature it is not useful at all. So, to get rid of this false feature what we do we do these operations? So,

that this false feature will go away and also remember once, you replace it by the average one then there was a suppose here, there is a white dots and others are not white dots.

So, this will be gone. That means, that will create a bridge between the neighbouring pixels is it clear. That will clear because that white part will go and it will be put by the replace by the centre average pixel average value of the neighbouring pixels. So, what will happen that we look a link between the neighbouring pixels? Noise reduction is also same one only the idea is that. Noise means that there are certain additional things is that, that is not you are put it or accessory it that point has come in your features. So, you want to remove that.

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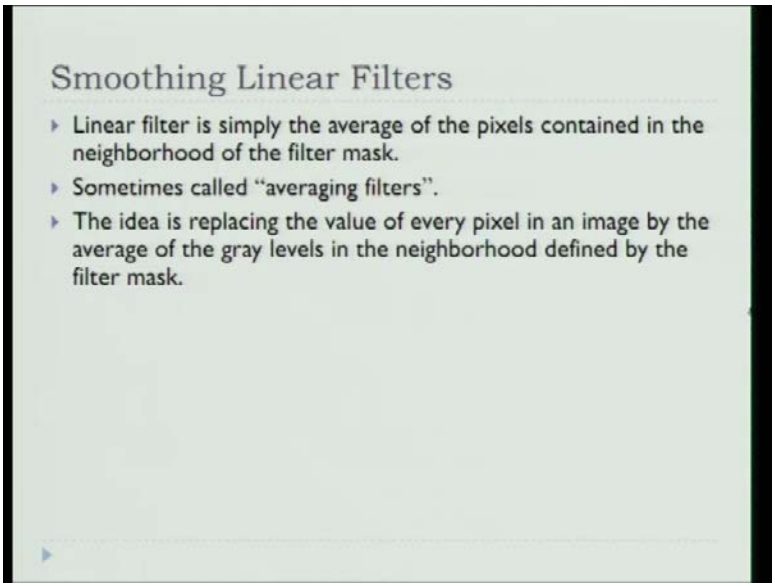

So, this blurring after effects is also noise removal. So, this is the linear filtering first one is the simple one that is just I take the average of it. You have a mask that mark contains some weights that mask will be moving from top corner to another corner. Centre pixel value will be replaced by the average value and that is your average filtering.

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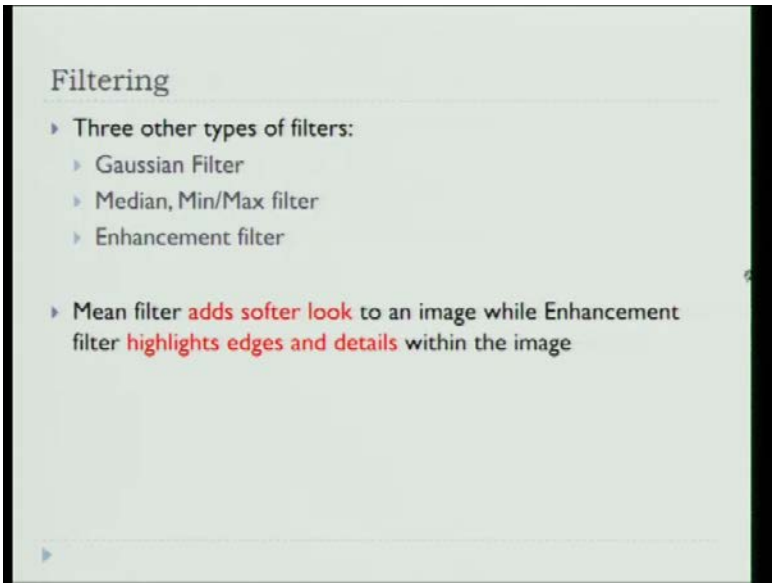

There are other types of linear filtering one is known as Gaussian filter median, this is not linear median mean max filter there is non-linear filter and enhancement filters. So, if you observed that mean filter will give you the softer look because you are replacing the centre pixel value by the average value. So, it will you know suppress some of the details it will look give you the softer look, it will blur by image and so on. Whereas, we will be show that enhancement filter will enhance the image it will give you sharpen the you will get the better look on the edges. You can usually see that there is a sharp edge if it exits that will be visible through enhancement filter.

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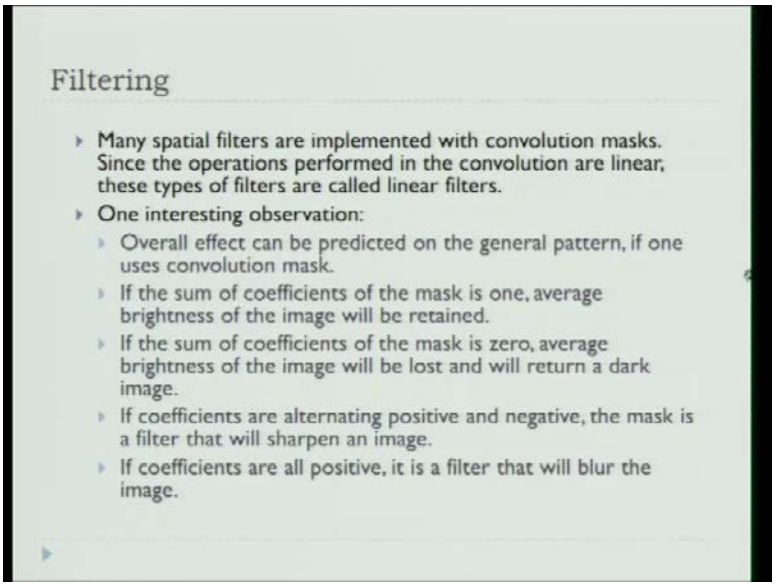

Now, one interesting observations, that over by seeing the mask itself you can understand what is the pattern of the image output pattern of the image. That you have the mask it has the content certain weight by seeing the content itself you can realize what will be my output convoluted image. That if the some of the coefficient is one, then average brightness will be retain if some of the coefficient of the mask is 0 than the image become dark. The average image will be dark the brightness will be lost. If the coefficient alternatively positive, negative, positive, negative and so on, then that image will be sharpen. If the brightness then you knows the edge you can see properly, but if it is all positives, all positives then the image will become dull image bright you know it will be blur.

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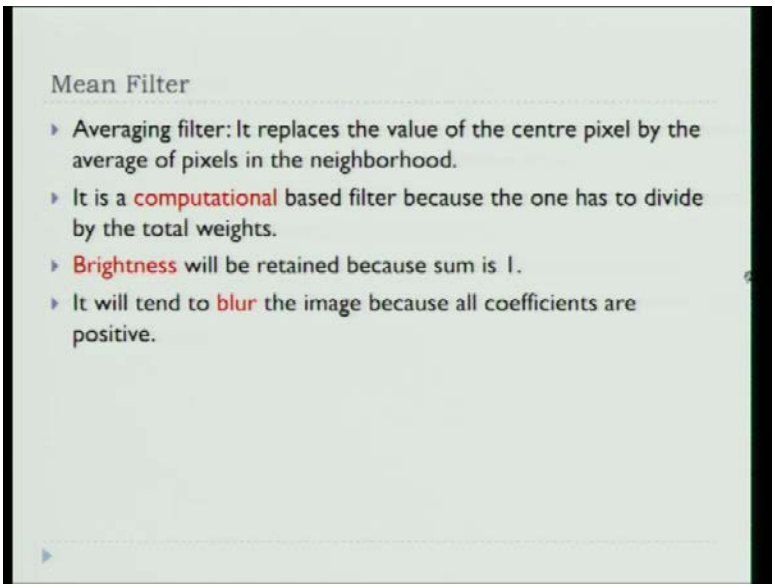

So, in the case of average filtering basically, what you will be doing you will be taking the neighbouring pixels. And some weights will be given on each the weights are nothing, but the coefficient and then you replace centre pixel by the average value of that. So, but it is the computationally it is not that very simple because once you are computing the average there is a question of division will be coming in between. So, for competition of every center pixel you have to divide it by some total number of weights I am right.

There is a definition of average. (No audio from 21:32 to 21:38) So, this division will come in between. Now, since the coefficient will be showing since the coefficient is all

positives than W i is are all positive, then that is why that brightness average brightness of the image will be retain, But since all of them are positive integer in the mask what it will give the blur or soft look image will be there.

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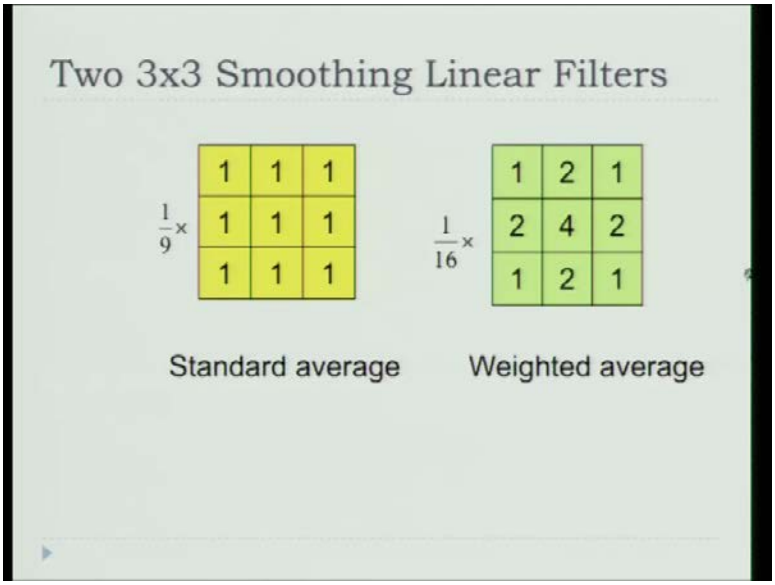

So, from the previous slide now, you observe that this is the 3 cross 3 linear filters there are weights or coefficient t are all ones and divided by because I could have written 1 by 9, 1 by 9, 1 by 9 instead of making. So, many division what I have done I have taken 1 by 9 outside after computing. I will just divide it by 9 and this is the weighted average. So, you observe that 1 by 16 is the 16 weights. I have given the submission over W i 16. Now, here in this case I am giving all equal importance to each side. The diagonally I am giving one weight this is also one weight horizontal I am giving the equal weights.

But here is the different case you see that I am giving the weight age on my center pixel, which value is 4 4 weights I am giving the centre pixel then the horizontal vertical finally, diagonal thing. So, if there is an image like this there is a road here then you will find. So, this is a diagonal edge will be there I will you will not get much importance in this side only this value will get four times this will be getting one time weight, one time weight, but other places this side is two times weight, two times weight, two time weight, two time weight to get the thing. So, if the lines are diagonal one it may be affected in your image convoluted image you understood clears.

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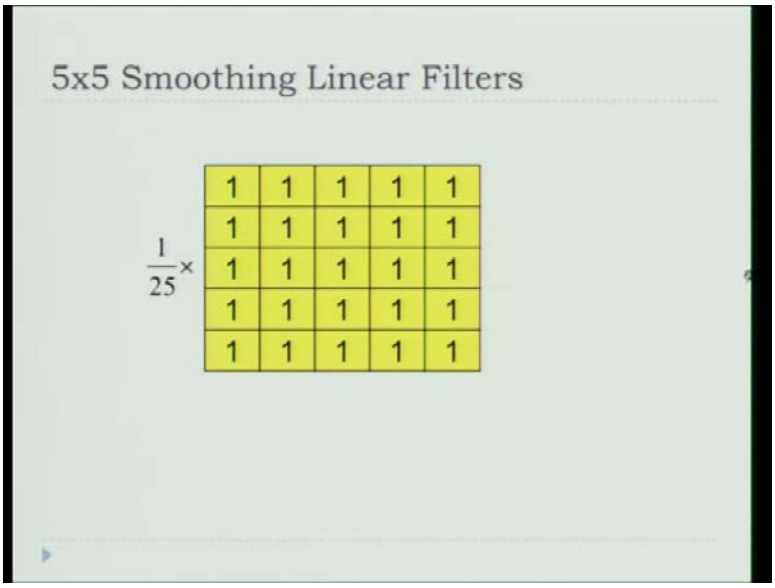

Now, why I have taken 3 cross 3. I could have taken 5 cross 5 also, as I told you that if you can have very large size of your sub image, but only thing is that this will increase your computational cost. You will be losing some side things and also finally, what you are getting you will be center pixel will be dependent on the two many neighbouring pixel. So, it center pixel property may be lost. This is the general formula for in any image you will find this picture, this is a linear photograph and all sorts of operations you do on this image.

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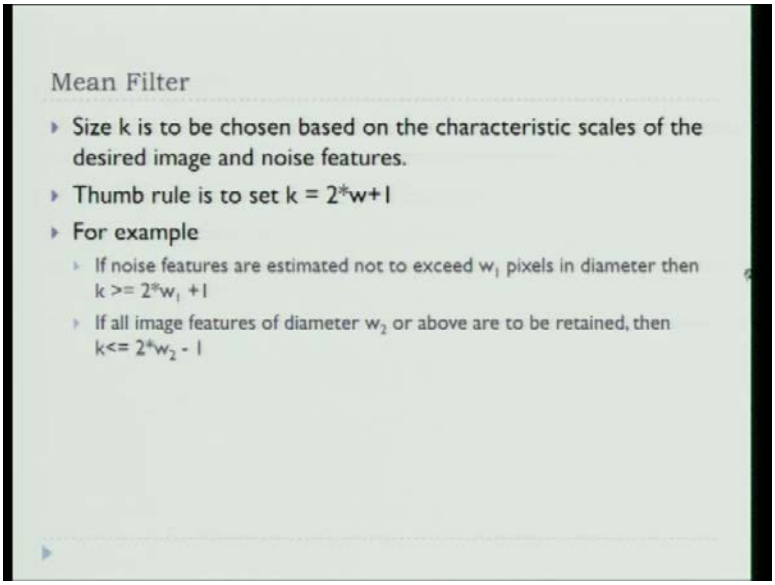

So, if this is a 3 cross 3 images 5 cross 5 convoluted image and there is 7 cross 7. I do not know whether it is visible see if it is visible or not. They are not same that dull part is much more when you consider 7 cross 7 this is a little sharper than 5 and so on. Now, value of k as I told you that selecting the value of k is very important you cannot select randomly a number k is odd first part is k k must be odd, but after that also what shall be k is it 3 cross three is it 5 cross 5 or is it 7 cross 7 suppose, I know by my noise is of size is 5 cross 5. Then my sub image will be more than 5 plus 5 otherwise you cannot suppress this noise.

So, if the noise size is more than diameter is more than w y than w1 then k must be greater than 2 times w 1 plus 1. Similarly, I do not want to lose the information at the right because detail information I cannot lose also. So, if I know that I want to retain the diameter less than w 2 then k must be less than equals to 2 w 2 minus 1. So, this is the two parameters you have to keep in mind. To estimate the value of k k is odd and k must satisfy this two condition. Next is.

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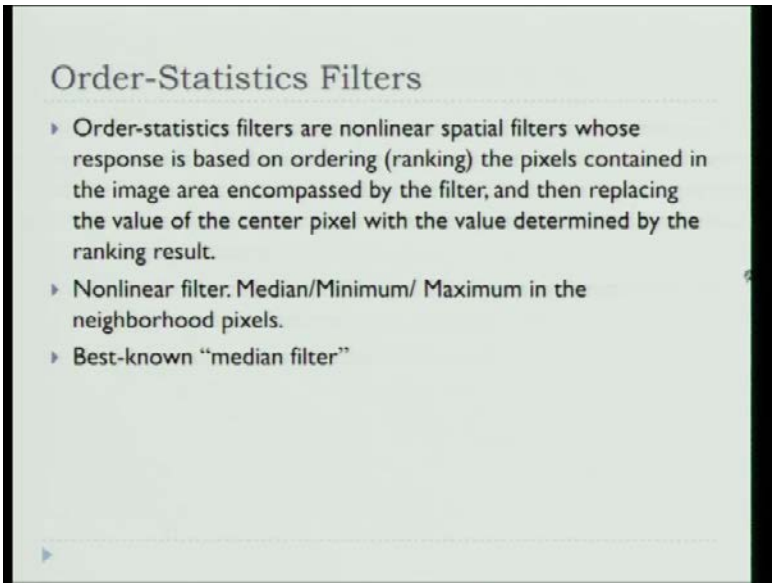

Order statistic filter as I told you this is a non-linear filters here. It is not considering any coefficient in the sub image to get the value of the center pixel. What is, but it is the same idea that mask will be moving from top corner top left corner to the bottom right corner. And what it does he will be taking that all the pixel values of the sub mask and then use the order statistic to determine the value of the center pixels. So, only the this

filter are either medium than n you have the k cross k sub image you can find out the median of it that median will be used to replaced centre pixel. It can be min max minimum or maximum and so on, generally we use median filter.

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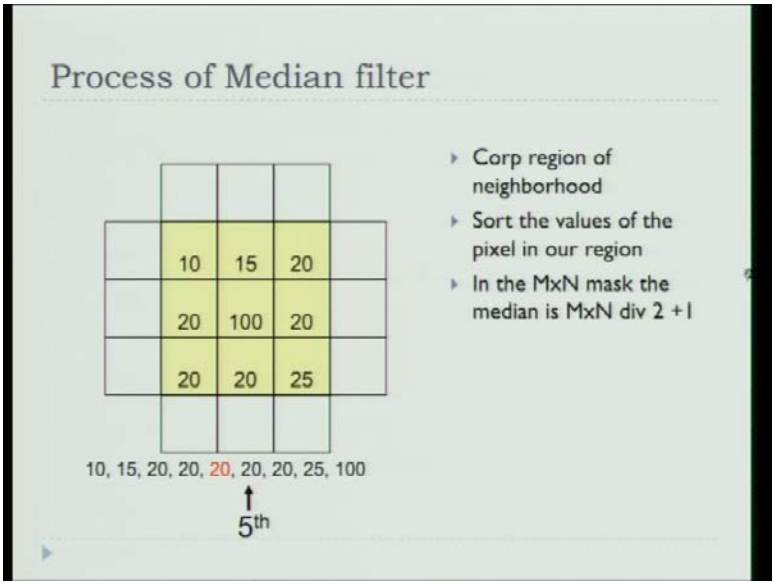

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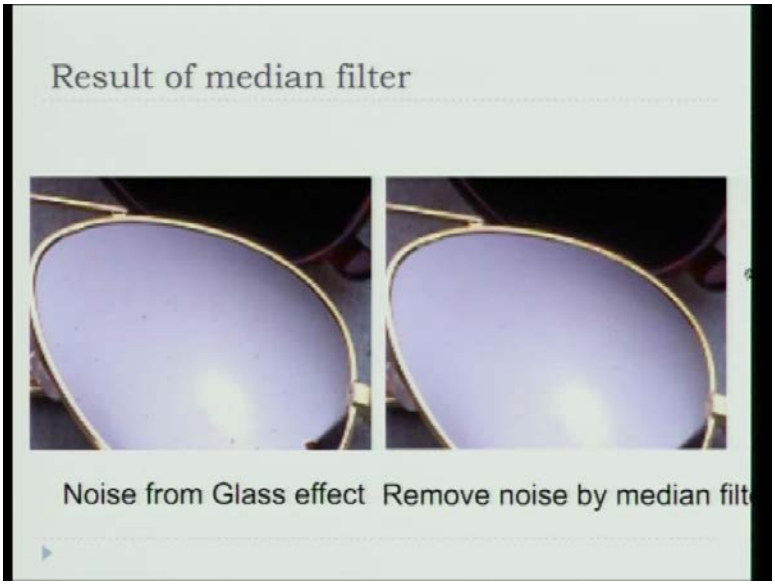

But median filter is not that simple if you see those if I had the 3 cross 3 and every time you have to compute the median. That means the nine elements every time you have to solve to get the fifth element. It is a complex one. Now, you remember how much time you do what is the k th element and the k th elements enacts. What is the complexity k th

element order and using bulbs algorithm right yes or no. So, you could have used there also bulbs algorithm, but number of elements is 9. So, does the mean much sense to you bulbs algorithm best way is to just sort it and get the middle element.

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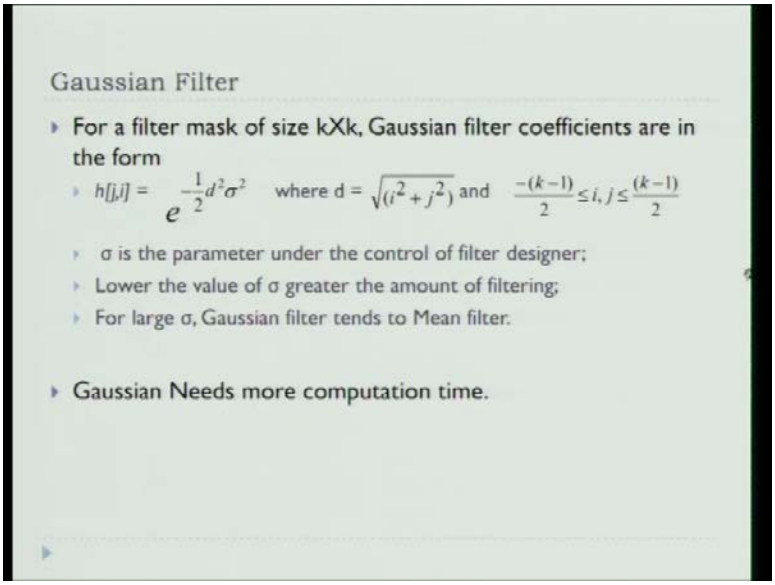

So, this is a sun glass you see that lot of noise is here. The noise you can see here and here after median filtering you will be getting this type of then the Gaussian filter this is the filter. Now, you have observed that you need to find out how to compute the centre pixel using the neighbouring pixel that is the problem. So, h i j is the centre pixel coordinate. So, I can find out what d d is am I square plus j square. So, I will check again, but most probably it is d Square even though minus half d square sigma square, where d is equals to this. That is I at position I th column and j th rho and I j both of them are because you have the mask k cross k.

So, that is a minus k by 2, minus k minus 1 by 2 and k minus 1 by 2. Now, the here the sigma plays the major role, you do not know what is sigma is the designer dependent and sigma is the thing who you will be telling. What is the amount of filtering you need for the small value of sigma that higher value of filtering. But if you make sigma is very large then this becomes you know average filter this becomes average filter because a to the power this will become one right it becomes average filter.

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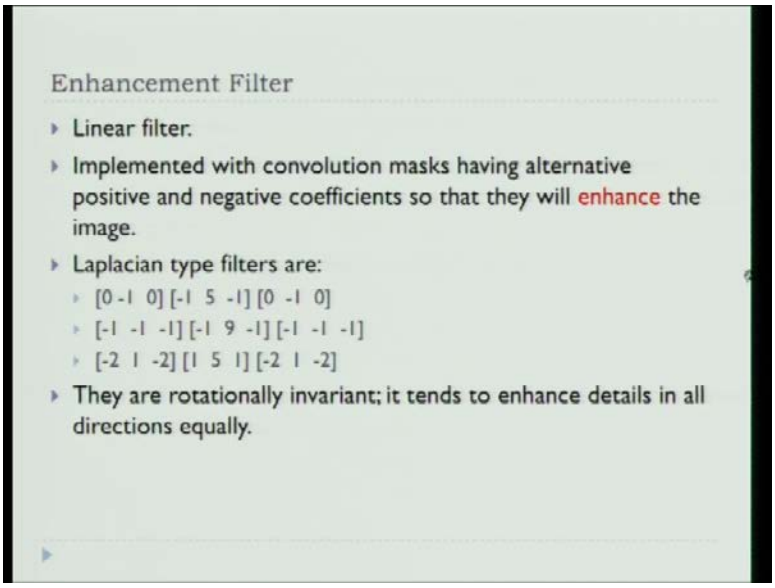

But obviously, if this is more competition, then I told you that there is another filter, which is known as the enhancement filter. And this enhancement filter will enhance the image basically, sharpens the edges that wherever there is an edge you want to give more importance. And this is laplacian type of filter and this filter is 3 cross 3 is there.

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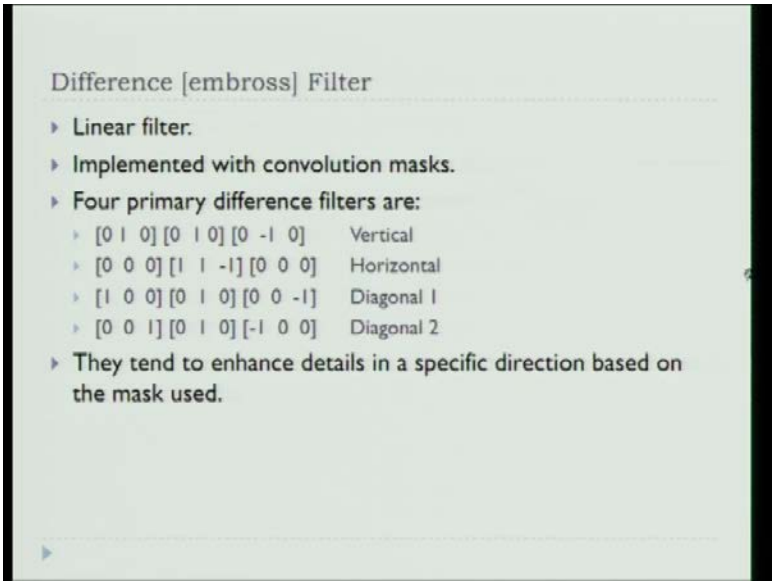
This is 1 filter 0 minus 1 0, minus 1 5 0, 0 minus 1 0 and you observed here. I am what I am giving I am giving I do not give them any importance of the diagonal elements I am giving comparatively less importance to the horizontal and vertical, but maximum importance on my center pixel. So, this will reflect on horizontal direction and vertical directions, horizontal direction and vertical directions and also you see that the coefficients are alternatively positive and negative.

What it means that edges will be sharpen edges will be sharpen in which direction because here I am reducing the weights edges will be sharpen this direction. This directions am I right also, that some is one average brightness will be retain. Now, think about the say third and second here weight age I have given minus 1, minus 1, minus 1, minus 1, minus 1, minus 1 minus 1, minus 1 and here it is 9 here. Then I am giving equal importance to the vertical and horizontal along with the diagonal.

So, in this case you could have seen the diagonal edges enhance form here you will be finding that in all directions you are getting the equal importance you have given. So, all of them will be brighten in the third one can you tell me what is the impact third one horizontal directions and vertical directions materials will be enlighten better than the diagonal ones. However the average brightness wills retained average brightness of the image will be retained agreed because some of the coefficient is one. So, since I am giving the importance in the all the directions.

(Refer Slide Time: 33:27)



So, this are rotationally in variant there is another one, which is known a filter which is known as difference filter. Sometimes will tell embross filter these are also linear filter you have to convert it from one corner to another corner. And the mask are given this is the vertical impact, this is horizontal impact, this is diagonal impact one. And this is also diagonal impact right and this is also linear filter up to the second tend all filtering. So, this about your filtering, this filtering mainly used first part is that what I told you that to reduce the noise.

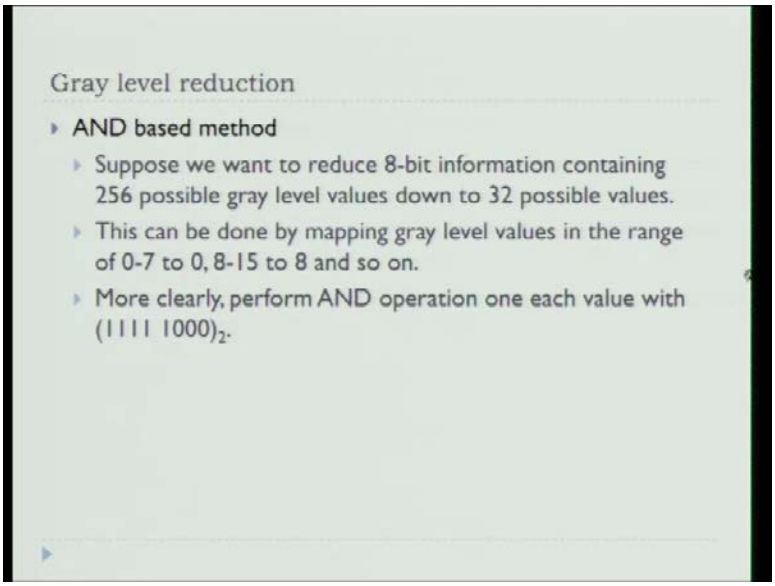
And this you have to do before you any feature extraction to get they to get rid of all the noise or the any detail information, which you do not want in the image. Now, of you want that no in my features, that I want the edges should be taking into account then you should use the enhance enhancer element filter. If you feel that no I want to give the equal weight age then you should give other median filter or mean filter. Now, next one

is image quantization this is also very important thing see I have an image size n cross n no, but if I have huge volume of data or huge volume of images. I may not like to retain all of that. So, is it possible to reduce my image size?

So, one way could be a simple way, you can think sir I have a call image n cross n and instead of instead of taking all the image. I take only the odd columns of the image and odd rows of my image I drop the even rows and even column, which size will b reduce by 4 this is possible another way could be that suppose, I have a 8 bit data 40 for an image for a pixel value. I tell no I do not want 8 bit I want to retain only 4 bit or 5 bit or 6 bit. What it means that I have 8 bits and last few bits. I want to discard say 63 is my grace scale value, grey value and another one is having 62.

So, one is 63 another one is 62, 63 is 8 value this is one and in 8 value this is 0 and remaining are same.. So, if I suppress, if I do not consider this one then I get the data 7 beat and 7 beat only thing is that 63 has been converted to 62 only. Nothing more than that, but my image and one grey value change we will not spoil your thing. So, one way is that you can perform the operations on the grey values another one is that you can perform the operations on the column row thing. You can skip the some columns, you can skip some rows to get the reduce the size.

(Refer Slide Time: 37:18)



So, simplest one or what you do the grey level reduction that is in the grey level reduction first one is the and operations suppose I have 8 bit data and this 8 bit data I

want to convert in to 32 pixels values. What it means that all pixels, all pixel values lying there is 0 and 7. I want to put 0. All pixel values lying between 8 and 15 I want to put value 8 and so on. All pixel value lying between 16 and 23 or 24, 23 or 24 I want 23 I want to put 16 and so on. So, base you could have done it dividing by 8 and you get the value.

So, instead of dividing by 8 we just perform the and operations we get the value. And once you do the and operations you will be getting the value 0 to 7, you get 0 8 to 15, you get 8 and so on. Is it clear? Now, next one is instead of doing that I want that no 0 to 7, I do not want 0, I want to put 7 depending upon your idea or you are seeing the image you may have to take the decision.

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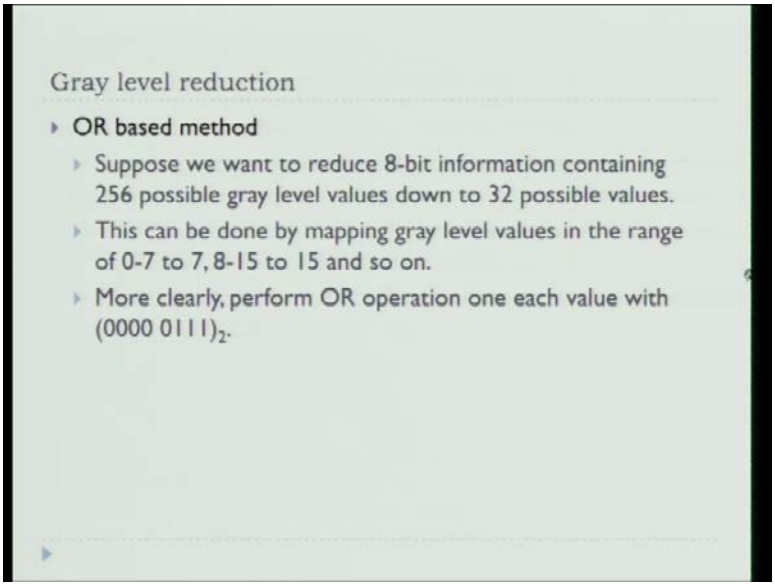
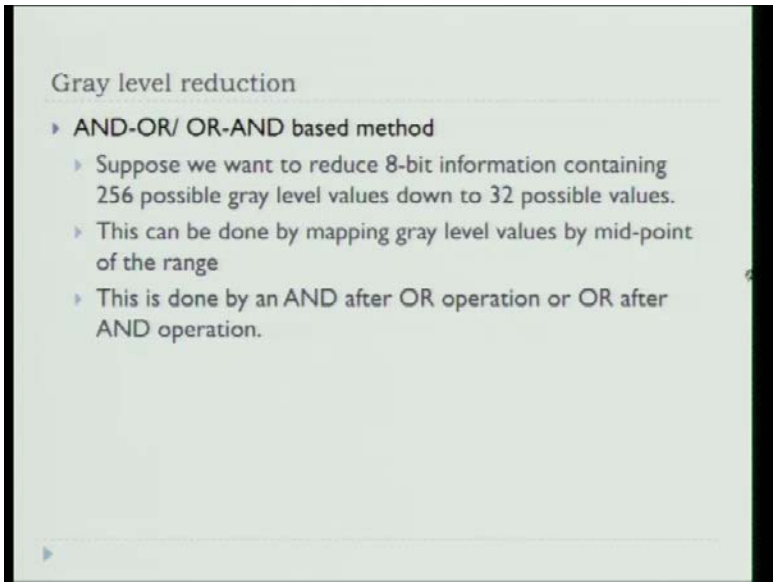


The 0 to 7 I want to put 7 and 8 to 15 I want to put 15 and so on. In that case you will be performing the or operation on with theses values. Why I have taken 8 bits because it is a 256 0 to 255 which is 8 bit. So, that is why I have taken the 8 bits operations. Now, can you tell me what I should put or what should be the operations to replace 0 to 7 by its middle value, middle value is what 0 to 7, middle value 4 or 5, 4 not 3 0 1 2 3 4 5 6 7 (No audio from 39:31 to 39:39) So, I want to put by it is medium middle value what operations I will perform.

So, I told you that if I want to replace 0 to 7 by 0, then I perform the and operations if I want to perform 0 to 7 by 7 I put operation on this with this mask am I right. Now,

suppose I want to perform the operation or perform the I want the image that, which will be like that 0 to 7, which will be replaced by the middle of this either 3 or 4 and 8 and 15 by 11 and 12 and so on. What types of operations I need to perform (No audio from 40:24 to 40:30) divide by why you need here?

(Refer Slide Time: 40:25).



So, either and or will give you one of this other one will give that one and that shift operation anyway you have to do it otherwise you will not get the reduction. So, suppose we this can be done by both of them. So, either and or and operations is it clear. So, this is all about the material what do I covered first one is what is convolution any doubt on convolution. That I have discussed about the filtering, in the filtering I told the why I need the filtering and there are 4 types of filtering I told one is average filtering, order statistic filtering or median filtering I told them I told Gaussian filtering and enhancement filtering.

Finally, we told also what should be the appropriate size of k why you need the k is odd and what is the constrain you have to put or you have to see. So, that the perfect value of k you can obtain and also the how to reduce the size of your image. This is important because sometimes for example, 10 mega pixel image you got it, but you cannot handle 10 mega pixel images. For I need only 100 cross 100 may be or 110 cross 110 like that type or 220 or 230 from 10 mega pixel you have to reduce, it how to reduce it.

So, we currently what we are doing we are dropping some columns and rows, but dropping columns and rows is create may create problem because some of the important features may be I am losing then there was no need of getting image of from the 10 image of size 10 pixel 10 mega pixel thing. But because we have the constant, we have the limitation of handling such a you now, large image. What we are doing that even though the sensor is giving the larger image I am reducing it to the smaller image, then I am doing the pre prosing to get the features.